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Questions or Comments?
Correspondence regarding editorial matters should be addressed to the Editor: Claire Johnson, DC, MSEd, Journal of Manipulative and Physiological Therapeutics, 200 E. Roosevelt Rd, Lombard, IL 60148-4583.

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Single-copy prices will be charged on missing issues older than 3 months (6 months international) from mail date. Back issues generally are available for the previous 5 years.

Indexing/Abstracts
The Journal is indexed or abstracted in Index Medicus, EM-Base/Excerpta Medica, Index to Chiropractic Literature, Current Contents/Clinical Medicine, Russian Academy of Sciences, and BS/CCML Database. Volume index appears in the December issue.

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EDITORIAL

ENSURING THE PRIVACY OF PROTECTED HEALTH INFORMATION IN RESEARCH

Bart N. Green, DC, MSEd
Associate Editor

An issue of mounting importance for health-care providers and researchers in the United States is that of ensuring the privacy of health information of patients involved in research. Laws and statutes dealing with this issue may be germane in other countries. What do authors and research centers need to know about privacy? How can readers be assured that private information is protected and that patients’ civil rights are respected? This editorial provides an overview of this developing area of responsibility for health-care providers and researchers.

The topic of confidentiality in health care is not new. However, US federal law and various rules pertaining to protecting health information are fairly new topics for authors, editors, and publishers since the Health Insurance Portability and Accountability Act (HIPAA) of 1996, also known as the Privacy Rule, went into effect on April 14, 2003.1 Most health-care providers in clinical practice in the United States are aware of HIPAA from the perspective of protecting health information in the clinical setting. However, the Privacy Rule also applies to research efforts, and there are regulations to follow as manuscripts make their way to publication. The Journal of Manipulative and Physiological Therapeutics (JMPT) is not alone in addressing HIPAA issues; editors of other biomedical journals are dealing with these concerns.2-5

The question pertaining to HIPAA that an author needs to answer is, “Am I allowed to conduct this research without the authorization of the patient?” This involves determining whether the patient was cared for by a “covered entity” and also the dates of when the care was provided. A covered entity is one or more of the following: (1) a health-care provider that conducts certain transactions in electronic form, (2) a health-care clearinghouse, or (3) a health plan. Readers can determine if they are a covered entity by using the online decision-making tools available from the Centers for Medicare and Medicaid Services (www.cms.hhs.gov/hipaa/hipaa2/support/tools/decision_support/default.asp).

Because there are several caveats to answering this question, it is best for authors from institutions, hospitals, and health-care groups to submit a proposed research project (regardless of research design) to either an institutional review board (IRB)/ethics review board or privacy officer for guidance. Institutional review board/ethics boards reviewing clinical trials for approval usually ensure the protection of information through appropriate data safety and monitoring processes. Therefore, manuscripts derived from such research are usually in compliance with HIPAA, assuming that the IRB/ethics board has compliance measures in place.7

Projects performed at institutions (eg, colleges, universities, hospitals) that receive expedited review or exemption from an IRB/ethics board (eg, case reports, case series, and quality improvement studies) also need to be HIPAA compliant. When obtaining patient authorization is not practical, an IRB/ethics board or privacy board may be able to waive or alter the authorization requirement. The Privacy Rule also provides alternatives to obtaining an authorization or a waiver or an alteration of this requirement, such as limited data sets or with representations provided for certain research activities. HIPAA contains a provision that “grandfathers” research that is ongoing before the compliance date to facilitate compliance with the Privacy Rule.8

Summarily, researchers and clinicians at institutions should have projects approved by the HIPAA or privacy officer before initiating the project and certainly before submission of a manuscript to a journal.8

Authors submitting works from individual private practices may also be covered entities and can explore the online decision-making tools described previously to determine this. The simplest way to ensure that patient privacy is respected is to have patients (whose care was rendered on or after April 15, 2003) reported in a study provide written authorization to have information pertaining to their case published in a public medium (www.wame.org/hipaa.htm). Information is available in the JMPT instructions for authors (www.mosby.com/jmpt).

In compliance with the Privacy Rule, the JMPT now requires all authors to obtain IRB/ethics board or privacy officer approval of the project and/or the written author-
ization of patient(s), and to include such a statement in the methods section of the submitted manuscript. As is customary, protected health information (eg, name, social security number, medical record number, address, and others) should never be included in a manuscript or visible on figures submitted with the manuscript. A complete list of protected health information is available in the booklet Protecting Personal Health Information in Research: Understanding the HIPAA Privacy Rule. If a photograph of the patient is included with the manuscript, the author should protect the identity of the patient or the author should also acquire written permission from the patient to publish the photograph if the identity of the patient cannot be preserved.

The Privacy Rule provides ways to access vital information needed for research and publication in a manner that protects the privacy of the research subject. Many researchers are accustomed to complying with federal and state regulations that protect participants from research risks, although some may find these new policies yet another obstruction on the road to publication. Yet, it is our responsibility to be compliant with federal regulations and to protect the identity and privacy of our patients. Failure to do so may result in a patient filing a health information privacy complaint with the Office of Civil Rights. The Department of Health and Human Services is currently developing rules for the imposition of monetary penalties for those who violate HIPAA and is seeking public commentary on these rules. Authors may find the US Department of Health and Human Services question and answer Web site valuable for answering specific questions related to this topic. For a complete discussion of how HIPAA applies to research, acquire the free booklet Protecting Personal Health Information in Research: Understanding the HIPAA Privacy Rule from the Department of Health and Human Services.

How HIPAA and privacy rules in other countries apply to research, scientific writing, and journalism is a developing conversation. As time passes, the uncertainties surrounding this topic will hopefully become clearer through discussion and public interaction with federal agencies. The JMPT supports ensuring the privacy of health information in publication and requires appropriate documentation of such assurance as outlined in this editorial. Readers are encouraged to investigate the resources cited in this article.

REFERENCES

2. Schachat AP. What is HIPAA and what effect may it have on our journal? Ophthalmology 2003;110:1074-5.
Measuring the curve. Harrison et al (p. 516) evaluate the reliability of the flexicurve instrument in determining cervical sagittal skin contour.

Pain and physical impairment.

Lee et al (p. 479) study students who use computers to examine the relationship between the location of neck pain on pain drawings and physical impairments.

Manipulation influences EMG activity.

DeVocht et al (p. 465) investigate if manipulation induces a change in resting electromyographic levels in patients with low back pain and tight paraspinal muscles.

Two cases of myelopathy.

Patel et al (p. 539) present diagnostic images and clinical findings for one patient with acute transverse myelitis and another patient with posttraumatic syringomyelia.

A difference between manual vs machine?

Shearar et al (p. 493) examine if either mechanical or high-velocity low-amplitude chiropractic adjustments would reduce pain and disability in patients diagnosed with sacroiliac joint syndrome.

Chiropractic and neck pain.

Haneline (p. 520) summarizes the current evidence on chiropractic manipulation for the treatment of acute neck pain.

Type O or type M?

Pollard (p. 547) suggests a model for the chiropractic profession that might act as a bridge between various, and seemingly self-excluding, approaches to patient management.

A pain in the behind.

Cox and Bakkum (p. 534) correlate the anatomy of the gluteal region with the clinical findings of retrotrochanteric and posterior thigh pain.

Case series of MUA.

Cremata et al (p. 526) present the results of 4 cases for patients with chronic spinal, sacroiliac, and/or pelvic and low back pain undergoing manipulation under anesthesia.

Reliable outcome measures.

Agarwal et al (p. 487) examine if the Spin-T goniometer and a laser pointer is a reliable way of measuring cervical ranges of motion.

Response to manipulation.

Hemmilä (p. 508) examines if manual therapy has a measurable effect on cervical spine pain and mobility over time.

Long-term outcomes for LBP.

Leboeuf-Yde et al (p. 472) investigate distinct subgroups of patients with low back pain. These findings may help to predict treatment outcome in chiropractic practice.

Cortical processing and the spinal adjustment.

Lersa et al (p. 502) investigate the relationship between the number of sites of spinal dysfunction and a range of measures of cognitive processing.
ORIGINAL ARTICLES

SPINAL MANIPULATION ALTERS ELECTROMYOGRAPHIC ACTIVITY OF PARASPINAL MUSCLES: A DESCRIPTIVE STUDY

James W. DeVocht, DC, PhD, Joel G. Pickar, DC, PhD, and David G. Wilder, PhD

ABSTRACT

Objective: To examine the effect of spinal manipulation on electromyographic (EMG) activity in areas of localized tight muscle bundles of the low back.

Methods: Surface EMG activity was collected from 16 participants in 2 chiropractic offices during the 5 to 10 minutes of the treatment protocol. Electrodes were placed over the 2 sites of greatest paraspinal muscle tension as determined by manual palpation. Spinal manipulation was administered to 8 participants using Activator protocol; the other 8 were treated using Diversified protocol.

Results: Electromyographic activity decreased by at least 25% after treatment in 24 of the 31 sites that were monitored. There was less than 25% change at 3 sites and more than 25% increase at 4 sites. Multiple distinct increases and decreases were observed in many data plots.

Conclusion: The results of this study indicate that manipulation induces a virtually immediate change, usually a reduction, in resting EMG levels in at least some patients with low back pain and tight paraspinal muscle bundles. In some cases, EMG activity increased during the treatment protocol and then usually, but not always, decreased to a level lower than the pretreatment level. (J Manipulative Physiol Ther 2005;28:465-471)

Key Indexing Terms: Chiropractic; Electromyography; Manipulation; Spinal

Chiropractors have delivered spinal manipulations (SM), also known as chiropractic adjustments, for more than 100 years with the intention of correcting clinically determined spinal dysfunctions. Although theories abound, little is definitively known about the exact nature of such dysfunctions, often referred to as subluxations. However, subluxations are commonly thought to have deleterious biomechanical or neurophysiological effects. It is further thought that chiropractic treatment involving SM corrects or at least reduces the severity of a subluxation and consequently removes or reduces its deleterious effects.

Little is known about the detailed mechanisms by which chiropractic treatment corrects spinal dysfunctions. There is substantial evidence showing that SM does affect central processing for motor control. Central motor excitability has been shown to increase after SM. Specifically, when transcranial magnetic stimulation is used to directly activate descending corticospinal tracts, the resulting electromyographic (EMG) activity from the gastrocnemius muscle is larger if preceded by manipulation of the lumbar spine as compared with simply positioning the patient for manipulation. On the other hand, the tibial nerve H-reflex is inhibited by side-posture manipulation of the L5-S1 joint. It has also been shown that SM produces a nearly immediate increase in paraspinal muscle EMG activity, presumably reflexive in nature.

Many chiropractors palpate for tight muscle bundles in the paraspinal musculature as one indication of where to adjust. It seems reasonable to expect resting muscle activity, which can be monitored by EMG, to be abnormally high in...
the region of a tight muscle bundle. If the presence of a tight muscle bundle is functionally associated with a spinal dysfunction that is correctable by SM, it would consequently follow that the tight muscle bundle, and the associated higher EMG level, would diminish after appropriate SM. However, to our knowledge, no studies have directly investigated this issue.

At least 2 references have been made in the literature to reductions in resting surface EMG from paraspinal musculature after SM. Shambaugh\(^7\) collected EMG data just before and just after the subject received SM. Three pairs of electrodes were placed at preset sites 4 cm to each side of midline over the upper trapezius and the upper and lower erector spinae muscle groups. One site at a time was monitored by visually reading the level of EMG activity from a gauge. He reported an average 25% reduction in EMG activity in 20 subjects and no reduction in 14 controls. Herzog\(^8\) reported the observation of a single but very dramatic decrease in resting EMG activity in thoracic musculature within 1 second of SM.

In this descriptive study, we have further explored the phenomenon of reduced EMG activity after SM to better understand the immediate effects of SM. Electromyographic changes during and after SM were recorded in participants receiving Activator and Diversified manipulative approaches.

### Table 1. Summary of EMG data collected during Activator protocol

<table>
<thead>
<tr>
<th>ID</th>
<th>Data type</th>
<th>Pad</th>
<th>Location</th>
<th>Pretreatment (µV)</th>
<th>Posttreatment (µV)</th>
<th>Change (µV)</th>
<th>Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Raw</td>
<td>A</td>
<td>L5-L</td>
<td>1.97</td>
<td>0.72</td>
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<td>−63</td>
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<tr>
<td>1</td>
<td>Raw</td>
<td>B</td>
<td>L5-R</td>
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<td>−10.18</td>
<td>−77</td>
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<tr>
<td>2</td>
<td>Raw</td>
<td>A</td>
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<td>−88</td>
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<tr>
<td>2</td>
<td>Raw</td>
<td>B</td>
<td>L4-R</td>
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<tr>
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<td>L3-R</td>
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<tr>
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<td>−67</td>
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<tr>
<td>5</td>
<td>Raw</td>
<td>A</td>
<td>L3-L</td>
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<td>5</td>
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<td>7</td>
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<td>0.96</td>
<td>0.73</td>
<td>−0.24</td>
<td>−25</td>
</tr>
</tbody>
</table>

T, Thoracic; L, lumbar; -R, right; -L, left.

### Table 2. Summary of EMG data collected during diversified protocol

<table>
<thead>
<tr>
<th>ID</th>
<th>Data type</th>
<th>Pad</th>
<th>Location</th>
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<th>Posttreatment (µV)</th>
<th>Change (µV)</th>
<th>Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>RMS</td>
<td>A</td>
<td>T10-R</td>
<td>0.26</td>
<td>0.63</td>
<td>0.38</td>
<td>147</td>
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<td>9</td>
<td>RMS</td>
<td>B</td>
<td>R LG</td>
<td>1.36</td>
<td>0.27</td>
<td>−1.10</td>
<td>−80</td>
</tr>
<tr>
<td>10</td>
<td>RMS</td>
<td>A</td>
<td>T9-R</td>
<td>0.49</td>
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<td>B</td>
<td>T3-R</td>
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<td>11</td>
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<td>0.55</td>
<td>0.39</td>
<td>−0.16</td>
<td>−30</td>
</tr>
</tbody>
</table>

T, Thoracic; L, lumbar; -R, right; -L, left; LG, lateral gluteal.
METHODS

Participants were solicited from patients as they were seeking treatment in the private offices of 2 local chiropractors who served as the treating clinicians. One used the Activator protocol\textsuperscript{9} and the other used the Diversified approach. The Diversified approach is not as well defined\textsuperscript{10} as the Activator approach but is the most commonly used chiropractic technique.\textsuperscript{11} Both chiropractors identified patients with low back pain as potential participants in this study, as they would be most likely to have tight paraspinal muscle bundles in either the lumbar or lower thoracic region. The nature and extent of the study were explained to each patient, and each signed an institutional review board–approved informed consent form. Patients received no compensation for their participation. Every patient who was approached for the study agreed to be a participant. No advertising was done as a recruitment effort.

The participant was placed prone on the clinician’s adjusting table. The treating clinician palpated to identify the 2 most distinct tight muscle bundles in the paraspinal musculature of the lumbar or lower thoracic spine. These 2 spinal levels were marked using a water-soluble marker to place an “x” on the skin over the tip of the spinous process. The paraspinal area was cleaned with alcohol, and an EMG electrode was attached approximately 2 cm lateral to the spinous process at the segmental levels of the tight muscle bundles. This left sufficient room for the contact of either the instrument or the hand of the treating clinician.

Adjustments given by the Activator clinician were delivered using the Activator Adjusting Instrument II (AAI) and the Activator Methods protocol.\textsuperscript{9} The AAI is modeled after a dental impact hammer but fitted with a blunt, rubber tip. It delivers a very short (approximately 5 milliseconds), shallow (approximately 5 mm) thrust when set for maximum magnitude.\textsuperscript{12} A small accelerometer (Isotron Model 2250A-10, ENDEVCO, San Juan Capistrano, Calif) was taped near the tip of the AAI to signal the precise moment each adjustment was given. The accelerometer output was passed through a signal conditioner (ENDEVCO model 2775A) and into one of the channels of the EMG unit. The accelerometer output was plotted along with EMG data. The accelerometer was not calibrated to provide a measurement of the magnitude of the AAI tip’s acceleration but served only to indicate when the thrust occurred relative to the EMG data being monitored. Occasionally, this system would fail to record a thrust from the AAI, which was apparent by watching the accelerometer tracing in real time on the computer screen as data were being collected. Therefore, along with a written record of the spinal level where each thrust was given, it was also annotated whether the accelerometer responded to each thrust given with the AAI.

Manual adjustments given by the Diversified clinician were delivered by applying a short, quick thrust with his hand after positioning the patient according to the specific adjustment.\textsuperscript{10} The approximate onset time of each Diversified adjustment was obtained using the accelerometer. It was placed near the data acquisition system, and the person recording the EMG data simply tapped it when an adjustment was given. This method was not as precise as that used with the Activator, but it did provide an indication of when each adjustment was given relative to the EMG data.

Electromyographic activity was obtained with a FlexComp data acquisition system model 9501 using software version 1.51B (Thought Technology, Montreal, Quebec). Electrodes were 2.25-in (5.72 cm) triodes, disposable, and adhesive with Ag/AgCl snaps. Data were sampled at 1984 Hz, which was the fastest sampling rate of the system. The data were electronically filtered through a 100- to 200-Hz bandpass filter as well as a 60-Hz notch filter. The data acquisition system could collect raw EMG signals for a short period (20-30 seconds), or it could average the data in 65-millisecond segments as root mean square (RMS) values. Root-mean-square data were less detailed compared with raw data but could be collected for longer periods (ie, throughout the entire treatment protocol of 5-10 minutes).

For those cases in which raw EMG activity was measured, data collection began just before a manipulation was applied in the area near where the EMG electrodes had been placed. Data collection stopped after that immediate

![Figure 1. Comparison of resting paraspinal EMG activity before and after 2 types of chiropractic spinal manipulation. The diagonal represents the region of no change, when pre- and posttreatment EMG activity levels were the same. Points above the line represent cases where posttreatment EMG was greater than pretreatment EMG, whereas those below the line indicate a decrease in EMG activity level after treatment. One outlier during the Activator protocol is not plotted with a pretreatment value of 13.2 and final of 3.0 μV.](image-url)
area was treated and then resumed again for a few seconds after all treatment was completed. Participants were at rest, with no movement, during the time raw EMG data were being collected.

For those cases in which EMG activity was measured in RMS values, data collection began before any treatment was given and continued until all treatment was complete. Those participants were at rest with no movement during the first few seconds of RMS EMG data collection, and again for a few more seconds at the very end of data collection. They often made movements during the 5 to 10 minutes of the treatment protocol, although the times of those movements were not recorded.

Resting EMG levels were calculated as the lowest level of EMG activity averaged over a representative segment before and at the end of the treatment protocol. The specific segments selected were chosen because they contained no obvious artifacts. Participants were instructed to lie prone without moving and to relax as fully as possible.

Each of the 2 clinicians treated the participants just as they would treat any other patient (one using Activator Methods and the other using Diversified). No effort was made to standardize the adjustments given or to control the treatment in any way. The intent was to monitor paraspinal EMG activity in response to the clinicians’ normal manner of treatment.

**RESULTS**

Tables 1 and 2 summarize data collected from the 8 participants receiving Activator treatment and from the 8 participants receiving Diversified treatment, respectively. Of the 15 sites monitored in 8 Activator-treated participants, 11 decreased 25% or more, 3 increased by less than 25%, and 1 increased more than 25%. Of the 16 monitored sites on 8 Diversified-treated participants, 13 decreased 25% or more, and 3 increased by more than 25%. The type of EMG metric (raw or RMS) and pad location is given for each electrode pad (columns 2 and 4). Pads were always located approximately 2 cm left or right of the spinous process of the designated vertebra.

For the Activator group, pre-SM values ranged from 0.41 to 13.15 μV (median, 1.93 μV), whereas post-SM values ranged from 0.41 to 2.97 μV (median, 1.06 μV). For the Diversified group, the pretreatment values ranged from 0.26 to 2.01 (median, 0.96 μV), and the posttreatment values ranged from 0.27 to 0.89 (median, 0.41 μV). Paired measurements for each individual showed that the percent change in EMG activity ranged from 88% to 255% for Activator (median, −39%) and from −80% to 147% for Diversified (median, −43%).

**Fig 2.** Plot of RMS EMG data from pad A (2 cm left of L4 spinous process) of participant 7. The lowest values in the band of EMG activity represent resting EMG activity, which is seen to vacillate somewhat over the almost 5 minutes of data collection. Resting EMG activity ended at a somewhat lower level (<2 μV at 290 seconds) than at the beginning (mostly >2 μV for the first few seconds). Large amplitude EMG activity likely represents voluntary movement by the participant. Accelerometer tracing represents onset of spinal manipulation. Small but perceptible drops in activity are noted to occur very shortly after most of the thrusts. Other small drops occur where there are not thrusts.
Fig 2. Shows RMS data taken continuously throughout the 5 minutes of an Activator protocol. Inasmuch as participants make many movements during the course of the protocol, momentary increases of EMG activity associated with those movements were recorded. Most thrusts were followed by small but noticeable drops in EMG activity and the posttreatment level of activity (270-290 seconds) is noticeably lower than the pretreatment level (0-5 seconds).

Fig 3. Shows raw EMG data taken continuously for 20.9 seconds during 6 Activator adjustments. The general level of EMG activity was relatively constant until a few seconds after the third and last sacral adjustment, at which time (9.5 seconds) EMG activity dropped abruptly. This lower level of EMG activity was maintained until approximately 19.5 seconds, representing a few seconds after the third and last lumbar adjustment. At that time, a second distinct and abrupt drop occurred. The new, still lower level of EMG activity was maintained for the next 1.5 seconds until a break in data collection occurred. When data collection resumed at the completion of treatment, approximately 4 minutes later, EMG activity was still low and remained low during the final segment of data collection lasting an additional 4.5 seconds.

Fig 4. Plot of RMS EMG data from pad A (2 cm left of T2 spinous process) of participant 12. The resting EMG level is relatively constant for the first minute and then abruptly increases to a much higher level. The sustained increase, which lasted from 70 to 330 seconds, suggests that additional motor units were recruited. The EMG level fluctuates but remains relatively high for almost 5 minutes when it abruptly drops to a level lower than the initial level. The resting EMG level then vacillates over the remaining 3 or 4 minutes, but always remains below the pretreatment levels.
Fig 4 shows RMS data taken continuously throughout a Diversified treatment lasting approximately 9 minutes. Electromyographic activity is relatively constant for the first 60 seconds, then increases for almost 5 minutes during the course of the manipulative protocol. After treatment, EMG activity abruptly drops, stabilizing at values lower than the initial level. The large EMG peaks during the time interval around 100 seconds as well as those in the last few minutes are likely indicative of voluntary movement. Although the overall effect shown in this figure is a definite decrease in EMG activity, it is noted that most thrusts were not immediately followed by a perceptible decrease in EMG activity.

Although not formally documented in this study, it was noted that pretreatment resting levels of EMG activity did not always seem to correspond well with the current symptoms of the participants. That is, the participants with the worst back pain did not always have the highest levels of resting EMG activity at what had been perceived to be the tightest muscle bundles. Nor did the patients with the least low back pain always have the lowest resting EMG activity levels.

**DISCUSSION**

This study showed that resting EMG activity level usually decreased in 16 participants after SM using either an Activator or a Diversified treatment protocol. With EMG recordings obtained from 2 paraspinal muscle sites on each participant (except for one), 27 of the 31 pretreatment resting EMG levels decreased after treatment. During the 5 to 10 minutes of the treatment protocol, distinct changes (both increases and decreases) in the level of EMG activity were often observed.

The clinical consequences of SM were not investigated in this study. However, the reduction of resting EMG activity after SM that we observed in the greater majority of cases is consistent with and supportive of the commonly held perception that tight muscle bundles are associated with low back pain and that they can be alleviated by SM. This line of thought is the basis of many styles of chiropractic treatment.

Before doing this study, we anticipated seeing elevated resting EMG activity levels associated with palpable tight muscle bundles. Furthermore, we anticipated seeing elevated resting EMG levels decrease after the treatment protocol, or possibly remain elevated if that particular treatment was not completely effective. It was presumed that elevated resting EMG levels would be indicative of some aberrant neuromuscular and/or biomechanical state that was correctable by SM. Most of the cases observed were consistent with our expectations. However, it is curious to note that in some cases the level of EMG activity increased quite markedly during the early part of the treatment protocol and then most often but not always ended at a level lower than the pretreatment level (Fig 4).

Specifically, in 4 cases it was observed that EMG activity was at a higher level after the treatment protocol compared with its beginning (above the diagonal in Fig 1), although the increase was small in 3 of those 4 cases.

One possible explanation for this phenomenon of increasing EMG activity levels is that the entire treatment protocol may be required to achieve maximum benefit and that an incomplete treatment may be worse than no treatment at all. If the resting EMG level remained high at the very end of the protocol, it could be that that particular visit was not executed properly or completely. Alternatively, the elevated EMG activity at the end of the protocol may have been transitory, and recordings of longer duration could have revealed this.

There are likely other possible explanations for elevations in the resting EMG activity as well. Minor changes may be insignificant. Indeed, it is not well established just what the significance is for large changes. Perhaps the elevations are simply transitory and would be found to be decreased if measured some considerable time later. Similarly, the clinical consequence of the decrease in EMG induced by SM and the duration of the decreases remain to be established.

It cannot be determined just how much of the elevated EMG activity seen in the RMS data taken during the treatment protocol (Figs 2 and 4) can be attributed to an increase in resting EMG activity as opposed to voluntary muscle activity. It is theoretically possible that all of the momentary increases of EMG activity were the direct result of muscle contraction associated with voluntary movements. However, increased EMG activity resulting from voluntary muscle movement is likely to be greater in magnitude and shorter in duration than increased resting EMG activity. An increase in resting EMG activity would seem to be especially likely in those cases where elevated levels of EMG activity are maintained continuously for many seconds, or even minutes, as shown in Fig 4 from approximately 60 to 340 seconds. It is unlikely that the participant could have been in continuous motion for almost 5 minutes. This suggests that at least some of the increased activity is due to involuntary central nervous system control, presumably in response to the SM.

**Limitations**

There were several limitations in this study, including our inability to compare across participants. This limitation stemmed from 2 separate issues: one was the use of 2 methods for collecting EMG data (raw and RMS), and the other was the fact that EMG levels were not normalized to some constant standard. Raw EMG activity has the advantage of showing the most detail but has the limitation of generating a large amount of digitized data. Our recording system had memory limitations and was capable of collecting raw EMG for short periods (15-20 seconds) with data taken at 2000 Hz (Fig 3). Root-mean-square EMG activity is
averaged over segments of time, which smoothes the data and takes much less memory space. Although much of the detail is lost, RMS data were collected over much longer periods (continuously over the entire treatment protocol), as shown in Figs 2 and 4.

Another limitation of the study was the lack of a control group. This made it difficult to solely ascribe the observed decreases to treatment response as they could be due to relaxation as the participant continued lying in a prone position. However, the abrupt nature of the decreases, especially when in close temporal and physical proximity to SM in the immediate area of electrode placement, and the marked and sustained increases in activity levels (Fig 4) suggest that at least some of the changes were in direct response to the treatment. Similarly, Shambaugh measured no change in resting paraspinal EMG levels in control participants who relaxed in a prone position for 5 minutes between EMG recordings. This finding is consistent with the interpretation that the changes we observed were in response to the SM and not simply to the relaxation of the participant while lying down.

CONCLUSION

The results of this descriptive study support the notion that SM has a virtually immediate and presumably beneficial effect on at least some patients with low back pain usually resulting in lower EMG activity of hyperactive paraspinal muscles. These findings are consistent with the premise of chiropractic treatment that tight muscle bundles are indicative of spinal dysfunctions that are correctable by SM. However, EMG levels sometimes increased during the course of chiropractic treatment. This observation has unknown clinical implications. If these EMG levels do not subsequently decrease, this might suggest that incomplete chiropractic treatments are worse than no treatment at all. Further studies should be completed to assess this phenomenon.

REFERENCES

The Nordic Back Pain Subpopulation Program: The Long-Term Outcome Pattern in Patients With Low Back Pain Treated by Chiropractors in Sweden

Charlotte Leboeuf-Yde, DC, MPH, PhD, a Iben Axén, DC, b Jess James Jones, MSc, c Annika Rosenbaum, BAppSc (Chiro), d Peter W. Lovgren, DC, e Laszlo Halasz, MHSc (ClinBiomech), f and Kristian Larsen, MPH, PT g

Abstract

Objectives: (1) To describe the low back pain (LBP) pattern at baseline; (2) to describe the long-term outcome pattern; (3) to investigate the presence of distinct subgroups in relation to outcome; (4) to establish whether short-term outcome is a predictor of long-term outcome.

Methods: A 3- to 6- and 12- to 18-month, multicenter practice–based, prospective descriptive study was performed in private chiropractic practices in Sweden. Fifty-eight of 64 previously compliant chiropractors each recruited a maximum of 30 consecutive patients with LBP. Complete baseline clinical information was provided on 1054 patients, of which 93% were interviewed approximately 3 months later, and 57% responded to a questionnaire at approximately 12 months. Chiropractic treatment was decided by the treating chiropractor. Twelve descriptive subgroups were created based on (1) duration of LBP at baseline, (2) duration of LBP in the past year, and (3) LBP pattern in the past year. The predictive value was tested for outcome status at the fourth visit. Information on self-reported LBP status and improvement over the past months were collected.

Results: Patients were spread in a U-shaped fashion from benign to severe with the 2 extreme groups being most prevalent. About half the participants reported “no LBP in the past week” at 3 months and somewhat fewer at 12 months. Almost 75% claimed to be definitely better at 3 months, and approximately 50% at 12 months. Specific predictive subgroups can be identified, mainly in relation to the past-year history of LBP. Improvement at the fourth visit is a predictor of long-term outcome.

Conclusion: Knowledge of specific subgroups may improve the quality of care and the selection of homogeneous study populations in clinical trials. (J Manipulative Physiol Ther 2005;28:472-478)

Key Indexing Terms: Low back pain; Manipulation; Chiropractic; Prognosis

There is a need to study the amorphous group consisting of patients with “nonspecific” low back pain (LBP) to find out if it consists of specific subgroups. If such specific subgroups exist, they may cause confusion when they, if unidentified, are grouped together and investigated in relation to cause and treatment.

Also, the long-term outcome pattern is not well understood in patients with LBP receiving chiropractic treatment. For these reasons, a prospective study was designed, in which a large number of patients typical to chiropractic practice were followed for more than 1 year, to find out whether it is possible to identify specific subgroups on the basis of their baseline characteristics and long-term outcome pattern. In addition, the prospective design of the study made it possible to consider whether outcomes at 3 and 12 months were associated with the short-term outcome. The latter aspect is an important clinical issue, as patients and chiropractors often have divergent expectations of the
treatment process. The patient expects it to be quick and will want to stop treatment as soon as the acute pain has abated, whereas the chiropractor wants to complete the treatment until the patient has reached his/her optimal status and is left with a feeling of frustration when patients disappear “prematurely.” It is not known which approach is the best, the “quick-fix” or the “let’s-improve-the-spinal-function-to-its-maximum,” and for which types of patients.

It was previously noted that duration of LBP at the time of consultation is a predictor of short-term treatment outcome, so that patients with a maximum duration of 1 week were more likely to improve than those with a duration of 1 to 2 weeks, and that the short-term prognosis for patients with a baseline duration of more than 2 weeks is even less favorable.2

In the present study, data were available on patients examined at baseline, interviewed after 3 months, and surveyed through a questionnaire after 12 months. This made it possible to obtain answers to a number of specific questions: (1) What is the distribution of subgroups in chiropractic patients with LBP? (2) What is the long-term outcome in chiropractic patients with LBP? (3) Is the outcome pattern similar across the different subgroups and outcome variables? (4) Is early improvement a predictor for long-term outcome in a mixed LBP group of chiropractic patients?

METHODS

The present project is one in a series of studies performed as part of the Nordic Back Pain Subpopulation Program, in which several groups of Nordic chiropractors conduct practice-based research, with the explicit goal of identifying specific subgroups of patients with LBP, with the aim of improving the level of quality in clinical practice.

The study was designed as a prospective outcome study carried out among 64 previously compliant chiropractors, practicing in Sweden in 2002. Each chiropractor was asked to collect data on a maximum of 30 consecutive patients with LBP. These patients were treated as typically done by the chiropractor. Ninety-two percent of these patients received spinal manipulative therapy, on its own or in combination with other therapeutic approaches.3 A team of 5 chiropractors supervised these chiropractors during the data collection period, as previously described.45 Patients were consecutively enrolled in the study if they had LBP with or without sciatica, and if they had not consulted a chiropractor during the preceding 3 months. The local ethics committee reviewed this study and did not request formal acceptance to carry out this study, as it was defined as a quality assurance project.

Baseline information was previously reported on 1057 patients in a study in which patients were monitored at the first, second, and fourth visits.3 The baseline questionnaire included a consent form for patients who gave the investigators permission to make contact for the follow-up studies.

On the basis of the information collected at the first visit, patients could be classified into 12 subgroups, in relation to (1) the duration of the problem at the first consultation (1-7, 8-14, or >14 days), described hereafter as “baseline 1 week,” “baseline 2 weeks,” and “baseline >2 weeks”; (2) the total duration of the problem over the preceding year (≤30 or >30 days), described hereafter as “nonpersistent LBP” and “persistent LBP”; and (3) the pattern of pain when present in the preceding year (intermittent or daily), described hereafter as “intermittent” and “daily.” An additional item used in the analyses was outcome at the fourth visit (“definitely improved” or “not definitely improved”).

Three to 6 months (“3 months”) after the original consultation, one of the team members (IA) conducted structured telephone interviews with the patients. They were asked 2 questions on their present LBP status. Question 1 was related to the severity of LBP in the past week (unbearable, bad, moderate, weak, none). Question 2 was related to the effect of LBP on daily living in the past 2 months (considerable, small, varying).

In addition, 4 questions were asked on the development over the past months as compared with the situation at baseline: What was the duration of the LBP problem (longer, as long, shorter, no pain at all)? What was the resistance to developing LBP (definitely better, probably better, no change, worse)? What was the frequency of LBP problems (definitely more frequent, probably more frequent, as frequent, less frequent, don’t know)? A final question was related to global assessment (definitely worse, probably worse, unchanged, probably better, definitely better).

In the analyses, the best response possibility was held up against all the others to create dichotomized variables. In relation to status, these were (1) “No LBP past week” and (2) “Small effect on daily living”; and in relation to improvement: (3) “Definitely shorter duration,” (4) “Definitely more resistant,” (5) “Less frequent,” and (6) “Definitely better.”

Twelve to 18 months (“12 months”) after the first consultation, a questionnaire consisting of the same questions was sent to the patients to be returned to an administrative office. No reminder was posted to the nonresponders.

Descriptive data of the baseline subgroups and the 6 outcome variables were presented as percentages and 95% CI. The patterns of associations between the subgroups and the outcome variables at 3 and 12 months were studied using bivariate analyses and logistic regression. In addition, the associations were tested between outcome at the fourth visit and “definitely better” at 3 and 12 months, respectively. It was not the purpose of this study to establish treatment effect but to investigate the subgroup pattern, the outcome pattern, and the outcome pattern in relation to the various
subgroups. The data were analyzed with STATA 7 (StataCorp, LP, College Station, Tex). This study design did not allow for analysis of the possible effect of any continued pattern of care, whether in chiropractic practice or elsewhere.

RESULTS

Description of Study Sample

Valid baseline data were available on 1054 patients, that is, 3 of the records previously included in the baseline study could not be used in the present analyses. At 3 months, it was possible to interview 983 of the patients who had provided valid baseline data (93%). No dropout analysis was performed for the 3 months' follow-up data, as the number of nonresponders was small. At 12 months, 601 (57%) of 1054 patients returned their questionnaires. A comparison of the characteristics of the study sample at baseline and at 12 months revealed that it consisted of 59% vs 54% of men. Their mean age was 43 years (SD 14) vs 47 years (SD 14), and the proportions of patients classified as definitely better at the fourth visit were 76% vs 78%.

Distribution of Subgroups in Chiropractic Patients With LBP

The 12 subgroups are described in Table 1. A comparison of the baseline subgroups and those at 12 months revealed that the responders at 12 months were similarly distributed between the subgroups defined at baseline (data not shown).

At baseline in relation to the history over the past year, “nonpersistent LBP” was more common (56%) than “persistent LBP” (44%), and “intermittent pain” (59%) more common than “daily pain” (41%) (Table 1). In relation to duration of LBP at consultation, the 2 extreme groups were most common, “baseline 1 week” (43%) and “baseline >2 weeks” (44%). As the duration of LBP at baseline increased, so did the proportion of patients with “persistent LBP” over the preceding year. The proportion of patients who reported that the pain pattern in the past year was “daily” as opposed to “intermittently” was also positively associated with the baseline classification (Table 2).

When all 3 factors were taken into account, the 2 “extreme” groups were the largest, namely, subgroup 1, consisting of “baseline 1 week” plus “nonpersistent LBP” plus “intermittent pain” (25%); and subgroup 12, consisting of “baseline >2 weeks” plus “persistent LBP” plus “daily

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Table 1. Description of the baseline population in relation to duration of LBP at baseline reported as number of subjects (%) (N = 1054)

<table>
<thead>
<tr>
<th>Duration of LBP at baseline</th>
<th>Total</th>
<th>Nonpersistent*</th>
<th>Intermittent</th>
<th>Daily</th>
<th>Persistent**</th>
<th>Intermittent</th>
<th>Daily</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-7 d</td>
<td>451</td>
<td>262 (25%)</td>
<td>124 (12%)</td>
<td></td>
<td>53 (5%)</td>
<td>12 (1%)</td>
<td></td>
<td>451 (43%)</td>
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<tr>
<td>8-14 d</td>
<td>142</td>
<td>63 (6%)</td>
<td>43 (4%)</td>
<td></td>
<td>29 (3%)</td>
<td>7 (1%)</td>
<td></td>
<td>142 (14%)</td>
</tr>
<tr>
<td>&gt;14 d</td>
<td>461</td>
<td>381 (36%)</td>
<td>214 (20%)</td>
<td></td>
<td>242 (23%)</td>
<td>217 (21%)</td>
<td></td>
<td>1054 (100%)</td>
</tr>
</tbody>
</table>

* Nonpersistent: <30 days LBP in past year.
** Persistent: ≥30 days LBP in past year.

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Table 2. Duration of LBP in the past year and pattern of pain in the past year described in relation to the duration of LBP at baseline (N = 1054)

<table>
<thead>
<tr>
<th>Duration of LBP at baseline</th>
<th>Proportion of patients with persistent LBP (%)</th>
<th>Proportion of patients with daily LBP pain pattern (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-7 d (n = 451)</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>8-14 (n = 142)</td>
<td>74</td>
<td>35</td>
</tr>
<tr>
<td>&gt;14 d (n = 461)</td>
<td>78</td>
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</tbody>
</table>

Fig 1. Histogram showing the prevalence of 12 different subgroups of LBP in chiropractic practice (y-axis is percentage of patients in each group). The subgroups are ordered from the most benign to the more severe to add up to 100% (n = 1054). Groups: 1—baseline 1 week, nonpersistent, intermittent; 2—baseline 1 week, nonpersistent, daily; 3—baseline 1 week, persistent, intermittent; 4—baseline 1 week, persistent, daily; 5—baseline 2 weeks, nonpersistent, intermittent; 6—baseline 2 weeks, nonpersistent, daily; 7—baseline 2 weeks, persistent, intermittent; 8—baseline 2 weeks, persistent, daily; 9—baseline >2 weeks, nonpersistent, intermittent; 10—baseline >2 weeks, persistent, daily; 11—baseline >2 weeks, persistent, intermittent; 12—baseline >2 weeks, persistent, daily.
pain” (19%) (Table 1). When the subgroups were ordered from the most benign subgroup (group 1) to the most severe subgroup (group 12), a U-shaped distribution emerged (Fig 1).

**Long-Term Outcome in Chiropractic Patients With LBP**

The self-reported outcomes for the whole-study sample at 3 and 12 months are shown in Table 3. At 3 months, almost half reported “no LBP past week,” and approximately 60% claimed “small effect on daily living.” Only approximately 10% considered their back to be “definitely more resistant,” and approximately 25% claimed that their LBP appeared less frequently. Nevertheless, almost half said that it was of “definitely shorter duration.” In all, 70% considered their back to have been “definitely better” in the past months as compared with baseline.

At 12 months, somewhat fewer than at 3 months reported “no LBP past week,” “small effect on daily living,” and fewer patients thought that they were “definitely better” in the past months. For the remaining 3 variables (relating to resistance, frequency, and duration), the self-reported results were considerably better than those at 3 months.

<table>
<thead>
<tr>
<th>Table 3. The 6 different outcomes at 3 months (n = 983) and 12 months (n = 601) for chiropractic patients with LBP, reported as percentages (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Six outcome variables</strong></td>
</tr>
<tr>
<td>Time for follow-up</td>
</tr>
<tr>
<td>3 mo</td>
</tr>
<tr>
<td>12 mo</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 4A. The pattern of significant differences between baseline subgroups in relation to the 6 LBP outcome variables at 3 months’ follow-up reported as P values obtained through bivariate analyses (n = 983)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Six outcome variables</strong></td>
</tr>
<tr>
<td>Baseline variable</td>
</tr>
<tr>
<td>Baseline duration: 1-7*, 8-14, &gt;14 d</td>
</tr>
<tr>
<td>Total duration of LBP preceding year: ≤30*, &gt;30 d</td>
</tr>
<tr>
<td>Pain pattern in the preceding year: intermittent* vs daily</td>
</tr>
</tbody>
</table>

* Most favorable subgroup.

<table>
<thead>
<tr>
<th>Table 4B. The pattern of significant differences between baseline subgroups in relation to the 6 LBP outcome variables at 12 months’ follow-up reported as P values obtained through bivariate analyses (n = 601)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Six outcome variables</strong></td>
</tr>
<tr>
<td>Baseline variable</td>
</tr>
<tr>
<td>Baseline duration: 1-7*, 8-14, &gt;14 d</td>
</tr>
<tr>
<td>Total duration of LBP preceding year: ≤30*, &gt;30 d</td>
</tr>
<tr>
<td>Pain pattern in the preceding year: intermittent* vs daily</td>
</tr>
</tbody>
</table>

* Most favorable subgroup.
Outcome Pattern Across Different Subgroups and Outcome Variables

When each baseline factor (duration at baseline, duration past year, and pain pattern past year) was considered in relation to each outcome variable, a pattern emerged at 3 months, which was partly retained at 12 months. Individually, all 3 baseline factors had an effect on the patients’ status at 3 months; those with the most benign history were more likely to report (1) “no LBP past week,” (2) “small effect on daily living,” and (3) to have been “definitely better” in the past months (Table 4A). At 12 months, about the same was found but only in relation to (1) “no LBP past week” and (2) “definitely better” (Table 4B).

Because there was overlapping between the baseline factors, a logistic regression analysis was undertaken, in which all 3 baseline components were included. All 3 baseline factors remained important in relation to “no LBP past week” variable at 3 months, but the duration of pain at baseline was no longer important for the other 2 outcome variables (“daily living” and “definitely better”) (Table 5A). At 12 months, the baseline factors lost much of their predictive importance. The past-year LBP history retained its associations with “no LBP past week” and “definitely better.” The pain pattern in the previous year retained its association with “no LBP past week,” whereas the pain pattern in the preceding year retained its association only with “no LBP past week” (Table 5B).

The 3- and 12-month global outcomes (“definitely better”) were compared for those with persistent LBP vs those with nonpersistent LBP, while controlling for the other 2 baseline factors. In a previous study of various predictive models using data from the baseline study (to be reported elsewhere), it became obvious that it was easier to predict the absence of improvement rather than improvement. The odds ratios in the present analyses were therefore calculated in relation to not reporting “definitely better” and found to be 2.5 (95% CI 2.0-3.3) at 3 months and 1.7 (95% CI 1.2-2.3) at 12 months for persistent vs nonpersistent LBP.

Early Improvement as a Predictor for Long-Term Outcome in a Mixed LBP Group

At the 3-month follow-up, it was more common also for patients who did not report definite improvement by the

---

**Table 5A.** The pattern of significant differences between baseline subgroups in relation to the 6 LBP outcome variables at 3 months’ follow-up after logistic regression (n = 983)

<table>
<thead>
<tr>
<th>Baseline variable</th>
<th>No LBP past week</th>
<th>Small effect on daily living past months</th>
<th>Definitely more resistant past months</th>
<th>Less frequent past months</th>
<th>Definitely shorter duration past months</th>
<th>Definitely better past months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline duration: 1-7, 8-14, &gt;14 d</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total duration of LBP preceding year: ≤30, &gt;30 d</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain pattern in the preceding year: intermittent vs daily</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Yes indicates significant association that remained after controlling for the other baseline variables; blank, no significant association.

**Table 5B.** The pattern of significant differences between baseline subgroups in relation to the 6 LBP outcome variables at 12 months’ follow-up reported as P values obtained through bivariate analyses (n = 601)

<table>
<thead>
<tr>
<th>Baseline variable</th>
<th>No LBP past week</th>
<th>Small effect on daily living past months</th>
<th>Definitely more resistant past months</th>
<th>Less frequent past months</th>
<th>Definitely shorter duration past months</th>
<th>Definitely better past months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline duration: 1-7, 8-14, &gt;14 d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total duration of LBP preceding year: ≤30, &gt;30 d</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain pattern in the preceding year: intermittent vs daily</td>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
fourth visit not to report “definitely better” in the past months as compared with those who did report definite improvement at baseline (45% vs 26%, OR 2.3, 95% CI 1.7-3.1). At 12 months, the corresponding figures were 63% vs 50% (OR 1.7, 95% CI 1.1-2.5).

**DISCUSSION**

The present study, which consists of a large sample of patients obtained in a wide variety of chiropractic practices, seems to be the first study in which the long-term outcome is mapped in relation to various outcome measures and different baseline subpopulations after chiropractic treatment.

The response rate at the 3-month interview was excellent, and although only 57% returned their questionnaires in the 12-month postal survey, there appeared to be no obvious differences between responders and nonresponders in relation to age, sex, LBP characteristics at baseline, and the proportion of patients who reported definite improvement by the fourth visit.

In previous studies, 2 predefined study populations were investigated in relation to outcome pattern and predictors for outcome, namely, patients with (1) less than 2 weeks of LBP at the time of the first consultation and nonpersistent LBP, and (2) more than 2 weeks of LBP at the first consultation and persistent LBP in the preceding year. It was interesting to note that these were 2 substantial subgroups in our total study population. In fact, chiropractic patients with LBP range from the 2 extremes (short-lasting, nonpersistent LBP of intermittent type vs more long-lasting, persistent LBP of daily type), with some of the other subgroups being fairly substantial.

Three months after the initial consultation, approximately half of the patients have no prevalent pain, and the majority report only minor (if any) problems in relation to their daily activities. The majority also felt generally better 3 months after the study than at baseline. Nevertheless, it is less common to claim shorter spells of LBP or reduced frequency of attacks, and even less common to feel that the back is more resistant to LBP.

As time passes by, at 12 months, the present status is considered somewhat less favorable, and the general improvement is rated somewhat lower. However, more patients report to be more resistant, to experience less frequent pain, and to have shorter duration of their LBP events. In other words, at 3 months patients feel good, but it is difficult to pinpoint specific areas of improvement. At 12 months, their LBP status is considered less favorable, but they, nevertheless, feel improved. It is not known whether this seemingly conflicting pattern of reporting can be trusted. However, it seems likely that patients can accurately describe whether they had LBP the last week or not, that they can remember if they were in some way disabled because of LBP, and that they can give an overall judgment on whether they have improved or not. However, it is perhaps more doubtful whether patients can accurately remember the level of discomfort and details of previous LBP for as long ago as 1 year. Also, as LBP is a recurrent condition for many, the outcome pattern for these 3 variables (better results at 3 months than at 12 months) seems most plausible. Based on the face validity of these outcome variables (Table 3), it appears acceptable to use and trust the 2 “present-status” variables and also one of the “development-over-the-past-months” variables, namely, the most global one (“definitely better”).

It has been suggested that one reason for the relatively small mean differences in treatment outcome between different treatment methods could be the presence of underlying subgroups of patients, resulting in varying treatment effects. According to this study (Table 4A and B), not only specific subgroups at baseline but also the choice of outcome variables will affect the results. Again, 2 outcome variables that can be used to detect differences between baseline subgroups at both 3 and 12 months are “no LBP past week” and “definitely better.”

As for the underlying baseline factors, an interesting pattern was noted: The duration of the patient’s present complaint (the LBP event) appears to have less importance than the pain pattern in the preceding year, which, in turn, is less important than the total duration of pain in the past year (the LBP disease). This concept, which is illustrated in Table 5A and B, is probably new to those clinicians who concentrate on the present LBP event when making their diagnosis, choice of treatment, and prognosis. In clinical practice, it will now be necessary to take into account that the prognoses at both 3 and 12 months are associated with the LBP disease.

In summary, our findings indicate that there are several distinct subgroups of chiropractic patients with LBP, based on a simple classification system relating to the LBP event and the LBP disease. Some of these subgroups are fairly substantial and can be used to predict treatment outcome in chiropractic practice as well as to create homogeneous study populations, for example, when testing treatment effect in clinical trials. Clinicians have a particular responsibility toward patients who have not shown considerable improvement by the fourth visit, as they are also more likely than others not to report improvement at 3 and 12 months.

**Clinical Significance**

It is noteworthy that the duration of patients’ complaint at baseline (the circumstances surrounding the LBP event) is of less prognostic value than the duration in total over the past year (the circumstances surrounding the LBP disease).
Another important point is that attention should be paid not only to the history of LBP in the past year but also to the status at the fourth visit. Patients with persistent LBP with or without leg pain over the past year and those who have not reported definite improvement by the fourth visit will require particular vigilance to avoid long and unsuccessful treatment programs.

Research Significance

From a researcher’s point of view, several distinct subgroups have been identified based on this simple classification system, and some of these are of sufficient size to make data collection feasible. Future randomized controlled clinical trials should concentrate on such specific subgroups. Care should also be taken in selecting appropriate outcome variables at different points in time.

Conclusion

Knowledge of specific subgroups may improve the quality of care and the selection of homogeneous study populations in clinical trials. The present study design should be considered to systematically test other classification systems with the view of identifying clinically relevant subgroups of patients with LBP.

REFERENCES

Objective: To test computer-using students to examine the relationship between location of neck pain as indicated on pain drawings and physical impairments compared with those subjects not reporting pain.

Methods: This cross-sectional study enrolled 81 healthy student volunteers at the College of Rehabilitation Science, Daegu University, Korea, aged 18 to 30 years. Outcomes were endurance time of neck muscles and neck range of motion (ROM) sensitization or stretch effects on repeated range tests. Active neck ROM measures were taken twice, 10 minutes apart. Neck muscle endurance time was obtained using a horizontal head-holding test with a 10-minute goal. After all physical measurements were completed, information about any neck pain was collected and 4 groups were formed on the basis of the pain location noted on the body chart.

Results: Sixty-seven subjects experienced recurrent neck pain. Nineteen had right-side pain, another 19 had left-side pain, 29 reported pain on both sides, and 14 did not experience neck pain. Neck muscle endurance time was significantly lower for all pain groups. For extension, left and right rotation movements at the second test, ROM decreased for subjects reporting subclinical pain and increased for those with no pain. Location of the pain to one side was related to the ROM decreased, in that the amount of reduction in the second-test rotation range was significantly greater on the side opposite to the pain.

Conclusions: The location of neck pain that occurs intermittently, but is not present during range testing, affects the second test when the rotation involves stretching of tissue on the side of pain. (J Manipulative Physiol Ther 2005;28:479-486)

Key Indexing Terms: Neck Pain; Range of Motion; Articular; Physical Endurance; Pain
nature of posture during computer use, specifically its repetitiveness and associated static, long-term, and abnormal physiological loads that place strain on the musculoskeletal system, particularly at the neck and shoulders. Habitual, excessively forward head postures have been suggested to be pain provoking, with an associated reduction in range of motion (ROM) and muscle strength.17-20

As a consequence of strong government support for educational computer use in Korean schools, computer use is high in the Korean student population,21,22 so these high-frequency computer users, therefore, represent a population where a relatively high proportion of subclinical neck pain might be expected.

One way of obtaining more detail about pain is to ask subjects to shade the affected area on an outline drawing of the body. Pain drawings are commonly used for analysis of musculoskeletal symptoms in research and clinical settings,23-28 and are a reliable tool.29-32 Accordingly, the aim of this study was to test computer-using students to examine the relationship between location of neck pain as indicated on pain drawings and physical impairments (specifically any reduction in neck ROM upon repeated testing, and any lower level in neck muscle endurance) compared with those subjects not reporting pain.

**METHODS**

**Subjects**

Advertisements placed on notice boards at the College of Rehabilitation Science, Daegu University, South Korea, sought healthy subjects over 18 years of age, stating we were searching for subjects with no experience of neck, upper back, or spinal problems that had resulted in a restriction of normal activity or time off work. Eighty-one students aged 18 to 30 years (mean, 23.2; SD, 3.3) volunteered. Subjects who had sought medical attention for neck pain and/or related problems within the last 6 months, or those with any medical condition likely to affect mobility of the cervical spine (eg, ankylosing spondylitis), were excluded from participation in the study. Ethics approval for the study was obtained from the University, and each subject gave informed consent before testing.

**Procedure**

The measurement procedure was as follows: after volunteers agreed to be subjects and signed the consent form, first occasion of ROM measures was taken with 3 to 4 attempts at each direction to obtain a repeated (stable) range value. Six different directions of neck ROM measures (flexion, extension, left and right lateral flexions, and left and right rotations) were taken in a comfortable sitting position using a cervical ROM device with the cervical ROM operation conducted as described by Youdas et al.33 Demographic data were then collected, including age, sex, driving status, dominant side, sitting hours (including hours

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**Fig 1.** The grouping was based on the area identified by the subject on a body chart. The “left pain group” of subjects indicated their pain on the left side of the body chart (A), those in the “right pain group” showed their pain on the right side (B), and those in the “central pain group” mainly complained of pain on both sides including central (C).

**Table 1.** Contrast weights applied to the 4 groups to generate specific planned tests within the ANOVA

<table>
<thead>
<tr>
<th></th>
<th>No pain</th>
<th>Central pain</th>
<th>Left-side pain</th>
<th>Right-side pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contrast 1</td>
<td>3</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>Contrast 2</td>
<td>0</td>
<td>2</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>Contrast 3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>-1</td>
</tr>
</tbody>
</table>
per day of computer use), and hours per week of recreational activity (sport). After a 10-minute interval, second occasion ROM measures were taken in the same manner as before, after which, neck muscle endurance was tested.

The neck extensor endurance test was based on the Biering-Sorensen low back extensor test and has been previously described and validated by Lee et al. Neck muscle endurance time was taken using a head-holding test. Based on a pilot study, 10 minutes was set for the time goal for termination of endurance; the pilot study showed that subjects with no pain could usually last longer than 10 minutes, whereas those with neck pain could not.

Pain information was collected at the end of all physical measures. This was done to keep the measurer blind with respect to pain classification and to minimize any role bias (ie, performing to expectation) on the part of the subject. Information requested included current status and history of any recurrent neck pain and/or discomfort, frequency of neck pain and/or discomfort on a visual analog scale (VAS) (from never to all the time), location of neck pain and/or discomfort on a body chart (Fig 1), treatment of neck pain, and any experience of neck injury.

Analysis

To compare ROM between pain classification groups and across repeats (occasion 1 and occasion 2) and to test for interactions, we used groups-by-repeated-measures analyses of variance (ANOVAs). The group factor had 4 levels (no pain, right-side pain, left-side pain, central pain), and the 2 repeated measure factors each had 2 levels: movement direction (left, right) and time (occasion 1, occasion 2). The 3 degrees of freedom associated with the between-groups factor were allocated to 3 orthogonal planned contrasts. The first of these tested for differences between subjects with no pain and subjects with pain in any location. The second tested differences between the central pain and unilateral pain groups, and the final contrast examined differences between the right and left-side pain groups. The contrast weights are given in Table 1. Neck muscle endurance times were examined for differences across groups using Mann-Whitney $U$ tests.

RESULTS

Fourteen subjects reported no experience of any neck pain and/or discomfort. Sixty-seven subjects reported having neck pain and/or discomfort on a recurring basis; among these, 19 had left-side pain (left pain group), 19 had right-side pain (right pain group), and 29 had pain on both sides (central pain group), based on the information provided in the body diagrams (Fig 1). It was found using 1-way ANOVAs that the 4 groups thus formed did not differ significantly on any of the measured demographic variables, except for frequency of recurrent neck pain scored on the VAS scale, where all subjects in the no pain group scored zero. However, there was no difference in frequency of pain found between the 3 pain groups. Means, standard deviations, and $P$ values for these between-groups tests are presented in Table 2.

The mean values for each measure of neck ROM are presented in Fig 2. At the first set of ROM measures, no range in any direction showed a significant difference between the no pain and any pain groups, but at the second test, ROM for left and right rotation and extension movements showed a group-specific change, with ROM decreasing (sensitization) for subjects reporting subclinical pain, and increasing (stretching) for the no pain group.

All pain groups showed a significant ROM reduction on the second test in both directions of rotation, and a 3-way interaction was found ($F_{1,77} = 22.43; P < .01$). In this interaction, the side that changed most from occasion 1 to occasion 2 was different between the left and right pain groups. Subjects with left-side pain showed more right rotation sensitization than left ($−5.47°$ vs $−1.68°$), whereas those with right-side pain had their left rotation ROM reduced more than their right ($−6.90°$ vs $−1.42°$ ($F_{1,77} = 10.38; P < .01$). Unilateral neck pain thus increased the magnitude of the second test sensitization effect when the rotation test was to the side opposite the pain, whereas the central pain group showed reduced rotation range on the second occasion of approximately the same magnitude on both sides ($−2.76°$ vs $−1.62°$). Conversely, the no pain group showed a stretching (increased range) effect on the second measurement for both left- and right-side rotations ($2.07°$ vs $2.86°$).

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**Table 2. The mean (standard deviation) and $P$ values of each group’s demographic data**

<table>
<thead>
<tr>
<th></th>
<th>No pain group (n = 14)</th>
<th>Left pain group (n = 19)</th>
<th>Right pain group (n = 19)</th>
<th>Central pain group (n = 29)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>21.4 (1.9)</td>
<td>20.1 (1.9)</td>
<td>20.9 (1.7)</td>
<td>20.8 (2.0)</td>
<td>.28</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>21.5 (2.1)</td>
<td>20.2 (2.3)</td>
<td>21.3 (2.6)</td>
<td>21.7 (3.1)</td>
<td>.28</td>
</tr>
<tr>
<td>Sitting hours per day</td>
<td>6.9 (2.4)</td>
<td>6.5 (1.8)</td>
<td>6.7 (2.3)</td>
<td>6.7 (2.3)</td>
<td>.96</td>
</tr>
<tr>
<td>Sport activity hours per week</td>
<td>5.2 (5.4)</td>
<td>6.3 (8.6)</td>
<td>5.2 (8.0)</td>
<td>7.7 (8.5)</td>
<td>.67</td>
</tr>
<tr>
<td>Dominant side</td>
<td>Right</td>
<td>Right</td>
<td>Right</td>
<td>Right</td>
<td></td>
</tr>
<tr>
<td>Frequency of pain (100-mm VAS)</td>
<td>0</td>
<td>32.4 (22.3)</td>
<td>35.1 (19.7)</td>
<td>29.1 (21.2)</td>
<td>.53</td>
</tr>
</tbody>
</table>

There were no significant differences between groups. BMI, Body mass index.
With extension ROM, the no pain group showed a stretch effect on the second occasion of measurement (0.86°), whereas all pain groups showed sensitization (−4.6°) (F$_{1,77}$ = 12.27; P < .01). Although this pattern was similar in flexion, with increased range (0.3°) with the no pain group but reduced range (−1.0°) in all pain groups, here, this difference was not significant (F$_{1,77}$ = 0.37; P = .54). Over all groups, irrespective of pain classification, both left- and right-side flexions were sensitized (−1.34° and −1.91°, respectively) by repeated measurement (F$_{1,77}$ = 24.5, P ≤ .01). Two other findings emerged as results common to all groups. Subjects showed greater extent of range in right rotation than left rotation (72.50° vs 70.58°; F$_{1,77}$ = 4.41; P = .04), and left-side flexion was found to be
greater than right-side flexion (41.57 vs 38.98; \( F_{1,77} = 21.3; P < .01 \)).

With all pain groups combined in contrast 1, this single group had significantly lower neck muscle endurance holding time when compared with the no pain group (\( F_{1,77} = 4.97, P = .03 \)), whereas there was no difference among pain groups, unilateral vs central pain (\( F_{1,77} = 0.03, P = .86 \)), or left-side vs right-side pain (\( F_{1,77} = 0.18, P = .68 \)). The mean holding times in each group are shown in Fig 3, and it can be seen that whereas almost all subjects with no pain could make the 10-minute target time, many subjects in the pain groups were unable to do so. Mean holding times were 602.6 seconds (95% confidence interval [CI], 588.9-616.3) for the no pain group, 519.4 seconds (95% CI, 451.3-587.4) for the left pain group, 534.7 seconds (95% CI, 472.8-596.6) for the right pain group, and 532.1 seconds (95% CI, 492.2-572.1) for the subjects with central pain. The minimum holding time for any subject reporting recurrent pain at final questioning was 200 seconds.

In terms of possible clinical application, a question arises as to the value on the dimension of the difference between end-of-range tests, which best classifies subjects into pain/no pain categories. This question can be asked for each of the body chart pain area subgroups in relation to each of the ROM tests and the endurance test. The appropriate analysis method here is receiver operating characteristic (ROC) analysis,36 which returns a value representing the sensitivity of each test, the area under the curve (AUC). AUC values range from 0.5 to 1.0, where 0.5 represents chance discrimination and 1.0 is perfect discrimination. An area under the curve value that maximizes sensitivity and specificity is given by Youden’s Index38,39:

\[
\text{Youden’s Index} = \text{sensitivity} + \text{specificity} - 1.
\]

This index has been used to determine the optimal predictive cutoff values on tests for intracerebral hemorrhage40,41 and bronchial hyperresponsiveness.42 For the current study, sensitivity and specificity data shown in Tables 3 and 4 illustrate that the most common cutoff value predicting neck pain was any range reduction of more than 4° upon the second test and failure to hold the head horizontal for 9 minutes.

**Discussion**

In a group of healthy young subjects with an occupational role that involves regular computer use, there was a high prevalence of recurrent neck pain; yet, those reporting pain were not seeking treatment. Whereas the proportion of otherwise healthy subjects reporting intermittent neck pain was less than half the total in a previous study,1 here, such subjects were in the majority. Subjects tested in the present study reported being intermittently conscious of neck pain; associations with this can be seen on physical tests. A directional difference in ROM tests related to pain location was found, and neck muscle endurance was significantly less with neck pain subjects compared with those with no pain.

Subjects with left-side pain showed right rotation sensitization more than left, such that there was a greater decrease in second-test range to the right than the left; those with right-side pain had left rotation range reduced more than the right. This side-specific nature of the ROM reduction is consistent with the notion that pain-sensitive structures might be stimulated by first occasion end-of-range testing and thereby inhibit the extent of range reached on the second rotation tests. When subjects do not have any pain, a stretching effect is seen, such that the second measure is greater than the first.

Extension showed an interaction with sensitization for those reporting any pain, but stretch for no pain subjects. Authors have reported this direction of movement for the cervical spine to be commonly reduced in neck pain patients.18,43,44 Because only pain groups showed a sensitization effect upon the second determination of end of range, this direction of movement may be a valuable sign for determining progression to clinical neck problems, or its reversal may be an indicator of positive change during treatment.

Regardless of whether or not they were experiencing neck pain, subjects did not go as far into either right- or left-side flexion upon repeated measurement. All second measurements were taken within a 10-minute period after the first. The experience of going to end-of-side flexion range within a short period might affect the measured
values. Functional stability is needed with this direction of movement in normal daily activities. Jordan and Mehl-
sen,\textsuperscript{44} observed no significant difference in the range of lateral flexion between clinical chronic neck pain and normal groups. It is possible that all groups of subjects in the present study were unfamiliar with moving into the end range in lateral flexion, and that these are movements that place stress on pain-sensitive structures. Decreasing range in the second occasion test of this movement may protect against stress on those structures and thereby decrease discomfort.

Data in the current study are also consistent with the “vehicle driving position” effect on rotation end of range, whereby the side of the car on which the driver sits influences the direction of neck range asymmetry.\textsuperscript{11} It is possible that this arises from neck position when reversing, when drivers look over their shoulder back into the vehicle. Studies on rotation range asymmetry from several countries show this effect.\textsuperscript{33,45-47} From this, it was predicted that right neck rotation would show greater range with subjects in South Korea, who drive on the right side of the road, and this was found to be the case. Our current hypothesis is that this can be seen as showing a use-based asymmetry. Differences in motor control and coordination have long been noted in the hand advantage commonly observed for skillful manipulative acts, where one hand specializes in executing the fine details of the act whereas the other supports and assists the act.\textsuperscript{48,49} Skill asymmetry between sides in humans has been argued to arise from extended practice rather than from any genetic predisposition.\textsuperscript{50} Associated with needs for direction-specific or side-specific range, it has been found that elite athletes, dancers, and musicians all present examples of body asymmetries arising from domain-specific training.\textsuperscript{31,52} Additional head-turning range on the side opposite to that on which the driver sits would seem to be a further example of this.

The current findings on neck muscle endurance with Korean subjects replicate and extend previous results obtained with Australian subjects.\textsuperscript{11} This previous research also found muscle endurance times to be significantly lower for subclinical neck pain subjects than for pain-free subjects when tested using the same modified version of the Biering-Sorensen low back endurance test. Decreased neck muscle strength has been found elsewhere when clinical neck pain groups are compared with normal groups,\textsuperscript{33-55} and muscle atrophy is often a reported finding in clinical neck pain subjects.\textsuperscript{56,57} Both the current and previous data, then, indicate that neck muscle dysfunction is an early correlate of neck pain. In the treatment of clinical neck pain, some neck strengthening programs have been shown to be of limited effectiveness,\textsuperscript{58-62} whereas some have shown positive effects.\textsuperscript{63} Accordingly, encouragement for early adoption of neck muscle exercise programs in “at-risk” groups and those experiencing subclinical neck pain may be needed to prevent neck problems from progressing.

The values obtained from the ROC analyses are relevant here, in that they show an association with neck pain in subjects who are more than 4° short of their first ROM on second rotation or extension test or who cannot perform a horizontal head hold for 9 minutes. These values can therefore represent treatment targets for subjects with posturally induced recurrent neck pain. Whether there is the same second range test, sensitization associated with pain status in the thoracic or lumbar spine is not known.

Current data suggest that there are early changes in physical measurements related to subclinical neck pain; however, it is not clear whether the changes are a cause of or an effect of neck pain. This would be best determined with a prospective longitudinal study to define which subgroup develops a clinical neck pain condition. With the subclinical neck pain subjects in the current study showing reduced range in the second set of ROM measures and less neck

<table>
<thead>
<tr>
<th>Table 3. Test sensitivity for distinguishing between groups when using 4 physical tests (area under the ROC curve and 95% CIs)</th>
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<tbody>
<tr>
<td><strong>No pain vs left pain</strong></td>
</tr>
<tr>
<td>Left rotation, T1-T2 difference</td>
</tr>
<tr>
<td>Right rotation, T1-T2 difference</td>
</tr>
<tr>
<td>Extension, T1-T2 difference</td>
</tr>
<tr>
<td>Muscle endurance</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Table 4. Pain/no pain classification cutoff values for ROM and muscle endurance change identified by Youden’s Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No pain vs left pain</strong></td>
</tr>
<tr>
<td>Left rotation, T1-T2 difference</td>
</tr>
<tr>
<td>Right rotation, T1-T2 difference</td>
</tr>
<tr>
<td>Extension, T1-T2 difference</td>
</tr>
<tr>
<td>Muscle endurance</td>
</tr>
</tbody>
</table>

For the dimensions where the Youden’s Index did not rise to a single maximum then decline, but rather 2 maxima were observed, both values had been included.
endurance, we propose that early treatment to restore flexibility and muscle strength might prevent development of clinical neck pain.

CONCLUSION

A previously shown second ROM test sensitization effect was replicated in the current study and found to be emphasized in a way that was consistent with indication of intermittent unilateral pain on body charts. Any more than a very small amount of range loss on the second test was found to be associated with having intermittent neck pain.

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ABSTRACT

Objective: To examine the intratester reliability of the Spin-T goniometer, a cervical range of motion device, in a normal Indian population.

Methods: Subjects comprised 30 healthy adults with mean age of 34 years (range, 18-65 years). The subjects were stabilized in the sitting position and the Spin-T goniometer mounted on the head of the subject. The study design was a within-subject repeated intratester reliability trial conducted for cervical range of motion in 6 directions of movement. Three measurements were taken in each direction (flexion, extension lateral flexion, and lateral rotation) per participant. Reliability coefficients, intraclass correlation coefficients, and 95% confidence interval were derived from repeated-measures analysis of variance (ANOVA). Where differences in ANOVA were detected, a paired t test was conducted and the typical error values and coefficient of variance were calculated.

Results: All repeated measures showed high intraclass correlation coefficients (all ≥0.96, P < .01). The ANOVA detected no differences between trials for all movements except rotation. The typical error values for the rotation trials did not exceed 2.5° and the coefficient of variance did not exceed 4%, which is clinically acceptable considering the normally variable cervical range of movement.

Conclusion: In this study, the Spin-T goniometer proved to be a reliable measuring instrument for cervical range of movement in an Indian population. The use of a laser pointer fixed to the instrument ensured a consistent neutral start position (J Manipulative Physiol Ther 2005;28:487-492)

Key Indexing Terms: Reproducibility of Results; Cervical Vertebrae; Range of Motion; Articular

Clinical measurement of cervical movements is complex because of its normal variability. Neck movements are influenced by pain,1,2 age,3 sex,4-6 trauma,7 and disease8 and depend upon whether the movement is measured actively or passively. In spite of this normal variability, the assessment of cervical range of motion (CROM) is often a fundamental component of clinical practice contributing to elements of clinical reasoning, diagnosis, and treatment efficacy. Therefore, an objective measurement technique for CROM that shows both clinical utility and reliability is essential in the context of normal clinical practice.

Although cervical movements within the clinical setting are commonly estimated visually, this method has poor intertester reliability with intraclass correlation coefficient (ICC) values varying between 0.42 and 0.82 for different neck movements.9 In comparison, the universal goniometer shows slightly improved reliability9 (intratester ICC values from 0.78 to 0.90 and intertester ICC values from 0.54 to 0.79 for different neck movements). The reliability of measurements varies according to the direction of movement and has been found to be lower for lateral movements separated into left and right components, in comparison with movements restricted to a single plane.10,11 Other measuring equipment promoted in reliability trials include the rangiometer,12 radiographs,13 3D kinematic method,14 electrogoniometers (CA 6000 Spine Motion Analyzer; Orthopedic Systems, Inc, Union City, Calif),15-18 potentiometer-based electrogoniometer,19 ultrasound-based motion analyzers (CMS 70P; Zebris Medizintechnik GmbH, Isny,
Germany),\textsuperscript{20} and FASTRAK (Polhemus, Colchester, Vt), an electromagnetic 3-dimensional tracking system.\textsuperscript{11}

The CROM instrument has been repeatedly tested for its reliability and has shown a high intratester (ICC \(N = 0.84\)) and intertester (ICC \(N = 0.73\)) reliability for all neck movements.\textsuperscript{9} Garrett et al\textsuperscript{21} used the CROM instrument (intratester reliability ICC = 0.93 and intertester reliability ICC = 0.83) for measurement of forward head posture in 40 patients with orthopedic disorders of the cervical spine. However, the CROM instrument does not seem to be designed to measure lateral cervical movements, which are composite in nature.\textsuperscript{22} Sophisticated and modern equipment such as the CA 6000 Spine Motion Analyzer,\textsuperscript{17} FASTRAK,\textsuperscript{11} and ultrasound-based motion analyzers (CMS 70P)\textsuperscript{20} are capable of reliably measuring natural combinations of planes of movements. The disadvantage of these tools is that they are expensive and nonportable and are therefore confined to dedicated research laboratories or institutions. The ideal method is a technique that is neither too invasive nor complex to operate and provides data that are clinically accurate and meaningful.

Fig 1. The Spin-T goniometer strapped on the subject's head. The T square is positioned along the spindle of the flexion-extension dial to provide a perpendicular reference to the wall.

Table 1. Summary of ROM (in degrees) in each direction of the cervical spine for 30 subjects

<table>
<thead>
<tr>
<th>Movement</th>
<th>Mean range of movement</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>57.1</td>
<td>21-80</td>
<td>12.1</td>
</tr>
<tr>
<td>Extension</td>
<td>65.3</td>
<td>25-104</td>
<td>18.2</td>
</tr>
<tr>
<td>Lateral flexion (right)</td>
<td>44.4</td>
<td>25-62</td>
<td>8.7</td>
</tr>
<tr>
<td>Lateral flexion (left)</td>
<td>45.7</td>
<td>21-62</td>
<td>8.4</td>
</tr>
<tr>
<td>Lateral rotation (right)</td>
<td>70.0</td>
<td>44-95</td>
<td>10.7</td>
</tr>
<tr>
<td>Lateral rotation (left)</td>
<td>70.9</td>
<td>36-95</td>
<td>11.8</td>
</tr>
</tbody>
</table>

Table 2. Intraobserver ICC values and their 95\% CI for all cervical spine movements

<table>
<thead>
<tr>
<th>Movement</th>
<th>ICC</th>
<th>Lower</th>
<th>Upper</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>0.98</td>
<td>0.97</td>
<td>0.99</td>
<td>64.87</td>
</tr>
<tr>
<td>Extension</td>
<td>0.98</td>
<td>0.97</td>
<td>0.99</td>
<td>87.04</td>
</tr>
<tr>
<td>Lateral flexion (right)</td>
<td>0.96</td>
<td>0.93</td>
<td>0.98</td>
<td>27.72</td>
</tr>
<tr>
<td>Lateral flexion (left)</td>
<td>0.97</td>
<td>0.94</td>
<td>0.98</td>
<td>33.75</td>
</tr>
<tr>
<td>Lateral rotation (right)</td>
<td>0.98</td>
<td>0.97</td>
<td>0.99</td>
<td>71.89</td>
</tr>
<tr>
<td>Lateral rotation (left)</td>
<td>0.98</td>
<td>0.97</td>
<td>0.99</td>
<td>79.56</td>
</tr>
</tbody>
</table>

Table 3. Repeated-measures ANOVA to measure differences between trials for movement in each direction

<table>
<thead>
<tr>
<th>Movement</th>
<th>df</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>2</td>
<td>1.79</td>
<td>.17</td>
</tr>
<tr>
<td>Extension</td>
<td>2</td>
<td>2.13</td>
<td>.12</td>
</tr>
<tr>
<td>Lateral flexion (right)</td>
<td>2</td>
<td>0.43</td>
<td>.65</td>
</tr>
<tr>
<td>Lateral flexion (left)</td>
<td>2</td>
<td>0.79</td>
<td>.45</td>
</tr>
<tr>
<td>Lateral rotation (right)</td>
<td>2</td>
<td>10.90</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Lateral rotation (left)</td>
<td>2</td>
<td>13.44</td>
<td>&lt;.01</td>
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</tbody>
</table>

The Spin-T goniometer, designed and developed by Haynes and Edmondston,\textsuperscript{22} is capable of measuring composite cervical movements. These include lateral cervical movements that cannot be measured with the CROM device. The reliability of the Spin-T has been established\textsuperscript{22} on 23 subjects who showed an intraexaminer reliability (ICC >0.87 and >0.91 for each examiner, respectively) and an interexaminer reliability (ICC >0.75) for different neck movements. A further issue was to identify a method to ensure consistency of the start position between each motion plane assessment.

A review of published literature revealed no study conducted on the Indian population to document the cervical range of movements of a normal or symptomatic population. The purpose of this brief report was to establish the intratester reliability of the Spin-T goniometer on an asymptomatic Indian population.

METHODS

The Spin-T consists of a spectacle-type aluminum frame, anchored on the nose and behind the ears with two Velcro straps. A lightweight laser pointer on the left arm of the Spin-T was used to reference the instrument and ensure that a consistent neutral position of the head was achieved between trials. Three 360° dials (marked at 1° interval) attached to the frame lie in orthogonal planes reflecting the cardinal movement planes of the cervical spine. An L-shaped rectangular plastic spindle pivots around the...
center of each dial (Fig 1) with the horizontal portion of the L touching the dial (a red line at one end of the spindle coinciding with the degree markings of the dial along its circumference). Measurement of neck movements with the Spin-T requires a corner of a room. The wall in front of the subject serves as a reference for flexion-extension and lateral rotation movements and the wall to the left of the subject serves as a reference for lateral flexion movements. The orientation of each dial is referenced and zeroed to the perpendicular plane of the wall. This is achieved by the use of a lightweight, rigid aluminum T square (Fig 1).

Once the reference position is established, using the T square to reset the spindle on each dial assesses the degrees of relative movement in each plane. From this, excursion in that plane can be documented. In a previous study, the Spin-T goniometer was validated against a high-resolution 3D motion tracking device called the MotionStar (Ascension Technology Corporation, Burlington, Vt). The maximum magnitude of error in this previous study was less than 1.5\(^{\circ}\).23

Thirty asymptomatic healthy subjects (7 women and 23 men; age range, 18-65 years; mean, 34 years \([\pm 11.4]\); mean height, 164 cm \([\pm 7.4]\); mean weight, 66 kg \([\pm 10.9]\); and body mass index, 24.8 \([\pm 3.6]\)) participated in this study. Subjects were recruited from the staff of Belle Vue Clinic, Kolkata, India, which comprised professional, clerical, and manual staff as well as persons accompanying patients. The sample represented people from different states of India and socioeconomic backgrounds, thereby contributing to the applicability of the results to the general population. The purpose and procedure of the study were fully explained to the subjects and a signed consent was obtained.

All subjects were seated upright on a straight back wooden chair with the upper trunk in contact and strapped to the back of the chair. The feet were firmly on the floor or a footstool and the knees close to the wall in front. The participants grasped with each hand the rear leg of the chair they were sitting on. The strap helped in preventing forward movement of the trunk during flexion; the back rest and the strap prevented the trunk from leaning back during extension; and by holding the rear legs of the chair, lateral movement of the trunk during lateral cervical movements was minimized.

Before strapping on the Spin-T goniometer, participants were asked to move their head twice in all directions to their end range, in any order, as a “warm up”. For flexion, participants were asked to move the head in the direction of chin to chest and to refrain straining the upper trunk during end-range movements. For lateral flexion, the head and neck moved toward the shoulder without allowing any shoulder elevation, and for rotation, the subjects were asked to rotate the head as if looking over the ipsilateral shoulder.

The Spin-T goniometer was mounted on the head of the seated participant. The laser pointer was used to reference the neutral position of the head at the beginning of each trial. The participants were given instructions to move their head in one direction as far as possible without causing pain or discomfort. Measurements were recorded with the T square aligning the spindle of the relevant protractor at the end point of movement.

Verbal instructions were the same and uniform for all participants. Measurements were taken in the following sequence: flexion, extension, lateral rotation right and left, and lateral flexion right and left. This cycle was repeated 3 times. The T square of the Spin-T was aligned to the wall in front of the subject for sagittal and axial plane measurements. For coronal plane measurements, the wall to the left of the patient was required; measurement of lateral flexion was last.

**Statistical Analysis**

All descriptive data are reported as mean and SD. Reliability coefficients, ICC (2, 1 a two-way random effects single-measure reliability model),24 and 95% confidence interval (CI) were derived from repeated-measures analysis of variance (ANOVA). Where differences in ANOVA were detected, a paired \(t\) test was conducted. The typical error and the coefficient of variance (CV), which expresses the variance as a percentage, were calculated to determine the

<table>
<thead>
<tr>
<th>Change in mean</th>
<th>SD</th>
<th>(t)</th>
<th>(df)</th>
<th>(P)</th>
<th>Typical error</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 1 vs 2</td>
<td>2.10</td>
<td>3.2</td>
<td>3.63</td>
<td>29</td>
<td>.001</td>
<td>2.24</td>
</tr>
<tr>
<td>Trial 2 vs 3</td>
<td>0.33</td>
<td>2.8</td>
<td>0.656</td>
<td>29</td>
<td>.517</td>
<td>1.97</td>
</tr>
<tr>
<td>Trial 3 vs 1</td>
<td>2.43</td>
<td>3.3</td>
<td>4.029</td>
<td>29</td>
<td>&lt;.001</td>
<td>2.34</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 1 vs 2</td>
<td>1.63</td>
<td>3.3</td>
<td>2.672</td>
<td>29</td>
<td>.012</td>
<td>2.37</td>
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<tr>
<td>Trial 2 vs 3</td>
<td>1.43</td>
<td>2.8</td>
<td>2.767</td>
<td>29</td>
<td>.010</td>
<td>2.01</td>
</tr>
<tr>
<td>Trial 3 vs 1</td>
<td>3.07</td>
<td>3.5</td>
<td>4.795</td>
<td>29</td>
<td>&lt;.001</td>
<td>2.48</td>
</tr>
</tbody>
</table>

Table 4. Results of paired \(t\) test as a post hoc test and typical error values with 95% CI for paired rotation trials
degree of error. \( P < .05 \) was considered significant. SPSS for Windows version 11.5 (SPSS, Inc, Chicago, Ill) was used for all analyses.

RESULTS

A summary of the ROM for all 30 subjects is given in Table 1. The ICC for all movements was high (\( > .96 \)), showing that the error was a small proportion of the total range of movement recorded and that the repeated measures were highly linearly correlated (Table 2).

The repeated-measures ANOVA (Table 3) showed no significant differences between the 3 trial measurements for flexion (\( P = .17 \)), extension (\( P = .12 \)), and lateral flexion (right \( P = .65 \), left \( P = .45 \)). However, lateral rotation showed a direction bias (\( P < .01 \)). A paired \( t \) test determined where the difference lay.

The paired \( t \) test established a significant difference (\( P < .01 \)) between all 3 rotation trials except trial 2 vs 3 for rotation, right side (\( P = .51 \)) (Table 4), which was reflected in the difference in mean (3.3°) for the same trial. Changes in mean for other rotation trials were larger. The typical error calculated for significant differences was less than 3.5°, and the CV was less than 4% for all movements (Table 4).

DISCUSSION

A review of literature revealed no published literature on the cervical range of movement for an Indian population. A possible reason for lack of studies in India could be nonavailability of economically priced, reliable, and valid measuring instruments. Establishing the reliability of the Spin-T on a normal Indian population also facilitates research on symptomatic populations and the development of a normal reference range.

The accuracy of the Spin-T has been established in a previous study. All for planes of CROM, the coefficient of determination (\( R^2 \)) revealed \( R^2 > 0.99 \). The Spin-T goniometer has the potential to reliably measure composite cervical movements, which can aid clinicians’ assessment of cervical spine movements easily in routine clinical practice.

In the present study, the mean values in all directions were lower as compared with Haynes and Edmondston. One possible explanation is that the mean age (29 years) of subjects was lower compared with this study (mean age, 35 years). Previous research has established that CROM includes physiotherapy students who may be more aware of movement patterns and would possibly perform better than a population that included people from different backgrounds, as in this study. The age range in this study extended from 18 to 65 years, and hence, a dedicated study including a larger sample size with more subjects for each decade is required to establish a normal reference range for this population.

Past literature reported higher reliability of total plane movements than separated into left and right. This is probably because the reliability coefficient (ICC) is a relative value and is range dependent. Therefore, ICC values increase as the range of measured values increase.

Standardization of the cervical neutral position is imperative for correct measurements. Comparisons of lateral movements, left vs right, are sometimes essential for clinicians. The concept of neutral position for spinal ROM is unclear and a potential source of error. To assume a neutral posture for lateral movements is comparatively easier because it can be based on body midline symmetry. For flexion-extension, there is no inherent axis of symmetry, and therefore, it is problematic and susceptible to error. There is a lack of a satisfactory solution in establishing a cervical neutral and the neutral position set by the clinician seldom differs from the neutral position assumed by a healthy subject. The common strategy is to have seated subjects sitting erect and looking ahead without any further attempt to standardize the resting neutral position. In this study, the neutral position of the head was standardized with a laser pointer and concurrently aligned with a T square on the zero mark of the protractor. This minimized error between opposite direction movements, which was evident on adding the left and right rotation trials. Similar ICC values were achieved for total and rotation trials to right and left. The addition of a laser pointer to the Spin-T goniometer is a variation from the original design of the Spin-T and confers an additional advantage of ensuring a repeatable starting position between trials. This simple and inexpensive strategy can be recommended to many other cervical spine range instruments as a means of reducing error. Zachman et al measured the neutral cervical position by positioning the dial indicator of a rangiometer on the sagittal and coronal plane and noting the degrees of deviation from neutral. The dial indicator was then replaced with a vertical indicator arm for measurements of neutral in the axial plane. Pearson \( r \) was less than 0.45 for intertester reliability for neutral position assessment in all 3 planes.

Extreme protraction and retraction can affect cervical flexion-extension and rotation movements and need to be addressed during measurement. The Spin-T measures natural composite cervical movement, which is a combination of glides and rotation. Strapping the upper trunk and further asking the subjects to avoid upper trunk movement seemed to be effective in minimizing unintentional movements. Repeated instructions about chin to chest for flexion movements during familiarization prevented subjects from initiating flexion from the lower cervical spine and maintained uniformity of movement patterns.

The cervical spine comprises a complex series of multiaxial joints in which movements are controlled by
numerous muscles attached segmentally and across several spinal segments.9 Neck movements are easily influenced by pain, spasm, mental/physical stress, and the time of the day. Variability of cervical spine movements exists in a normal population even when assessed on the same day.19 A higher Variability of cervical spine movements exists in a normal population due to pain, spasm, mental/physical stress, and the time of the day. In another study,11 a higher interobserver reliability (flexion-extension >0.70, rotation >0.70, lateral flexion >0.60) for movements tested on the same day was obtained than for intraobserver reliability (>0.60) for all movements completed on different days. A source of variation (subject, observer, equipment, diurnal effects) exists for within-day reliability tests as well as between-day tests. Between-day variation is smaller than between day because of variability in symptom response and individual differences.11

Equipment limitations need to be accounted for in reliability studies and in clinical practice. In two separate studies,17,18 reliability was found to be lower for flexion-extension compared with lateral movements using the same system, the CA 6000 Spine Motion Analyzer. This may be attributed to deficiencies of the instrument for measurements in the sagittal plane. One limitation of the Spin-T is that blinding the tester is not possible because the design of the Spin-T involves close reading of the protractors. For repeat measures, a tester bias may exist. Therefore, instead of repeating 3 consecutive movements in one direction, the applicable method in this intratester same time reliability trial was completion of one full cycle of measurements in all directions before the next cycle of measurements. This involved repositioning to neutral 18 times for 18 measurements. The Spin-T sits on the nose of an individual like a spectacle frame. With a small head circumference, it does not fit snug on the nose, which may contribute to error. A large head circumference makes it difficult to fit the two arms of the Spin-T along both sides of the head. In this study, two subjects had very small head circumference. These subjects were given padding along the sides of the head, above the ears, to secure the Spin-T.

Another source of variability to be considered is the effect of the order of testing motions. Although rotation trials showed a systematic trend, it perhaps cannot be ascribed to the order of measurements because rotation was measured between sagittal and frontal plane movement trials. Lantz et al19 have also shown that the order of movements has no effect on the outcome of measurement.

The repeated-measures ANOVA and subsequent post hoc tests revealed differences in rotation trials. No such differences were noted for other movements. Comparing paired rotation trials, the difference noted for trial 3 vs trial 1 (both sides) was the highest. This may be due to the development of a bias on repeated testing with a minor increase in range effect or learning effect from trial 1 to trial 3. Another reason may be that on repeated best performances or moving the neck to end range, a biologic creep effect was observed, causing neck rotation range to increase. The reason for differences only in rotation trials and not other movements remains unclear. In a reliability study of the FASTRAK,11 a systematic bias was detected in all directions except flexion and right rotation. Contrary to the current results, range of movement reduced from measurements 1 to 3. The authors11 attribute this to initial subject enthusiasm and that subjects tend to stop their movements in the second and third trial based on experience rather than because of reaching the end range.

The 95% CI of the typical error provides a measure of the extent of variation between measurements obtained between trials. The 95% CI of the typical error for rotation was between 1.5° and 3.5°, which is a 2° difference. In the intratester trials, a typical error of 2.3° for left rotation for each examiner and 3.6° and 2.9° for right rotation for each examiner was reported for cervical spine reliability trials.22 The authors did not report any confidence limits of the error. A wide CI does not reflect good reliability. Zachman et al12 reported the intertester reliability of the rangiometer. The intertester standard error of estimate ranged from 5° to 12° for all movements of the cervical spine, with a large CI between the two testers (20°–48°). Based on these results, the authors advised caution in interpretation of results when using the rangiometer for future clinical trials.

The ANOVA detected no difference between the sagittal and coronal plane trials. The typical error for rotation trials was less than 3.5° with a CV less than 4%. These results were similar to previous studies.15,17 A typical error of less than 3.9° for all motions was stated by Petersen et al17 and CV between 2.4% and 10.9% by Christensen and Nilsson.15 This study has shown that changes in CROM of greater than 4° can be detected by the Spin-T system. This magnitude of change is likely to be less than what is clinically significant and therefore suggests that the instrument is of sufficient accuracy to be clinically useful. This article confirms, independently from the developers of the Spin-T, that the errors associated with the assessment of CROM are relatively small.

CONCLUSION

The Spin-T goniometer tested on this asymptomatic Indian population proved to be a reliable measuring tool for assessing composite CROM in an asymptomatic Indian population. The addition of a laser pointer to the Spin-T device provided a simple and reliable method to ensure consistency of the neutral start position between trials.

ACKNOWLEDGMENTS

The authors thank Professor Kamles Bhaumik, PhD, for statistical support; all subjects who volunteered to participate in this study; and Ms Reema Debnath for secretarial assistance.
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A RANDOMIZED CLINICAL TRIAL OF MANUAL VERSUS MECHANICAL FORCE MANIPULATION IN THE TREATMENT OF SACROILIAC JOINT SYNDROME

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ABSTRACT

Objective: To investigate the effect of instrument-delivered compared with traditional manual-delivered thrust chiropractic adjustments in the treatment of sacroiliac joint syndrome.

Methods: Prospective, randomized, comparative clinical trial. Sixty patients with sacroiliac syndrome were randomized into two groups of 30 subjects. Each subject received 4 chiropractic adjustments over a 2-week period and was evaluated at 1-week follow-up. One group received side-posture, high-velocity, low-amplitude chiropractic adjustments; the other group received mechanical-force, manually-assisted chiropractic adjustments using an Activator Adjusting Instrument (Activator Methods International, Ltd, Phoenix, Ariz).

Results: No significant differences between groups were noted at the initial consultation for any of the outcome variables. Statistically significant improvements were observed in both groups from the first to third, third to fifth, and first to fifth consultations for improvements (P < .001) in mean numerical pain rating scale 101 (group 1, 49.1-23.4; group 2, 48.9-22.5), revised Oswestry Low Back Pain Disability Questionnaire (group 1, 37.4-18.5; group 2, 36.6-15.1), orthopedic rating score (group 1, 7.6-0.6; group 2, 7.5-0.8), and algometry measures (group 1, 4.8-6.5; group 2, 5.0-6.8) for first to last visit for both groups.

Conclusions: The results indicate that a short regimen of either mechanical-force, manually-assisted or high-velocity, low-amplitude chiropractic adjustments were associated with a beneficial effect of a reduction in pain and disability in patients diagnosed with sacroiliac joint syndrome. Neither mechanical-force, manually-assisted nor high-velocity, low-amplitude adjustments were found to be more effective than the other in the treatment of this patient population. (J Manipulative Physiol Ther 2005;28:493-501)

Key Indexing Terms: Chiropractic; Sacroiliac Joint; Manipulation; Spinal; Pain

Low back pain (LBP) is a significant health problem that has a major impact on quality of life and on health care costs.1 The sacroiliac joint (SIJ) has been found to be a significant source of pain in 30% of mechanical LBP sufferers.2 Sacroiliac joint syndrome has been described as pain and decreased mobility of the SIJ, resulting from the mechanical derangement of the joint.3 Kirkaldy-Willis and Burton4 describe the symptoms of SIJ syndrome to include pain over the posterior aspect of the SIJ that varies in its degree of severity; referred pain to the groin, over the greater trochanter, down the back of the thigh to the knee, and occasionally down the lateral or posterior calf to the ankle, foot, and toes. Clinical findings including pain and palpable tenderness over the SIJ; aggravation by provocation tests; pain referral to the groin, trochanter, and buttock; and clinical asymmetry of movement of the SIJ are considered important in arriving at an SIJ syndrome diagnosis.5,6 However, identifying the SIJ as a sole or primary pain generator has been controversial. This controversy stems from the inherent anatomic location of the SIJ and its close proximity to adjacent spinal structures known to cause back pain.
addition, referred pain from the lumbar spine to the SIJ, as well as pain referral patterns from the SIJ to the buttock, lower lumbar spine, groin, and lower extremity confound the identification to a specific source. Nevertheless, some studies have identified the SIJ to be a primary source of back pain both experimentally and clinically.

Several treatments for SIJ syndrome have been advocated by clinicians, although research into their efficacy remains sparse or even nonexistent. In a recent study of patients diagnosed with SIJ syndrome, radiofrequency denervation of the involved SIJ was found to provide at least a 50% decrease in visual analog scores for a period of at least 6 months in 36.4% (12 of 33) of patients. The invasiveness of this procedure, however, makes other conservative SIJ treatments attractive options for patients suffering SIJ syndrome. Although several studies have reported various physiological or functional outcomes resulting from SIJ manipulation, such as a reduction in muscle inhibition, electromyographic neuromuscular reflex response, decreased Hoffman reflex, improvement in gait symmetry, and improved innominate bone tilt, few clinical outcome studies have evaluated the effectiveness of SIJ manipulation.

A variety of spinal manipulative techniques exist to provide clinicians with choices in the delivery of particular force-time profiles deemed appropriate for a patient or condition. In this manner, clinicians rely on mechanical advantages in performing spinal manipulation through patient positioning and mechanical assistance from a table or instrument. Manual articular manipulative and chiropractic adjusting procedures are classified into 4 categories to better describe their technique and mechanism of force production: specific contact thrust procedures (eg, high-velocity, low-amplitude [HVLA] thrusts), nonspecific contact thrust procedures (eg, mobilization), manual force, mechanically assisted procedures (eg, drop tables or flexion-distraction tables), and mechanical-force, manually-assisted (MFMA) procedures (eg, stationary or handheld instruments). Today, HVLA and MFMA procedures are reported to be the first and second most popular chiropractic adjusting techniques, used by 93% and 72% of chiropractic practitioners in the US, respectively, and similar numbers internationally. Few studies have evaluated the relative effectiveness of HVLA vs MFMA spinal manipulation in the treatment of musculoskeletal disorders, and no study has compared these two chiropractic adjusting techniques for their effectiveness in the treatment of SIJ syndrome. The objective of this study was to determine the relative effectiveness of MFMA as compared with HVLA chiropractic adjustments in patients diagnosed with SIJ syndrome.

METHODS

Subject Recruitment and Inclusion Criteria

Subjects were recruited from the greater Durban area (outpatient chiropractic clinic, Durban Institute of Technology, Durban, South Africa) by means of advertisements placed in local newspapers; pamphlets placed in local sports clubs, gyms, and shopping centers; and advertising by word of mouth. All respondents were screened telephonically and subsequently scheduled for an initial consultation provided they met the initial criteria of having LBP. No stratification of subjects took place, and they were accepted regardless of race, occupation, sex, and severity of their condition. Patients were included in the study if they had a recent history of LBP longer than a 2-week duration at the time of initial consultation with a total of more than 4 weeks of LBP in the preceding year and diagnosed with SIJ syndrome at the initial examination. Only patients between the ages of 18 and 59 years were included in this study to avoid parental consent and the possibility of the development of fibrous ankylosis in the SIJ after the sixth decade. Any mechanical conditions associated with but secondary to sacroiliac syndrome (eg, active myofascial involvement or facet syndrome) were assessed and noted in the lower back regional examination, but no treatment of these conditions was administered. Patients already taking anti-inflammatory or analgesic medication (ibuprofen, paracetamol, etc) were included in the study only after a 3-day washout period and willingness to discontinue its usage for the duration of the clinical trial.

Exclusion Criteria

Subjects presenting with conditions that were contraindicated to manipulation including destructive lesions of spine, ribs, and pelvis; healing fracture or dislocation; gross instability; cauda equina syndrome; abdominal aneurysm; or visceral-referred pain were excluded from the study. Specific to SIJ syndrome, differential diagnosis, infection, inflammatory arthritis (rheumatoid, Reiters, psoriasis, gout, degenerative, and ankylosing spondylitis), and neoplasms were grounds for exclusion as well. Collectively, these pathologies were excluded on the grounds of clinical history and examination, and in such event, no further investigations were performed (eg, radiographs or treatment). Patients who were receiving workers’ compensation or disability insurance for LBP, had previous lumbar surgery, were pregnant women (due to hormone-induced ligament laxity and possible resultant instability of the SIJ occurring during pregnancy), or had participated in any other previous research project at the Durban Institute of Technology Day Clinic during the past 3 months were excluded from the study. Further information on those excluded from the study can be found in Table 1. Once included in the study, participants were excluded only if they underwent any other form of treatment of LBP during participation in the research or if they changed their everyday activity levels or normal lifestyle, which was monitored by the examining clinician.

Subjects

Ninety-six patients displayed an interest in participating in the research study. Patients were excluded immediately if
they did not meet the age criterion or displayed any obvious signs of dermatomal radiculopathy indicative of spinal nerve root compression. Seventy-nine patients were further assessed at the Durban Institute of Technology Chiropractic Day Clinic, 66 of whom met the selection criteria and were accepted into the trial. Demographic data of the 36 subjects excluded from the study are shown in Table 1. Six patients were excluded during the course of the study because of noncompliance, leaving 60 participating patients (31 men, 29 women; age range, 18-59 years; mean age, 39.1 years; SD, 12.2 years) who completed the clinical trial. Sixty subjects exceeded the minimum sample size that was determined by power analysis.

The research in its entirety was approved by the institutional review board of the Durban Institute of Technology and monitored by a supervising senior clinician (HLW). All study participants were provided with an information sheet describing the study and its risks and benefits and provided written informed consent for their participation. Patients were randomly allocated into one of two groups, without the use of stratification, depending on a number drawn from a box. Table 2 provides the age distribution within the study participants.

### Sacroiliac Joint Syndrome Diagnosis

During the patient history and examination, subjects were initially screened for SIJ syndrome by noting whether their pain was unilaterally focused with intensity at the level of the SIJ or sacral sulcus. In addition to inclusion criteria of a minimum of 2 weeks of LBP focused unilaterally with intensity at the level of the SIJ, specific orthopedic tests were performed to confirm the presence of SIJ syndrome. The specific tests included posterior shear or “thigh thrust test,” Patrick’s FABER test,26 Gaenslen’s test,26 and Yeoman’s test.27 Each of these orthopedic tests was allocated a specific score when testing positive to collectively contribute to the orthopedic rating score (ORS). The posterior shear test was allocated 4 points; according to Laslett and Williams,25 it is a more sensitive test for the presence of SIJ syndrome. The other 3 orthopedic tests were each allocated two points. Completion of the tests resulted in an ORS with a maximum of 10. Those scoring 6 or more of 10 were included in the study. A respective change in the patient’s score indicated a change in the condition. The ORS is based on the principle that the specificity of the diagnosis is improved when based on a combination of diagnostic tests.28 The most symptomatic area of the SIJ was then confirmed by static and motion palpation of the SIJs and pain pressure threshold quantified with algometry. Motion Palpation was also used to identify the SIJs with restricted and/or abnormal motion in both groups. Furthermore, if the SIJ was found to be fixated in flexion, it was treated as a posterior inferior (PI) ilium subluxation, and likewise, an extension fixation was treated as an anterior superior (AS) ilium subluxation.27

### Treatment Intervention

Group 1 received treatment via side posture HVLA manipulation of the symptomatic SIJ using the diversified technique of chiropractic adjustment in accordance with the corrective line of drive for the AS or PI ilium subluxation, as determined from the examination in each case.27 Group 2 received treatment via MFMA chiropractic adjustment of the symptomatic SIJ using a handheld instrument, the Activator Adjusting Instrument (Activator Methods International, Ltd, Phoenix, Ariz).29 In the presence of a PI ilium subluxation, MFMA thrusts were administered to the segmental contact points as follows: (1) on the same side as the flexion fixation, the tip of the instrument was positioned in the soft tissue of the gluteus maximus muscle just medial to the ischial tuberosity and directed toward the spine of the ilium. The line of drive was superior, lateral, and posterior; (2) on the same side as the flexion fixation, the tip of the instrument was placed in the sciatic notch, under the sacrotuberous ligament. The line of drive was superior, lateral, and posterior; and (3) on the same side as the flexion fixation, the tip of the instrument was placed in the fossa just lateral to the SIJ, on the lateral aspect of the ilium. The line of drive was superior and anterior.

In the presence of an AS ilium subluxation, MFMA thrusts were administered to the following segmental contact points: (1) on the side opposite to the extension fixation, the tip of the instrument was placed on the base of the sacrum, approximately half an inch lateral to the first sacral tubercle. The line of drive was inferior and anterior; (2) on the side opposite to the extension fixation, the tip of

### Table 1. Demographic data of patients excluded from the study

<table>
<thead>
<tr>
<th>Exclusion criteria</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
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<td>Age &lt;18 y</td>
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<td>1</td>
</tr>
<tr>
<td>Age &gt;59 y</td>
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<td>Lumbar facet syndrome dominant</td>
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<td>Recent lumbar spine surgery</td>
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</tr>
<tr>
<td>Signs of nerve root entrapment</td>
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<td>4.2</td>
</tr>
<tr>
<td>Noncompliance</td>
<td>6</td>
<td>6.3</td>
</tr>
<tr>
<td>Score &lt;6 for ORS</td>
<td>15</td>
<td>15.6</td>
</tr>
</tbody>
</table>

### Table 2. Age distribution within the study participants

<table>
<thead>
<tr>
<th>Age (y)</th>
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<th>Percentage</th>
<th>Frequency</th>
<th>Percentage</th>
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<td>23.3</td>
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</table>
the instrument was placed on the crest of the ilium approximately 1 in superior the posterior superior iliac spine. The line of drive was parallel to the plane line of the SIJ (medial and inferior); and (3) on the side opposite to the extension fixation, the tip of the instrument was placed on the superior aspect of the ischial tuberosity. The line of drive was inferior and anterior.

This study did not make use of the leg length inequality assessment or stress tests used in Activator Methods Chiropractic Technique protocols.29 Purported safety of using a device such as the Activator Adjusting Instrument (Activator Methods International) is thought to be due to the prone neutral positioning of the patient during the spinal manipulation procedure (thus, no rotation) combined with the controlled repeatable low force of the thrust in the joint plane line.30

Each participant attended 4 consultations and treatments over a 2-week period, and then a follow-up consultation within 1 week after the fourth treatment. Objective and subjective outcomes data were collected at the beginning of the first, third, and follow-up consultations. If the patient became asymptomatic in subjective clinical findings before the final consultation, the patient continued to be evaluated for the remainder of the treatment period but received no further treatment.

Outcome Measures

Subjective pain was assessed by means of the numerical pain rating scale (NRS) 101, a questionnaire used to measure the changing intensities of pain experienced by the patient.31 The questionnaire includes two separate graphs; both ranging from 0 to 100, where 0 indicates “no pain” and 100 indicates “pain as bad as it could be.” The subjects were asked to rate their pain firstly according to the pain intensity when it is at its worst, and secondly, the pain intensity when the pain is at its least. The average of these two scores is an indication of the patients’ pain level. This method of pain rating has been found to enhance the responsiveness of the measures and is a more representative perspective of their pain experience.32 The validity of the NRS has been well documented in demonstrating positive and significant correlation with other measures of pain intensity.33 Self-reported pain and disability was recorded by means of the Revised Oswestry Low Back Pain Disability Questionnaire (Oswestry).34,35 The Oswestry is a validated questionnaire consisting of 10 sections encompassing pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life, traveling, and changing degree of pain. Each section consists of 6 statements, each allocated a score between 0 (indicating no disability) and 5 (indicating maximum disability). The final score was totaled out of 50 and then converted to a percentage, indicating perceived disability at that time.

Orthopedic rating scores were collected at each consultation to compare as an objective outcome measure in each group. In addition, to quantify the symptomatic status of the SIJ, an algometer was used. In this manner, pain pressure threshold, defined as the minimum pressure inducing pain or discomfort, was assessed using the Wagner FDK20 Force Dial (Wagner Instruments, Greenwich, Conn) using protocols developed by Fischer.36-39 The readings were taken over the most painful area of the symptomatic SIJ and over the same anatomic location from the asymptomatic SIJ. Such anatomic position was noted for follow-up assessment. Measurements were taken by placing the tip of the algometer to the most painful part of the symptomatic SIJ (and then the corresponding area of the other SIJ) and applying a posterior to anterior pressure at a rate of 1 kg/cm² per second until the patient verbally indicated pain. The readings were measured in kilograms per square centimeter (kg/cm²). A higher reading indicated lower pain sensitivity or higher pain threshold.

Statistical Analysis

Statistical analysis was performed using SPSS Version 9.0 statistical software program (SPSS Inc, Chicago, Ill). The statistical evaluation was aimed at measuring any significant changes occurring between the initial and third consultations, initial and fifth consultations, and the third and fifth
consultations between the two study groups. Both parametric and nonparametric testing were used to analyze the data obtained. Parametric tests were used to analyze the algometer data, ORS (percentage analysis), NRS, and Oswestry scores. Statistical tests included Mann-Whitney U-Test for intergroup analysis, and Friedman $t$ test for intragroup analysis. This analysis would determine any significant changes between the initial, third, and fifth consultations within each study group. All data were analyzed using a 5% significance level. The null hypothesis stated that there was no difference between the two groups. The Friedman $t$ test was used to determine if there was any significant difference between groups in Oswestry, ORS, and algometer readings between the first, third, and follow-up consultations. The null hypothesis was that there was no difference between groups for any of the subjective or objective variables. If the null hypothesis was rejected for Friedman $t$ test, then a multiple comparison procedure, Dunn procedure, was applied to determine which treatments are significantly different.

**RESULTS**

Of the 60 participating subjects 51.7% were men and 48.3% were women, with 16 men and 14 women randomized to group 1 and 15 men and 15 women randomized to group 2. The age distribution of the study participants is shown in Table 2. The number of patients in each age grouping was evenly spread across both groups with the highest proportion of subjects in the 18 to 30–year age range (33% and 37%, respectively, for groups 1 and 2). The 50 to 59–year-old grouping was the second largest (23% and 30%, respectively, for groups 1 and 2), whereas 5 subjects each made up the 31 to 40–year-old group (17%) and 27% and 17% were aged 41-50 years for groups 1 and 2, respectively.

At the initial consultation, no significant differences between groups were noted for age, sex, or any of the subjective or objective variables. Statistically significant improvements ($P < .001$) in mean NRS (group 1, 49.1-23.4; group 2, 48.9-22.5), Oswestry (group 1, 37.4-18.5; group 2, 36.6-15.1), ORS (group 1, 7.6-0.6; group 2, 7.5-0.8), and algometry measures (group 1, 4.8-6.5; group 2, 5.0-6.8) were observed from the first to last visit for both groups. From the first to the final consultations, statistical analysis of the subjective and objective data showed equal improvement for both groups with no difference in outcome between the groups. Intergroup analysis showed no statistically significant differences between groups for all the outcome measures examined.

With the exception of the algometry data, statistically significant improvements were observed for all subjective and objective outcome variables (NRS, Oswestry, and ORS) from the first to the third and third to fifth consultations. No statistically significant improvements in pain pressure threshold were observed in group 1 from the first to third consultation on either the symptomatic or asymptomatic SIJ. For group 2, no significant improvements in pain pressure threshold from the asymptomatic SIJ were noted from the first to third or third to fifth consultations. Mean NRS, Oswestry, ORS, and algometry (asymptomatic and symptomatic SIJ) values for groups 1 and 2 from initial, third, and final consultations are shown in Figs 1-4.

**DISCUSSION**

The results of this study showed that chiropractic care including both HVLA and MFMA-type chiropractic adjust-
ments were associated with a positive effect in the treatment of SIJ syndrome in this patient population. Because group 1 did not exhibit a greater effect over group 2 in either subjective (self-perceived pain and disability) or objective (ORS, pain pressure threshold) findings as hypothesized, this study found that both chiropractic adjustment regimens had an equal effect in the treatment of SIJ syndrome. The improvement in LBP symptoms, combined with improvement in objective clinical findings in both groups, is consistent with anecdotal claims of efficacy among clinicians using these forms of chiropractic adjustments in patients with SIJ syndrome. This is the first study to compare different forms of chiropractic adjustment/spinal manipulation in the management and treatment of patients with SIJ syndrome.

Because this study did not include a control group, these results cannot be taken as proof supporting the clinical efficacy of chiropractic adjustment for SIJ syndrome; however, the positive trends observed suggest the call for a well-designed randomized controlled clinical trial in a similar patient population. Noteworthy was that patients included in the study had LBP for at least a 2-week duration at the time of initial consultation with a total of more than 4 weeks of LBP in the preceding year. The significant improvements in subjective and objective findings of SIJ syndrome associated with chiropractic treatment over a relatively brief treatment regimen (4 visits over 2 weeks with 1-week follow-up) are encouraging for the conservative treatment of this disorder.

Because this study did not include a control group, the natural history of SIJ syndrome was not investigated. The natural progression of sacroiliac syndrome would be the natural history of SIJ syndrome was not investigated. Consequently, this acts to restrict SIJ motion and promotes a subsequent SIJ inflammatory response, which most probably contributes to the presented positive subjective and objective findings in this patient population. Indeed, other studies have reported alterations in spinal motion in chronic LBP subjects. Detecting alterations in SIJ biomechanics by qualitative means, such as palpation, has its limitations and is likely to have contributed to examiner error in the current study. Kinematic studies of SIJ motion have varied but similarly agree on the small amount of motion occurring at the joint, between 0.5° and 6° of rotation and 0.7 to 3 mm of translation. This small amount of movement is difficult to differentiate clinically and, thus, could have contributed to examiner error in the decision-making of type of SIJ fixation and the subsequent direction to apply the chiropractic adjustment, consequently also affecting our results.

In this study, confirmation of the SIJ syndrome diagnosis was made through correlation of patient history and physical examination findings including both the orthopedic and

SIJ capsular stimulation. A reduction in pain in patients treated for presumptive SIJ pain by injection of an anesthetic into the SIJ has also been shown, validating its status as a pain generator.

Although the SIJ has been shown to be a pain generator, confirming an SIJ syndrome diagnosis in the absence of SIJ block (arthrogram) is limited, thus presenting another limitation to the current study. Several noninvasive clinical methods such as the orthopedic tests as used in the current study have been found not to be reproducible and, thus, should not be used alone by practitioners to provide reliable information concerning where to direct a manipulative procedure in patients with chronic mechanical LBP. However, recent work has shown a strong correlation between 3 or more positive SIJ pain provocation tests (as used in the current study) and positive SIJ injection. Because the current study did not confirm the SIJ as the pain generator via SIJ block, it is possible that false-positive and false-negative clinical indicators for differential diagnosis of SIJ syndrome were present in our patient population. Such misdiagnosis may have affected our results. Although it would be advantageous to have confirmation of the SIJ as the primary pain generator via arthrogram, we believe that the invasiveness of this procedure would have affected our subject recruitment. Future studies, however, should include diagnostic SIJ block to confirm the SIJ syndrome diagnosis. Experimental stimulation of the SIJ has been further found to cause neuromuscular responses in the gluteus maximus, quadratus lumborum, and multifidus muscles. Such muscular activation assists in providing control of locomotion and body posture and provides stability of the SIJ and lumbar spine. Thus, sensitization of SIJ nociceptive afferents not only contributes to mechanical LBP, but also further plays a role in SIJ biomechanics via reflexogenic activation of the trunk and gluteal muscles. This acts to restrict SIJ motion and promotes a subsequent SIJ inflammatory response, which most probably contributes to the presented positive subjective and objective findings in this patient population. Indeed, other studies have reported alterations in spinal motion in chronic LBP subjects. Detecting alterations in SIJ biomechanics by qualitative means, such as palpation, has its limitations and is likely to have contributed to examiner error in the current study. Kinematic studies of SIJ motion have varied but similarly agree on the small amount of motion occurring at the joint, between 0.5° and 6° of rotation and 0.7 to 3 mm of translation. This small amount of movement is difficult to differentiate clinically and, thus, could have contributed to examiner error in the decision-making of type of SIJ fixation and the subsequent direction to apply the chiropractic adjustment, consequently also affecting our results.
algometry findings. The application of the pressure of the algometer can be therapeutic. However, algometry measures have been shown to be stable across treatment days, and inasmuch, we do not believe that the pressure applied during the algometry examinations contributed to the subjective and objective improvements observed in the study population. The pain pressure threshold on the symptomatic side was lowered on the side of SIJ syndrome from algometry measures in both groups (Fig 4). Algometry has been found to be a valid and reliable measure of pain pressure threshold. It is likely that the chiropractic adjustment, as delivered in this study, was delivered on the true symptomatic side. It is also possible that anatomic positioning error existed in the test-retest conditions of the algometry protocol that also may have contributed to error in the algometry results. Until strict validated clinical measures are established as diagnostic criteria SIJ syndrome, the validity and, ultimately, the efficacy of the treatments for this condition will continue to be questioned.

In general, the benefits of chiropractic adjustment or spinal manipulation involve biomechanical and neurophysiologic mechanisms. These mechanisms include restoring joint play to dysfunctional joints through releasing entrapped synovial folds or plica, relaxing hypertonic muscles, and disrupting articular or periarticular adhesions. Beneficial effects of chiropractic adjustments/spinal manipulation have been thought to be associated with mechanosensitive afferent stimulation and presynaptic inhibition of nociceptive afferent transmission in the modulation of pain, and improved functional ability. Although improvements in SIJ function have been reported after SIJ manipulation, manipulation has not been found to change the position of the SIJ. It is likely that SIJ manipulation acts indirectly on the supporting musculature, improving the global function of the region.

Several studies have presented physiological or functional outcomes resulting from SIJ manipulation. Suter et al found that SIJ manipulation caused a reduction in lower extremity muscle inhibition in patients suffering SIJ dysfunction and knee and anterior thigh complaints. Electromyographic reflex responses have been found to be elicited via both HVLA and MFMA manipulation of the SIJ. Murphy et al reported decreased Hoffman reflex responses indicative of a decrease in motor neuron excitability after HVLA SIJ manipulation in clinically relevant patients with LBP. Herzog et al found that HVLA SIJ manipulation was superior to a back school regimen on gait symmetry for patients with SIJ pain. Similarly, Cibulka et al noted improved innominate bone tilt after HVLA SIJ manipulation in patients with SIJ dysfunction. Few clinical outcome studies, however, have evaluated the effectiveness of HVLA or MFMA SIJ manipulation. In a case series of 10 subjects diagnosed with chronic SIJ syndrome, Osterbauer et al reported decreases in pain, disability, and pain pressure threshold initially and at 1-year follow-up in patients undergoing MFMA chiropractic treatment. In contrast to the findings of Herzog et al, Osterbauer et al found no effect on gait symmetry or postural sway in their patients receiving chiropractic (MFMA) treatment.

Despite its limitations, this study is one of few studies investigating conservative treatments of SIJ syndrome and the first study to compare different chiropractic techniques in its management. Noteworthy are the findings of the current study in contrast to the beliefs of an expert panel assembled to evaluate the efficacy of different chiropractic techniques in the treatment of LBP. In a recent report, Gatterman et al rated HVLA manipulation as more efficacious than MFMA manipulation in the treatment of low back conditions, which included SIJ dysfunction in concordance with the available evidence and their expert opinions. On the contrary, the results of the current study showed no difference in subjective or objective outcomes with either HVLA or MFMA treatments in this population of patients with SIJ syndrome. In this regard, this study adds to the sparse body of literature on efficacy of conservative treatments for mechanical LBP involving SIJ syndrome and forms the basis for a more rigorous investigation using chiropractic adjustments/spinal manipulation.

CONCLUSIONS

The results of this trial indicate that a relatively short regimen (4 visits) of MFMA or HVLA chiropractic adjustments were associated with beneficial effects of reduction in pain and disability in patients diagnosed with SIJ syndrome. Neither MFMA nor HVLA adjustments were found to be more effective than the other in the treatment of this patient population. Acknowledging and overcoming the limitations of this study will allow for designing further research contributing to a greater understanding of the clinical benefits of chiropractic adjustments/spinal manipulation in patients with SIJ syndrome.

ACKNOWLEDGMENTS

The authors thank the academic staff at Durban Institute of Technology Chiropractic Department and the clinical and administrative staff at the Department Day Clinic for their assistance and support throughout the completion of this study.

REFERENCES

THE RELATIONSHIP BETWEEN SPINAL DYSFUNCTION AND REACTION TIME MEASURES

Louise B. Lersa, BSc, a Cathy M. Stinear, BSc (Chiro), PhD, b and Roy A. Lersa, BSc c

ABSTRACT

Objective: The objective of this study was to investigate the relationship between the number of sites of spinal dysfunction and a range of measures of cognitive processing.

Methods: This double-blind, randomized, observational pilot study was performed at a chiropractic college clinical training facility. Thirty volunteers with clinical evidence of cervical spinal joint dysfunction participated. Subjects were classified into 2 groups depending on whether they exhibited signs of cervical spinal joint dysfunction at one or more sites. A range of computer-based tasks was used to determine simple reaction time (RT), choice RT, probe RT, and inhibition of a preplanned response.

Results: Multiple sites of cervical spinal joint dysfunction were related to impaired cortical processing as revealed by significantly higher loads on central capacity, significantly less accurate response selection, and a trend toward more variable performance of an anticipated response. Multiple sites of cervical spinal joint dysfunction do not appear to be related to the speed of response selection or the ability to inhibit a preplanned response.

Conclusion: This pilot study provides a context for the improvements in cortical processing observed after cervical spine adjustment. It shows that probe RT may be a useful tool in further studies examining the effects of cervical spine manipulation of joint dysfunction and the associated effect on cognitive function. (J Manipulative Physiol Ther 2005, 28:502-507)

Key Indexing Terms: Cervical Vertebrae; Reaction Time; Spine; Mental Processes; Joint Dysfunction

S

pinal manipulation is commonly used for conservative treatment of spinal dysfunction. Studies have shown that manipulative intervention can produce alterations in various aspects of neurological function. Manipulation of the cervical spine has been shown to alter visual function. Sacroiliac joint manipulation has been shown to alter the excitability of the H-reflex pathway. Although studies have examined the effects of spinal manipulation on neurological function, few have assessed the effects of spinal motion segment dysfunction on neurological function, independent of assessing the effects of manipulation. Rather than attempt to add to the growing body of literature showing the effects of spinal manipulation, we explore the effects of spinal motion segment dysfunction. The objective of this study was to determine whether the degree of spinal motion segment dysfunction has any relationship with the performance of a range of reaction time (RT) tasks. We predicted that more sites of spinal dysfunction may be related to slower and/or less accurate performance. If present, this relationship may only be detectable with more sophisticated tasks that require cognitive processing for accurate completion. For example, Kelly et al showed a significantly greater improvement in the performance of a mental rotation task in subjects who received an upper cervical toggle recoil adjustment as compared with those who also had indications of upper cervical joint dysfunction but did not receive any treatment. We chose the mental rotation task because it requires more cortical processing than does a simple RT task.

Although studies have examined the effects of spinal manipulation on neurological function, few have assessed the effects of spinal motion segment dysfunction on neurological function, independent of assessing the effects of manipulation. Rather than attempt to add to the growing body of literature showing the effects of spinal manipulation, we explore the effects of spinal motion segment dysfunction. The objective of this study was to determine whether the degree of spinal motion segment dysfunction has any relationship with the performance of a range of reaction time (RT) tasks. We predicted that more sites of spinal dysfunction may be related to slower and/or less accurate performance. If present, this relationship may only be detectable with more sophisticated tasks that require cognitive processing for accurate completion. For example, Kelly et al showed a significantly greater improvement in the performance of a mental rotation task in subjects who received an upper cervical toggle recoil adjustment as compared with those who also had indications of upper cervical joint dysfunction but did not receive any treatment. We chose the mental rotation task because it requires more cortical processing than does a simple RT task.

Reaction time is the period between the presentation of an imperative stimulus and the completion of the appropriate motor response. Reaction time testing is typically
used to determine the time a person takes to process information to produce a required response. The present study used a simple RT task, a probe RT task, a choice RT task, and a simple predictive motor task. The present study was double blinded, with one investigator responsible for administering the RT tests and a chiropractic student in the final year of training responsible for the assessment of spinal function. These two investigators did not communicate their findings to one another. The data they collected were given to a third investigator for collation.

**METHODS**

**Selection Criteria**

Thirty subjects volunteered for this study (12 female subjects and 18 male subjects; mean age, 26 years; range, 21-33 years). The subjects were verbally recruited from the student body and were all undergoing regular chiropractic care. Volunteers were included if they were between the ages of 20 and 35 years to avoid the confounding effects of age. Exclusion criteria for the subjects also included a history of neurological disease (eg, stroke or multiple sclerosis), any abnormal brain function (eg, epilepsy), and a history of head injury. Each subject read an information sheet and gave written informed consent before participating in the study. The New Zealand Chiropractic College Ethics Committee approved the procedures for this experiment.

**Assessment of Spinal Function**

One examiner assessed the cervical spine function of all subjects. This eliminated the possible confounding effects of multiple examiners having poor interexaminer reliability. Each subject was assessed for spinal dysfunction using a standardized procedure, as taught by the New Zealand Chiropractic College. With each subject seated, motion palpation was used to assess the passive range of motion of each cervical motion segment in bilateral lateral flexion, rotation, flexion, and extension. End feel was evaluated in bilateral lateral flexion and rotation. Tissue compliance over the facet joints and the tone of the posterior and lateral cervical spine musculature was also assessed using static palpation. Any indication of pain or tenderness by a subject was noted. Based on this standardized assessment procedure, the examiner then noted which levels of the subject’s cervical spine were dysfunctional. A motion segment was considered dysfunctional if the examiner noted abnormalities in at least 2 of the following: passive range of motion, end feel, and tissue compliance. The subjects then went to a separate room for the assessment of RT performance.

**Assessment of RT Performance**

Subjects were comfortably seated in front of a desk. A customized software on a personal computer (MacIntosh Performa 580; Apple, Cupertino, Calif) was used to assess RT. Three separate tests were administered, and the tasks were verbally explained to each subject by the same examiner. The instructions for these tasks were also outlined on-screen before the commencement of each task. Subjects were told that if they felt fatigued during testing or wanted to stop being tested, then they could do so at any time.

**Test 1: Simple and Probe RTs.** This test is designed to investigate simple RT and probe RT while performing an attention-demanding tracking task. Subjects were asked to rest their left index finger on the “F” key and their right index finger on the “J” key of the computer keyboard. The imperative stimulus was a crosshair presented in the middle of the screen. Subjects responded to this stimulus by pressing the “J” key. For the simple RT trials, subjects were instructed to ignore the vertical line (4 cm in length) moving back and forth across the screen at a velocity of 0.91 cm/s. Twenty-four simple RTs were collected in 2 blocks of 12. The crosshair stimulus (2 × 2 cm) was presented when the vertical line was at 100%, 90%, 70%, 30%, 50%, and 10% of its horizontal travel across the screen. Four presentations of the crosshair stimulus were delivered at each horizontal distance in a randomized order.

For the probe RT trials, subjects were instructed to reverse the direction of the vertical line moving across the screen by pressing the “F” key when the line was within a target area at each lateral edge of the screen. The targets were positioned 9 cm apart. Twenty-four probe RTs were collected with a large target area (1.5 cm) in 2 blocks of 12. The target area width was then reduced to 1 cm, and additional 24 probe RTs were collected in 2 blocks of 12. During the probe RT trials, the crosshair stimulus was presented when the vertical line was at 100%, 90%, 70%, 30%, 50%, and 10% of its horizontal travel between the target areas. Four presentations of the crosshair stimulus were delivered at each horizontal distance in a randomized order.

**Test 2: Choice RT.** This test is designed to investigate the relationship between RT and the number of stimulus-response alternatives. The test was divided into 4 trials, with the first trial having 1 response choice (simple RT), the second trial having 2 response choices, and the third and fourth trials having 4 and 8 response choices. Subjects were asked to place the fingers of their right hand on the “J,” “K,” “L,” and “;” keys and the fingers of their left hand on the “F,” “D,” “S,” and “A” keys. Their thumbs were placed on the space bar as they used them to initiate each of the 4 trials. The response keys were displayed on the screen (1 × 1 cm). For the single-response-choice trial, the “J” key was the response key displayed. For the 2-response-choice trial, the “F” and “J” keys were the response keys displayed. For the 4-response-choice trial, the “D,” “F,” “J,” and “K” keys were the response keys displayed. All 8 response keys were displayed for the 8-response-choice trial.
The outlines of the displayed response keys thickened as a warning signal to each subject that the imperative stimulus was about to be presented. After a variable foreperiod, the image of one of the response keys was inverted (the black letter on a white key became a white letter on a black key). Each subject was instructed to respond to this stimulus as quickly as possible by pressing the appropriate key on the keyboard. The foreperiod ranged from 500 to 2500 milliseconds. The intertrial interval was set to 1000 milliseconds. If subjects responded in shorter than 100 milliseconds or longer than 1000 milliseconds or pressed an incorrect key, the stimulus was re-presented randomly later in the trial. The stimulus for each response alternative was presented 10 times in a randomized order in each trial. The RTs for subjects’ responses to the “J” key were recorded and averaged for each of the 4 trials. The error rates (responses that were too fast, too slow, or on an incorrect key) were also recorded for each subject for each of the 4 trials.

**Test 3: Simple Predictive Motor Task.** This test measures the accuracy with which subjects can stop a moving target at a designated point and investigates their ability to inhibit a preplanned movement. A clock face (7.5-cm diameter) was displayed on the screen, with 12 digits at the appropriate hour positions and 60-minute marks around the edge of the clock face. To initiate each trial, each subject pressed the space bar, then a clockwise sweep of the clock face was started. The sweep took 1 second to complete and involved erasing all the minute markings from the clock face in a clockwise direction. The sweep was stopped with the subject clicking the computer mouse button. The subject was instructed to anticipate the time of the sweep to stop it at the 10-o’clock position (see Fig 1).

Each subject was given between 6 and 10 practice trials before the commencement of the test. Subjects were warned that on some trials the sweep would stop automatically, before reaching the 10-o’clock position. When this occurred, the sweep stopped at the 5-, 6-, 7-, 8-, or 9-o’clock positions; the subjects were instructed to inhibit their response on the mouse button. Seventy-five sweeps were completed in 5 blocks of 15 trials, with a short rest between each block. The sweep of the clock face stopped automatically on 25 trials. The actual time at which the subjects stopped the clock face sweep was recorded in milliseconds. For trials where the sweep stopped automatically, before the 10-o’clock position, the probability of the subjects inhibiting their response was recorded.

**Data Analysis**

Subjects were divided into 2 groups, based on whether they exhibited 1 or 2 sites of cervical spine dysfunction (1CD or 2CD). Simple, probe, and choice RTs and the probability of inhibiting a preplanned response were analyzed using mixed repeated-measures analyses of variance (ANOVAs). The absolute and variable errors in the performance of the sweep hand task were analyzed using 2-sample t tests. The a priori prediction that probe RT would be longer when the moving cursor approached the target (90% of its travel) was tested using paired t tests, with a
Bonferroni correction for multiple t tests (α = .01). For all other analyses, significance was set at α = .05.

RESULTS

Spinal Function

The incidence of dysfunction at each spinal level is shown in Fig 2. The 1CD group comprised 12 people (5 female subjects and 7 male subjects; mean age, 27 years; range, 22-33 years). The 2CD group comprised 18 people (7 female subjects and 11 male subjects; mean age, 26 years; range, 21-33 years). The 2CD group comprised 17 subjects with 2 levels of cervical spine dysfunction and 1 subject with 3 levels of cervical spine dysfunction.

Test 1: Simple and Probe RTs. The mixed repeated-measures ANOVA used to test the effects of group (1CD, 2CD) and task (simple RT, large target probe RT, small target probe RT) revealed a significant effect of task (F2,29 = 160.3; P < .001). The effect of task arose owing to the mean simple RT being significantly shorter than the mean probe RTs, whereas the mean probe RTs were not significantly different from each other (simple RT = 289.9 ± 5.7 milliseconds; large target probe RT = 421.4 ± 11.5 milliseconds; small target probe RT = 431.4 ± 14.4 milliseconds).

Based on this result, the probe RTs recorded under the large and small target conditions were pooled for each subject and a mixed repeated-measures ANOVA was used to test for the effects of group (1CD, 2CD) and task (simple RT, probe RT). As before, there were significant effects of task (F1,29 = 253.3; P < .001). There was also a significant interaction between task and group (F1,29 = 4.5; P < .05). The significant interaction between task and group arose because the mean probe RT was significantly longer for the 2CD group than for the 1CD group (1CD = 404.0 ± 19.4 milliseconds; 2CD = 448.8 ± 15.8 milliseconds; P < .05). There was no between-group difference in simple RT (1CD = 286.1 ± 8.7 milliseconds; 2CD = 294.7 ± 7.1 milliseconds; P = .75; Fig 3).

The effect of the position of the moving cursor on probe RT was tested using a mixed repeated-measures ANOVA, with group (1CD, 2CD), task (large target probe RT, small target probe RT), and position of the moving cursor (100%, 90%, 70%, 30%, 50%, and 10% of its travel). There was a significant effect of position (F5,29 = 3.7; P < .01) but none of task (F1,29 = 2.1; P = .16) or group (F1,29 = 3.2; P = .085). The effect of position arose because the mean probe RT was significantly longer for the 2CD group than for the 1CD group (1CD = 404.0 ± 19.4 milliseconds; 2CD = 448.8 ± 15.8 milliseconds; P < .05). There was no between-group difference in simple RT (1CD = 286.1 ± 8.7 milliseconds; 2CD = 294.7 ± 7.1 milliseconds; P = .75; Fig 3).

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Test 2: Choice RT. The mixed repeated-measures ANOVA of RT revealed a significant effect of the number of response
choices (F_{3,29} = 181.0; P < .001) but none of group (F_{1,29} = 1.35; P = .255). The interaction between the number of response choices and group was also not significant (F_{3,29} = 0.1; P = .91). For the complete group, each mean RT calculated under each response choice condition was significantly different from that calculated for the other 3 response choice conditions (Fig 5).

The error rates recorded for the 2 groups of subjects under each response choice condition were not normally distributed or homoscedastic. Therefore, a one-tailed Wilcoxon rank sum test was used to test for differences between the groups’ error rates under each task condition. No difference in error rate was found between the groups under the 1-response-choice and 2-response-choice conditions. However, the error rates for the 2CD group were significantly higher than those for the 1CD group under the 4-choice and 8-choice RT conditions. In the third task, the performance of the 2CD group in stopping the clock sweep was more variable than the 1CD group, although this did not reach the adopted level of statistical significance (P = .068).

Target size had no effect for the probe RT task. This was unexpected as it was thought that reversing the direction of the moving cursor with the smaller targets would be more difficult and would therefore require more attention than that with the larger targets. However, this was not the case.

One of the limitations of this testing procedure is that no data regarding the accuracy with which subjects reversed the cursor’s direction in the smaller targets were collected. We speculate that subjects may have reversed the cursor’s direction in the smaller targets with less accuracy and that this allowed them to perform the probe RT task with the same average speed as when the large targets were presented. We are unable to confirm this with the present data. As expected, probe RT was highest when the moving cursor had completed 90% of its travel toward the target. This is probably because as the moving cursor approached the target, subjects were required to shift more of their attention to the cursor to effect a timely reversal of its direction.

Table 2. Errors (mean ± SD) for stopping the sweep hand on the “10”

<table>
<thead>
<tr>
<th></th>
<th>1CD</th>
<th>2CD</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant error (ms)</td>
<td>20.6 ± 7.1</td>
<td>22.0 ± 3.8</td>
<td>.412</td>
</tr>
<tr>
<td>Absolute error (ms)</td>
<td>38.4 ± 4.0</td>
<td>39.6 ± 3.4</td>
<td>.413</td>
</tr>
<tr>
<td>Variable error (ms)</td>
<td>42.7 ± 3.8</td>
<td>51.4 ± 3.8</td>
<td>.068</td>
</tr>
</tbody>
</table>

(\text{F}_{1,29} = 0.012; P = .915), and the interaction between group and time was also not significant (\text{F}_{4,29} = 0.12; P = .975; Fig 6). The accuracy of subjects’ task performance is summarized in Table 2. There was no significant difference between the error rates of the 2 groups.

**DISCUSSION**

The results from this study support our prediction that more sites of spinal motion segment dysfunction may be related to slower and/or less accurate performance on a range of RT tasks. In the first task, the group with 2 or more sites of cervical spine dysfunction (2CD) had significantly longer probe RTs than the group with 1 site of cervical spine dysfunction (1CD). In the second task, the 2CD group had a significantly higher error rate than the 1CD group under the 4-choice and 8-choice RT conditions. In the third task, the performance of the 2CD group in stopping the clock sweep was more variable than the 1CD group, although this did not reach the adopted level of statistical significance (P = .068).

Target size had no effect for the probe RT task. This was unexpected as it was thought that reversing the direction of the moving cursor with the smaller targets would be more difficult and would therefore require more attention than that with the larger targets. However, this was not the case.

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Probe RT was significantly longer in the 2CD group. Because probe RT is a measure of the demands on central capacity, we suggest that multiple sites of cervical spine dysfunction may place an additional demand on central capacity. The cognitive processing involved in responding to the probe may therefore require more time.

The results of the choice RT task clearly show an increase in RT with an increasing number of response
choices, as expected. However, there was no difference in RT between the 2 groups. This finding initially seems at odds with that from the probe RT test. However, the fundamental difference between these 2 paradigms is that the choice RT test was a single-task paradigm whereas the probe RT test was a dual-task one. The RTs recorded during the probe RT test reflect the increased attentional demands of performing 2 tasks simultaneously, and this was increased with multiple sites of cervical spine dysfunction. The RTs recorded during the choice RT test reflect the speed of response selection, and this does not appear to be affected by the degree of cervical spine dysfunction. However, the accuracy of response selection was significantly impaired in the 2CD group when the number of response choices was higher, as compared with the 1CD group (Table 1). This suggests that in a choice RT task, the degree of cervical spine dysfunction alters the accuracy, but not the speed, of response selection.

The third task tested subjects’ accuracy in performing a simple anticipated response and ability to inhibit this response. As expected, there was a decrease in the probability of inhibiting the response at later sweep hand stop times. However, group had no effect, indicating that the ability to inhibit this unplanned response was not affected by the number of sites of cervical spine dysfunction. There was a trend toward a greater variable error in stopping the clock sweep at the 10-o’clock position for the 2CD group. This was despite the constant and absolute errors being equivalent. The constant error indicates the subjects’ bias toward stopping the clock sweep early or late. The positive values for mean error for both groups indicate that both groups were biased toward stopping the clock sweep slightly early. The absolute error indicates the absolute magnitude of the subjects’ average error, which was equivalent for the 2 groups. The variable error indicates the variability of the subjects’ performance, and this tended to be higher for the 2CD group but failed to reach the adopted level of statistical significance (P = .068).

Together, these results suggest that multiple sites of cervical spine dysfunction are related to impaired cortical processing, as revealed by significantly higher loads on central capacity, significantly less accurate response selection, and a trend toward more variable performance of an anticipated response. Multiple sites of cervical spine dysfunction do not appear to be related to the speed of response selection or the ability to inhibit a unplanned response.

These findings complement those of Kelly et al, who measured RT on a mental rotation task in subjects with evidence of upper cervical joint dysfunction. Subjects were randomly allocated to an experimental group and received an upper cervical toggle adjustment or to a control group and simply lay on the toggle adjustment table for 2 minutes. Mental rotation RT was then measured again in each subject. The authors found that RT decreased in both groups and that this decrease was significantly greater in the experimental group. One of the limitations of this study is that a third group comprised of subjects with no evidence of upper cervical spine joint dysfunction was not included. This meant that Kelly et al. were unable to determine whether mental rotation RT was normalized after cervical spine adjustment.

The present study is also limited by not having a control group of subjects with no cervical spine joint dysfunction. However, by showing that more sites of cervical spine dysfunction are associated with greater impairment of some aspects of cortical processing, this study provides a context for the improvements in cortical processing observed after upper cervical spine adjustment as shown by Kelly et al. The present study has also shown that probe RT may be a useful tool in further studies examining the effects of cervical spine manipulation on cognitive function. Further work is required to determine the mechanisms by which cervical spine joint dysfunction may impair aspects of cortical processing and the mechanisms by which cervical spine manipulation may improve aspects of cortical processing.

CONCLUSIONS

This pilot study provides a context for the improvements in cortical processing observed after cervical spine adjustment as shown by other authors. It has also shown that probe RT may be a useful tool in further studies examining the effects of cervical spine manipulation on cognitive function. Further work is required to determine the mechanisms by which cervical spine manipulation of joint dysfunction and the associated effect on cognitive function.

ACKNOWLEDGMENTS

We thank the Department of Sport & Exercise Science, University of Auckland, for the provision of the customized software used to test RT performance.

REFERENCES

BONE SETTING FOR PROLONGED NECK PAIN: A RANDOMIZED CLINICAL TRIAL

Heikki M. Hemmilä, MD

ABSTRACT

Objectives: To study the natural history of prolonged neck pain and the effectiveness of bone setting as its treatment.

Methods: A randomized clinical trial with blinded outcome assessment and 1-year follow-up was completed. Forty-two working-aged patients with nonspecific neck pain for at least 1 month and no contraindications to manipulative therapies were recruited. They were randomly allocated into 5 weekly sessions of bone setting provided by 2 experienced folk healers (22 patients) or follow-up without therapy (20 patients). The primary outcomes were neck mobility after the 5-week therapy period and the Million scales modified for neck pain at 5 weeks, and 3, 6, and 12 months after baseline. Secondary outcomes included self-rated improvement and pain drawing at 5 weeks, and 3, 6, and 12 months after baseline, Beck depression scales at 5 weeks and 12 months after baseline, and sick leaves, additional therapies, and pain medication during 1 year after baseline.

Results: At baseline, neck pain was reported constant or increasing by 51% and episodic by 49% of the patients with mean duration of symptoms of 4.3 years for the bone setting and 8.4 years for the control group. Seventy-eight percent of the patients participated in the clinical measurements at 5 weeks, and 90% returned the questionnaires after 1 year. The cervical mobility of the bone setting patients increased 29% in the frontal, 23% in the sagittal, and 16% in the horizontal plane, whereas the figures for the control group were -1.4%, 1.0%, and 3.0%, respectively. The mean Million index of the bone setting group (50.6 mm at baseline) was 18.5 mm at 5 weeks, 21.2 mm at 3 months, 22.9 mm at 6 months, and 14.2 mm at 1 year. The figures for the control group were 53.2 mm at baseline, and 4.0, 6.2, 5.4, and 5.5 mm at the corresponding follow-up points. After 1 year, improvement was reported by 80% of the bone setting and 28% of the control patients.

Conclusion: In this study, manual therapy had a measurable effect on the mobility of cervical spine at 5 weeks and an effect on pain that lasted for at least half a year. (J Manipulative Physiol Ther 2005;28:508–515)

Key Indexing Terms: Manipulation; Spinal; Randomized Controlled Trials; Complementary Therapies; Neck Pain

Chronic nonspecific neck pain is an increasingly common problem in industrialized countries.\(^1\)\(^2\) According to a study on the Finnish workforce, pain in the neck and shoulder region was reported by 33% of women and 20% of men in 1977 and by 43% and 29%, respectively, in 1997.\(^1\) Neck pain causes great costs to society in the form of consultations and work loss, which accounts for up to 1% of the total health care expenditure.\(^3\) The origin of chronic neck pain is mostly obscure.\(^4\)\(^5\) Radiography is necessary to assess trauma and radicular/myelopathic symptoms or suspected osteolytic conditions, but it usually adds little to the clinical examination.\(^4\) For practical reasons, a division into local pain, radiating pain, whiplash syndrome, myelopathy, and other specific painful neck conditions, including inflammatory and malignant diseases, has been suggested.\(^6\) For the most common syndrome, the nonspecific local neck pain, the diagnosis of “tension neck” has been widely used in Finland since the concept was introduced in the late 1960s.\(^6\) Regardless of the origin of the condition, it is thought to persist as a vicious circle, including pain, reflex muscle spasm with consequent ischemia that further increases pain, and concomitant muscular guarding.\(^7\) The prognosis of neck pain seems poor according to the few published studies. Borghouts et al\(^8\) reviewed 6 observational studies and 17 randomized controlled trials, and stated that after 1 year of follow-up, 46% of patients with chronic neck pain have less pain with a median of 47% general improvement. A higher severity of pain and a history of previous attacks at baseline were associated with a worse prognosis. After 10 years, 43% of patients were free of pain in a study by Gore et al.\(^9\)

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Sources of support: This study was financially supported by Finnish Cultural Foundation.

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0161-4754/$30.00

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There is a reasonable consensus on the effectiveness of multimodal treatments, including manipulation/mobilization plus exercise\textsuperscript{1,4,10} and proprioceptive or dynamic resistive exercise therapy, on chronic neck pain.\textsuperscript{11} There is insufficient evidence of the effectiveness of cervical manipulation or mobilization alone on either acute or chronic neck pain.\textsuperscript{4,10,12} Massage and manual therapy by folk healers are popular remedies in Finland\textsuperscript{13}: many patients visit a masseur once or twice every month in spite of the poor proof of the effectiveness of massage.\textsuperscript{14,15}

Traditional bone setting, regarded as the basis of academic manipulative therapies, such as chiropractic,\textsuperscript{16} has survived especially in the Ostrobothnian region of Finland\textsuperscript{13}. Many patients visit a bone setting once or twice every month in spite of the poor proof of the effectiveness of bone setting.\textsuperscript{17}

This study assessed the effectiveness of this lay manual therapy on prolonged neck pain in comparison with a nontreated group.

**METHODS**

The flow chart of the patients is shown in Fig 1. The patients were invited to participate by means of a newspaper article and an advertisement. The inclusion criteria were a diagnosis of tension neck syndrome with nonspecific pain between the shoulders and the occiput for at least 1 month and age between 18 and 64 years. The exclusion criteria were any therapy during the preceding month, any contraindication to manual therapy,\textsuperscript{18} and neck pain on a visual analog scale less than 25/100 mm.

The main outcome measures were neck mobility and the Million scales (scale 0-100 mm) adapted for neck pain.\textsuperscript{19} Additional outcome measures were self-rated improvement of neck pain, pain drawings,\textsuperscript{20} and the Beck Depression Inventory (BDI, scale 0-63).\textsuperscript{21} The use of all therapies, including alternative and complementary therapies, medications, visits to health care personnel, and sick leaves for neck pain were recorded.

Neck mobility was measured in 3 planes with a commercial instrument (CROM instrument; Performance Attainment Associates, St Paul, Minn) by a trained assistant blind to the therapy allotment. In addition to mean changes in the Million scales, the number of patients with a clinically significant improvement was calculated. The level of clinical significance was settled, in lack of published data, to 50%. The self-rated improvement was assessed on a 5-point scale from distinctly worse to distinctly better than at baseline. Numbers needed to treat were calculated on both 50% decrease of the Million index and the self-rated improvement of at least a slight degree. The pain drawings were colored red in the areas of pain and blue in the areas of
numbness. For analysis, the figures were divided into 31 appropriate anatomical areas and the numbers of colored areas served as numerical variables (scale 0-31) (Fig 2).

The study patients visited the Folk Medicine Centre, Kaustinen, Finland, 2 weeks before the baseline, during the baseline, and 5 weeks after the baseline. Additional follow-ups were carried out by mail 3, 6, and 12 months after the baseline.

During the first visit, the patients signed a written consent and completed the Million scales, the pain drawings, the BDI, and the questionnaires on sociodemographic variables and neck pain history. A clinical examination including diagnostic tests to find inflammatory, radicular, and neurologic diseases was completed by a general practitioner. After the clinical examination and final decision of inclusion, an independent person randomized the patients by drawing sealed lots. The result of randomization was immediately informed. The first therapy session was booked after a 2-week interval for the patients allocated to bone setting.

Two weeks later, the patients’ cervical range of motion (CROM) was measured, and the Million scales and the pain drawings were represented. These measurements served as the baseline. The 2-week interval with the patients knowing whether they will receive the study therapy or not was assumed to reveal if there is an effect of expectation, a part of the so-called placebo effect.

Five weeks after the baseline and the therapies, the CROM, the Million scales, the pain drawings, and the BDI measurements were repeated, and the self-rated improvement of neck pain was determined. The postal questionnaires at 3, 6, and 12 months after baseline included the Million scales, the pain drawings, the self-rated improvement, and the use of health care and sick leaves. The BDI was monitored at 12 months.

The study intervention was provided by 2 experienced folk healers. The treatment consisted of five 30-minute sessions of bone setting during a 5-week treatment period. Most patients were treated by a specific method where the healer, sitting behind the patient, first palpated the spinous processes of misaligned vertebra, and then adjusted it by asking the patient to bend the neck forward and backward while the bone setter pressed his thumbs on both sides of the next distal vertebra. Another method was to make careful rotating and bending movements of the patient’s head with one hand while the patient’s neck was stabilized by the other hand. Soft tissue massage was also applied, but no chiropractic-like adjustments were used. The therapy patients were charged a total sum of €22 (US$24.2) for the 5 therapy sessions.

The control patients served the second purpose of the experiment, to study the natural course of neck pain. They were urged to attend the clinical measurements and to return the postal questionnaires, but they were neither offered nor denied any therapy by the study protocol. The Ethics

Table 1. Baseline characteristics of study subjects

<table>
<thead>
<tr>
<th></th>
<th>Bone setting</th>
<th>Control</th>
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</thead>
<tbody>
<tr>
<td>n (males)</td>
<td>22 (9)</td>
<td>20 (4)</td>
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<tr>
<td>Age, y (SD)</td>
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<td>44.9 (9.7)</td>
</tr>
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<td>Education (%)</td>
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<tr>
<td>Trade (%)</td>
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<tr>
<td>Agriculture</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Service</td>
<td>65</td>
<td>74</td>
</tr>
<tr>
<td>Industry</td>
<td>30</td>
<td>21</td>
</tr>
<tr>
<td>Ever used folk medicine (%)</td>
<td>68</td>
<td>65</td>
</tr>
<tr>
<td>Neck pain history (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-3 mo</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>3-12 mo</td>
<td>30</td>
<td>22</td>
</tr>
<tr>
<td>&gt;12 mo</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>Mean years (SD)</td>
<td>4.3 (4.7)</td>
<td>8.4 (6.8)</td>
</tr>
<tr>
<td>Sick listed last year (%)</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>Treated last year by (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physician</td>
<td>68</td>
<td>75</td>
</tr>
<tr>
<td>NSAIDs</td>
<td>68</td>
<td>75</td>
</tr>
<tr>
<td>Physiotherapy</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>Naprapathy</td>
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<td>40</td>
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<tr>
<td>Chiropractic</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Bone setting</td>
<td>27</td>
<td>45</td>
</tr>
<tr>
<td>Massage</td>
<td>73</td>
<td>90</td>
</tr>
<tr>
<td>Other complementary</td>
<td>41</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NSAID, Nonsteroidal anti-inflammatory drug.

Statistically significant difference, \( P = .04 \), Mann-Whitney U test.

Table 2. Cervical range of movement measurements; sum of symmetric measures

<table>
<thead>
<tr>
<th></th>
<th>Baseline mean degrees (SD)</th>
<th>5 weeks mean change (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Frontal plane</td>
<td>Bone setting 21 66.4 (19.0)</td>
<td>20 18.9 (11.7-26.0)</td>
</tr>
<tr>
<td></td>
<td>Control 14 71.4 (17.2)</td>
<td>13 −1.0 (−10.4 to 8.4)</td>
</tr>
<tr>
<td>P</td>
<td>.4</td>
<td>.001</td>
</tr>
<tr>
<td>Sagittal plane</td>
<td>Bone setting 21 100.6 (25.9)</td>
<td>20 23.2 (15.4-31.0)</td>
</tr>
<tr>
<td></td>
<td>Control 14 99.6 (21.3)</td>
<td>13 1.0 (−5.8 to 7.8)</td>
</tr>
<tr>
<td>P</td>
<td>.9</td>
<td>.000</td>
</tr>
<tr>
<td>Horizontal plane</td>
<td>Bone setting 21 116.7 (18.1)</td>
<td>20 18.1 (10.2-26.0)</td>
</tr>
<tr>
<td></td>
<td>Control 14 112.5 (23.3)</td>
<td>13 3.4 (−5.8 to 12.5)</td>
</tr>
<tr>
<td>P(a)</td>
<td>.6</td>
<td>.02</td>
</tr>
</tbody>
</table>

CI, Confidence interval.

\( a\) Mann-Whitney U test.
Committee of the Central Ostrobothnia Central Hospital, Kokkola, approved this study.

The results were analyzed as intention to treat. The statistical analyses were performed with an SPSS for Windows 10.0 software package (SPSS, Inc, Chicago, Ill). The $\chi^2$ test was applied to the categorical variables in the between-group comparisons, whereas the continuous variables were analyzed with the nonparametric Mann-Whitney U test. The within-group comparisons were made with the Wilcoxon signed/rank sum test.

**RESULTS**

Fifty-nine patients contacted the Folk Medicine Centre in September 2002. Fifteen were excluded for having specific diagnoses other than tension neck or for contraindications. Two were excluded because of low pain ratings, leaving 42 patients in the study (Fig 1).

Thirty-three patients took part in both CROM measurements (20 bone setting patients, 13 control patients). Five of the 7 patients absent from the baseline measurements, however, returned the follow-up questionnaires by mail. After 1 year, the questionnaires were returned by 38 patients (20 treatment group patients, 18 controls). One patient in the treatment group moved to an unknown address after 5 weeks, and 1 died in a traffic accident after 3 months. Two control patients failed to return the forms after baseline in spite of repeated requests. The bone setting therapies were completed as planned except for the 2 dropout patients.

The 7 dropouts from the first CROM measurements (1 from the treatment group, 6 controls) had significantly higher pain scores on the Million scales (67.9, SD = 11 vs 51.0, SD = 13, $P = .002$ Mann-Whitney test) and distress scores on the BDI (15.1, SD = 8 vs 8.1, SD = 6, $P = .02$) than the other patients. The changes of their Million scores ($/C0$6.0, SD = 20.6) were comparable to those of the other control patients.

As shown in Table 1, the baseline variables of the randomized groups were similar, except for a longer history of neck pain in the control group ($P = .04$, Mann-Whitney U test). Of all patients, 41% described their neck pain as constant, whereas 49% had episodic pain and 10% experienced steadily increasing pain. A sudden onset was described by one patient (control), onset within days by 12%, and gradual onset by 86%. One patient (control) reported a traumatic onset of pain, 24% associated their neck pain with physical stress, 20% with mental stress, and the rest offered no explanation. The pain was most commonly depicted on the occiput, around the neck, and

<table>
<thead>
<tr>
<th>Table 3. Pain and distress measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean (SD)</strong></td>
</tr>
<tr>
<td>n</td>
</tr>
<tr>
<td>Million index</td>
</tr>
<tr>
<td>Bone setting</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>$P$</td>
</tr>
<tr>
<td>Pain drawing pain area</td>
</tr>
<tr>
<td>Bone setting</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>$P$</td>
</tr>
<tr>
<td>Pain drawing numbness area</td>
</tr>
<tr>
<td>Bone setting</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>$P$</td>
</tr>
<tr>
<td>BDI</td>
</tr>
<tr>
<td>Bone setting</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>$P^*$</td>
</tr>
</tbody>
</table>

Pain drawing areas indicate number of areas colored (0-31).

$^*$ Mann-Whitney U test.
on the thoracic spine. The shoulder areas were affected in half of the patients. Half of the patients had numbness of their hands or fingers (Fig 2).

After bone setting therapy, the CROM scores increased remarkably in all directions (side bending 29% forward bending 23%, and rotation 16%), whereas the control group remained unchanged (1.4%, 1.0%, and 3.0%, respectively) (Table 2).

The Million scores of the bone setting group improved markedly, whereas those of the control patients remained almost unchanged (Table 3). The clinically significant change (≥50% improvement) was experienced by more bone setting than control patients after 5 weeks (P = .04, χ² test) and 6 months (P = .002), but after 1 year, the difference was not significant (P = .2) (Table 4). One third of the bone setting patients seemed to be nonresponders, and half of the responders lost the benefit of therapy after 6 months. One-third seemed to gain relief of neck pain for more than 1 year (Fig 3).

Either distinct or slight self-rated improvement was reported after 5 weeks by 20 of the 21 bone setting patients, whereas 3 of the 17 control patients felt improved (P < .001, χ² test). After 6 months, 15 of 20 and 6 of 18 (P = .01), and after 1 year, 16 of 20 and 5 of 18 (P = .002), respectively, reported their neck pain to be better than at baseline. Three bone setting and 4 control patients reported deterioration at 1 year (Table 4). The pain area in the pain drawings had diminished more in the bone setting group during 1 year, whereas the numbness area had significantly diminished in the control group (Table 3).

The mean distress scores (BDI) of both groups experienced a statistically significant decrease by 5 weeks, but after 1 year, the BDI scores of the control patients returned to baseline (Table 3).

Voluntary therapies for neck pain after the 5-week study period had been taken by 14 bone setting patients and all control patients. Bone setting was obtained by 5 bone setting patients and 2 control patients, massage by 9 and 13, physiotherapy by 5 and 10, and other therapies by 5 and 3 patients, respectively. A doctor was seen by 4 bone setting patients and 10 control patients and a nurse by 2 and 4 patients, respectively. The average number of therapies was 7.4 (SD = 10) for the bone setting and 16.3 (SD = 15) for the control group (P = .03, Mann-Whitney test). The therapies were rather evenly taken throughout the year, roughly once a month.

Pain medication was reported after the baseline by 14 bone setting patients and by all of the control patients. The mean annual number of doses was 63 (SD = 146) for the bone setting and 188 (SD = 332) for the control patients (P = .1, Mann-Whitney test). Sick leaves for neck pain were prescribed for 3 bone setting patients and 5 control patients for 4.5 (SD = 20) and 16.9 (SD = 53) days on the average, respectively.

### Table 4. Numbers of improved

<table>
<thead>
<tr>
<th></th>
<th>5 wk</th>
<th>3 mo</th>
<th>6 mo</th>
<th>12 mo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bone setting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-rated improvement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distinctly better</td>
<td>11</td>
<td>11</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Slightly better</td>
<td>9</td>
<td>5</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Unchanged</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Slightly worse</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Distinctly worse</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Million index,</td>
<td>8</td>
<td>9</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>50% improved</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-rated improvement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distinctly better</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Slightly better</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Unchanged</td>
<td>10</td>
<td>11</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Slightly worse</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Distinctly worse</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Million index,</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>50% improved</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NNT**, Number needed to treat (to make one patient at least slightly better or 50% better).

![Fig 3](https://example.com/fig3.png)  
*Results of the Million scores. VAS, Visual analog scale.*
During the 2 week waiting period after randomization, the Million indexes did not improve markedly (3.2, SD = 11.9 for treatment group; 0.9, SD = 9.3 for controls, \( P = .5 \), Mann-Whitney test), nor were there differences between the groups. However, the pain drawings showed different trends for the patients randomized to bone setting and control. The pain area of the control patients slightly increased (0.9, SD = 4.8 for treatment group; –2.4, SD = 6.3 for controls, \( P = .07 \)), making a statistically significant difference between the groups (\( P = .05 \), Mann-Whitney test) (Table 3).

**DISCUSSION**

According to this study, neck pain seemed to remain stable without therapy for up to 1 year of follow-up. Traditional bone setting had a statistically significant effect on cervical mobility and perceived pain and disability, even as late as 1 year after therapy. The expectation of therapy by a bone setter did not seem to affect the reports of neck pain or disability.

The baseline characteristics were similar for the 2 groups except longer duration of pain in the control group. Controlling for this difference did not change the observed changes or their statistical significance, however. The patients in this study were a convenience sample recruited by a newspaper advertisement. This method of recruitment may invite patients specifically interested in the therapy under study, decreasing the credibility of the results. The patients’ neck pain history and the distribution of their pain mostly on the neck-shoulder angle and in the occipital region resembled those of the original tension neck patients of Valtonen6 and the large population sample of neck shoulder pain patients of Toomingas.22 Reported numbness of the upper extremities was common, although no patients with radicular findings in the clinical examination were recruited. Concomitant headache was equally common as in the musculoskeletal pain patients in a Norwegian study of Hagen et al.21 With only 5 (28%) of 18 of the untreated patients reporting improvement after 1 year and a mean improvement of Million index by 10%, they appeared to have worse than average prognosis compared to the patients reviewed by Borghouts et al.8

The number of patients who had consulted a folk healer before the study was high, but probably typical in the area, because earlier surveys have revealed figures of the same order: 55% of all adults in the area24 and 75% of a back pain patient population15 had consulted a folk healer, most often a bone setter, during their lifetime. The dropout rate in the cervical range of movement measurements was high and biased. The subjects’ distressed state may have augmented their disappointment at not receiving therapy, resulting in refusal of active participation, which required travel to the center. Their pain relief, however, was comparable to that of the other control patients, which means that they hardly distorted the results.

The effect of bone setting on pain and disability was slightly smaller than that observed in earlier studies of manual25-27 or high-tech exercise therapy.28 The improvement of the control group was smaller, too, rendering the differences in many measures between the groups statistically significant. The control group subjects were offered neither reference therapy nor placebo, and the controls thus served the second purpose of this project to assess the natural course of neck pain. All the control patients reported having had some form of therapy during the follow-up year, roughly twice as often as the bone setting patients did, and even more than the bone setting patients had obtained together with the study therapies. The confounding therapies should have decreased the observed differences between the groups. In this case, it seemed that more therapy actually resulted in less effect.

There may be a threshold of the number of therapy sessions until a permanent change takes place. Occasional therapies may lose their benefit during the intervals. The confounding therapies may also represent a continuum that has kept the study patients in their baseline condition; practically, all patients had therapies for their neck pain during the previous year. Any extra therapy, intensive enough, might have had the same effect as bone setting did in this study. One explanation may be the added placebo effect of the therapy under study in comparison with the voluntary therapies. Alternatively, there is a possibility that our bone setters’ therapy was more effective than the average of the different alternatives.

It was a conscious decision not to compare bone setting with placebo or any reference therapy. A credible placebo for a manual therapy is hard to find, and the “golden standard therapy” of nonspecific neck pain has not yet been introduced. The gross effect, the combined specific, and the nonspecific effects of bone setting was measured instead of comparing it with an artificial placebo or another therapy, with inevitably a different placebo. Finally, this study was the first of its kind, with limited resources available. More solid conclusions could have been drawn from a study with 2 equally attractive therapies in comparison with no therapy, such as what Jull et al did.25

Some aspects of the placebo effect were, however, observed. Olesen and Barfod,29 in their discussion on placebo effect, divided the course of disease and its treatment into 4 components: spontaneous remission, initial therapeutic effect, specific therapy, and additional therapeutic effect. We informed the patients whether they would receive bone setting or not 2 weeks before the beginning of the therapy. The measurements of pain were repeated after the 2-week waiting period. There was a slight decrease in the Million indexes, not different between the groups, suggesting that the “spontaneous remission” was similar in both groups, and that the “initial therapeutic effect” did not start by the promise of being treated. The observed increase of the pain area in the pain drawings of the
control group may represent a “nocebo” effect, probably caused by the patients’ disappointment on not receiving the study therapy. The “additional therapeutic effect” of bone setting remained unmeasured.

The charisma of an original folk healer may be stronger than that of a busy municipal physician or a private physiotherapist. Dixon30 found statistically significant effects of “healing” on pain, depression, and anxiety of chronic pain patients. The effects existed at least for 3 months. Lewith et al,31 on the other hand, found that patients’ attitudes toward or beliefs about complementary medicine did not affect the outcomes of homeopathy in the treatment of asthma. It is common knowledge that a third of the effect of pain medication can be brought about by a similar but inactive tablet. There are voices arguing that even as little as 25% of the effect of antidepressant medication is attributable to the active drug.32 More studies are needed to unveil the essence of placebo.

There were, however, distinct differences in the blinded physical measurements and the use of medication and concomitant therapies. If, in addition to lowering measures of pain, saving of health care resources is considered a positive outcome, traditional bone setting has been proved to be of value, regardless of its mechanisms of action.

CONCLUSIONS

This study is the first to show effectiveness of bone setting on chronic neck pain. In spite of its limitations, it indicates that this type of traditional folk medicine provides at least transient relief of nonspecific neck pain, which seems rather stable when left untreated. These results may explain the continued survival of the practice. A larger study with more inventive ways to scrutinize the different components of the therapy is needed.

ACKNOWLEDGMENTS

The Folk Medicine Centre, Kaustinen, Finland, kindly provided the personnel and the facilities for the study. The technical assistance by Henna Känkäkoski and Saija Rihimäki, students of Department of Social and Health Care Education, Central Ostrobothnia Polytechnic, Kokkola, Finland, is warmly appreciated.

REFERENCES


Sagittal Skin Contour of the Cervical Spine: Interexaminer and Intraexaminer Reliability of the Flexicurve Instrument

Deed E. Harrison, DC,a Jason W. Haas, DC,b Donald D. Harrison, PhD, DC,c Burt Holland, PhD,d and Tadeusz Janik, PhD,e

ABSTRACT

Objectives: To evaluate reliability of a simple instrument, the flexicurve, in determining cervical sagittal skin contour.

Methods: This study obtained repeated random measurements involving 3 investigators and 30 subjects once per day over a 2-day trial period. Thirty normal subjects were examined for cervical spine skin contour twice by 3 separate investigators with a 1-day delay. With subjects in a neutral standing position, investigators placed the flexicurve on the posterior portion of the subject’s neck from the external occipital protuberance to the vertebral prominens and traced the flexicurve shape onto paper. The tracings were divided into 6 equal arcs and digitized. Statistical computation was performed on the depth at 5 points, arc angle, and arc radius of curvature. Interexaminer and intraexaminer correlation coefficients (ICCs) were calculated to determine reliability.

Results: All interexaminer correlation coefficients were in the poor range (<0.40). For the arc radius, arc angle, depth at top one third, and depth at bottom two thirds, the intraexaminer correlation coefficients were in the poor range. For the 3 deepest depths, the intraexaminer correlation coefficients were in the fair range (0.4-0.50).

Conclusion: The flexicurve showed marginal reliability with most (12/16) ICCs in the poor range (ICC <0.40) and 4 values in the fair range (0.4 < ICC < 0.5). (J Manipulative Physiol Ther 2005;28:516-519)

Key Indexing Terms: Radiography; Reproducibility of Results; Flexicurve; Surface Contour

Disorders of the cervical spine are becoming more frequent in our society.1-2 It has been suggested that sagittal postural alignment is a desirable clinical outcome,3-5 and normal values for the cervical spine have been reported.6,7 Verification of alignment has traditionally been in the form of the criterion standard, radiography. Clinicians are always looking for conservative noninvasive measuring tools. For sagittal alignment, such tools have been used to measure sagittal skin contour.8,9

The clinical use of such tools has the underlying assumption that these methods are reliable and valid replacements for radiographic measurements. Previous studies comparing surface contour with spinal position have found mixed results concerning reliability and validity of surface assessment compared with radiography.10-16 The flexicurve is a simple, inexpensive, readily available drafting tool that keeps it shaped when deformed. It has been used in a few studies on sagittal skin contour.8,14,17

For the cervical region, only 2 investigations have been performed comparing the surface contour of the skin with radiographs of the cervical spine in the same subjects.12,13 Neither of these studies performed a complete comparison of measurement variables between surface contour and x-ray, and neither used the flexicurve. Because reliability of the flexicurve had not previously been studied in the cervical spine, it was decided to perform a repeatability study with 3 examiners and 30 subjects to obtain intra-examiner and interexaminer reliability data. It was hypothesized that the flexicurve would be a reliable instrument for measuring skin contour.

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0161-4754/$30.00
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METHODS

Thirty volunteers were seen by 3 investigators randomly, once on Saturday and again after a 1-day delay, Sunday. Subjects reviewed the institutional review board–approved study protocol, provided informed consent for their participation, and filled out a numerical rating scale (NRS) of 0 to 10, with 0 being no pain and 10 being the worst pain they had felt. The investigators were not privy to the results of each other’s measurements.

The subjects were told to loosen any bulky clothing from their collars and instructed to stand, nod their head up and down twice with their eyes closed, and then assume what they felt to be neutral head posture. Afterward, they were told that they could then open their eyes but were instructed to not move their heads from this neutral position. The investigators told the subjects that they would feel some pressure on the back of their skull and neck but were not to move their head from neutral. The investigators then placed a flexible ruler, generally used in drafting and engineering, on the volunteers’ posterior neck (Fig 1). The ruler is a flexible metal band coated with plastic, termed flexicurve. This ruler only deforms in one plane and retains the position of deformation.

The flexicurve was placed at 2 distinct landmarks, the external occipital protuberance (EOP) and the vertebral prominens (VP). These landmarks were chosen because these are easily identifiable in most normal subjects, and they make a general demarcation between the cervical and thoracic spine. The flexicurve was placed in direct contact with the skin of the patient to assure accurate conformation to the patient’s neutral cervical posture. The investigators then placed the ruler on a blank sheet of paper and, using a ballpoint pen, traced the ruler from the point correlating to the EOP to the VP. The investigator measured the distance and wrote the measurement on the paper. Each investigator measured each volunteer randomly. On the following day, the same procedure was used for each volunteer by each investigator.

The paper traces of the flexicurve were partitioned into sixths by finding the apex and then splitting the path from the top point to the apex into thirds and the apex to the bottom point into thirds. The tracings of the flexicurve were digitized and analyzed using a system composed of a GP-9 sonic digitizer (Science Accessories Corporation, Shelton, Conn) and a personal computer. The manufacturer’s resolution of the sonic digitizer is 0.125 mm, and the average accuracy of digitized x-ray points is 0.5 mm.18 Height/length ratios, radius of curvature, angle of curvature, and depth of curvature to each of the 5 interior points along the tracing were calculated (Fig 2). The main outcome measures were mean values, SDs, intraclass and interclass correlation coefficients, standard errors of measurements, and mean absolute differences of examiner measurements.
Table 1. Results of reliability analysis for 3 examiners evaluating the skin contour of 30 subjects with a flexicurve, twice, with a 1-day delay for the second evaluation

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
<th>Interexaminer correlation coefficient</th>
<th>95% CI</th>
<th>Intraexaminer correlation coefficient</th>
<th>95% CI</th>
<th>Mean ab diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dep 1/3 top</td>
<td>11.08</td>
<td>3.16</td>
<td>0.27</td>
<td>0.17-0.41</td>
<td>0.39</td>
<td>0.26-0.56</td>
<td>2.3 mm</td>
</tr>
<tr>
<td>Dep 2/3 top</td>
<td>19.88</td>
<td>5.44</td>
<td>0.33</td>
<td>0.23-0.48</td>
<td>0.48</td>
<td>0.33-0.64</td>
<td>3.6 mm</td>
</tr>
<tr>
<td>Dep apex</td>
<td>23.55</td>
<td>5.86</td>
<td>0.35</td>
<td>0.24-0.51</td>
<td>0.50</td>
<td>0.36-0.67</td>
<td>4.1 mm</td>
</tr>
<tr>
<td>Dep 1/3 bot</td>
<td>20.88</td>
<td>4.20</td>
<td>0.32</td>
<td>0.22-0.48</td>
<td>0.47</td>
<td>0.31-0.64</td>
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<tr>
<td>Dep 2/3 bot</td>
<td>12.17</td>
<td>2.46</td>
<td>0.28</td>
<td>0.17-0.44</td>
<td>0.39</td>
<td>0.20-0.59</td>
<td>2.0 mm</td>
</tr>
<tr>
<td>H/L ratio</td>
<td>0.91</td>
<td>0.11</td>
<td>0.36</td>
<td>0.25-0.52</td>
<td>0.46</td>
<td>0.32-0.63</td>
<td>0.02</td>
</tr>
<tr>
<td>Cv radius</td>
<td>83.93</td>
<td>25.35</td>
<td>0.19</td>
<td>0.12-0.31</td>
<td>0.25</td>
<td>0.16-0.40</td>
<td>20.0 mm</td>
</tr>
<tr>
<td>Arc angle</td>
<td>97.22</td>
<td>23.96</td>
<td>0.18</td>
<td>0.11-0.29</td>
<td>0.23</td>
<td>0.14-0.37</td>
<td>26.4°</td>
</tr>
</tbody>
</table>

Correlation coefficients were calculated with a cross-factors method rather than nested. 95% CI, 95% Confidence interval; Mean ab diff, mean absolute differences of examiners’ measurements; Dep 1/3 top, depth at one third from the top of the flexicurve tracing; Dep 2/3 top, depth at two thirds from the top of the flexicurve tracing; Dep apex, depth at the apex of the flexicurve tracing; Dep 1/3 bot, depth at one third from the bottom of the flexicurve tracing; Dep 2/3 bot, depth at two thirds from the bottom of the flexicurve tracing; H/L ratio, height/length ratio as measured on the flexicurve tracing; Cv radius, the radius of the curvature as measured on the flexicurve tracing; Arc angle, the arc angle of curvature as measured on the flexicurve tracing.

All statistical calculations were done using SAS 8.2 (SAS Institute, Inc, Cary, NC).

RESULTS

The volunteers were composed of 7 women and 23 men, with a mean age (±SD) of 30.9 (±9.19) years. Their mean height was 175.4 (±10) cm, and mean weight was 78.1 (±18.3) kg. The mean NRS for pain was 0.5 (±0.78).

All interexaminer correlation coefficients are in the poor range (<0.40) as defined by Shrout and Fleiss. These are all 5 depth measurements from a line connecting the EOP and VP to the flexicurve arc, height/length ratio, arc radius, and arc angle. For interexaminer reliability, the correlation coefficients for arc radius (0.25), arc angle (0.23), depth at top one third (0.39), and depth at bottom two thirds (0.39) are in the poor range. For depths at two thirds from the top of the arc, depth at apex, and depth at one third from apex toward bottom of the arc, the intraexaminer correlation coefficients are in the fair range (0.4-0.50).

The mean absolute differences for examiners’ measurements were 4.1 mm or less for the depth measurements. However, for the arc radius of curvature and the arc angle, these mean examiner differences were high, being 20 mm for the radius of curvature and 26° for the total arc angle. Table 1 provides mean values, SDs, 95% confidence intervals, interexaminer and intraexaminer correlation coefficients (ICCs), and mean absolute differences of examiners’ measurements.

DISCUSSION

For a reliability analysis of the sagittal cervical spine skin contour with a flexicurve, 3 examiners evaluated 30 subjects on each of 2 different occasions. It had been hypothesized that the flexicurve would be a reliable method to evaluate sagittal cervical spine position. However, 12 of 16 ICCs were in the poor range (<0.40) as suggested by Shrout and Fleiss. The remaining 4 intraexaminer correlation coefficients were only in the fair range (0.40 < intraexaminer correlation coefficients < 0.50). Thus, the data indicate that the flexicurve is only marginally reliable for evaluating the sagittal skin contour of the cervical region.

Possible limitations of this study might be that these subjects represent an asymptomatic population with an average NRS of 0.5. Additional limitations may be the inherent flexibility of the flexicurve and the fact that gravity or slight pressure to the metal band contained within may slightly deform the curve before an accurate paper tracing can be made. Poor reliability may also result from transferring the deformed shape to a tabletop to trace the shape onto paper. Furthermore, an intrinsic limitation to this study is the use of palpation in finding the EOP and VP of the individual’s spine. In the past, palpation has been shown to have a very low interrater reliability rating, and this may have had a negative outcome on the investigation.

The flexicurve has been used in the lumbar and thoracic regions. For example, Burton investigated sagittal mobility of the lumbar spine using the flexicurve technique. He found a 3° to 4° difference in repeatability for mobility of upper and lower segments of the lumbar spine, and overall variation may be 6° higher or less than the measurement on the radiographs. Ettlinger et al investigated the surface contour in the thoracic spine of postmenopausal osteoporotic women. They found that the use of the flexicurve had a very poor coefficient for reproducibility (variation, 12.6%). The flexicurve was found to be poor in determining the presence of 1 or more vertebral fractures. In an additional flexicurve study by Lunden et al, it was concluded that the flexicurve may be a reliable tool for measurement of the thoracic kyphosis.
measurements of cervical lordosis is warranted. Comparing the surface measurements to radiographic flexibility, there is no point in measuring their reliability. They reported that the flexicurve may be as reliable as the more expensive DeBrunner’s kyphometer and may be a useful tool in monitoring a patient with increased thoracic kyphosis or the potential to develop complications such as fracture from conditions such as osteoporosis.

In another recent study by Leroux et al., sagittal lumbar skin contour was measured using a computerized device. These investigators found that the correlation coefficients of skin contour and radiographic measurement for the lumbar lordosis were weak. They suggested that, although the method of skin contour analysis is less invasive, the use of radiographs provides much more information than surface contour analysis of the thoracolumbar spine. Thus, it appears that skin contour measurement methods, such as the flexicurve, may have some value in the thoracic region but, in general, have reliability and validity concerns in the lumbar spine.

Our data suggest that the reliability of the flexicurve device has only marginal reliability for assessment of the sagittal cervical skin contour. Proponents of this type of noninvasive assessment of sagittal cervical position may perceive this evidence to be promising, in as much as future studies might be able to improve test methodology and analysis and, therefore, examiner reliability. We believe that this is placing the “cart before the horse” because, as Dreyfuss et al.11 stated, “…if the tests have no external validity, there is no point in measuring their reliability.” Therefore, before additional resources are spent on improving reliability of the flexicurve device, a validity study comparing the surface measurements to radiographic measurements of cervical lordosis is warranted.

CONCLUSION

When 3 examiners measured the skin contour of 30 subjects twice with the flexicurve instrument, all interexaminer and 4 of the intraexaminer correlation coefficients were less than 0.40 and in the poor range. The remaining 4 intraexaminer correlation coefficients (for measurements for 3 depths near the apex of the curvature) were only in the fair range (0.4-0.50). Thus, in the measurement of the surface skin contour of the neck region, the flexicurve instrument is only marginally reliable for clinical research.

REFERENCES

Objective: The aim of this study was to review the chiropractic and medical literature in an effort to determine the extent of current evidence supporting the use of chiropractic manipulation for the treatment of acute neck pain.

Methods: A literature search of the MEDLINE/PubMed and MANTIS (Manual Alternative and Natural Therapy Index System) databases, extending from 1966 to September 2003, was conducted. Search terms included “cervical,” “neck,” “chiropractic,” “neck pain,” “patient satisfaction,” and “manipulation.” The inclusion criteria for article selection were studies dealing with the treatment of neck pain by means of chiropractic manipulation, regardless of the number of subjects involved or whether randomization was implemented.

Results: Two hundred sixty-seven citations were identified. Most were eliminated because they either did not specifically deal with the treatment of acute neck pain with manipulation or were not written in English. Less than 10 articles marginally dealt with the treatment of acute neck pain with cervical manipulation. Moreover, there has only been one randomized clinical trial published in the English language that specifically dealt with the treatment of acute neck pain by manipulation. Other studies involved patients with neck pain of a subacute or chronic nature or treated test subjects with mobilization techniques rather than manipulation.

Conclusion: There has been scant investigative research into the treatment of acute neck pain with chiropractic manipulation. Consequently, more data are needed and appropriate studies should be initiated. (J Manipulative Physiol Ther 2005;28:520-525)

Key Indexing Terms: Manipulation, Chiropractic; Cervical Vertebrae; Neck; Pain

Neuromusculoskeletal (NMS) system disorders and associated complaints have an enormous impact on public health in relation to associated disabilities, medical expenses, and lost production in the workplace. Nearly 26% of functional disabilities in the Netherlands are caused by NMS disorders.¹ In the United States, neck pain is a very common and pervasive NMS disorder, with prevalence rates in the general population estimated to be between 16% and 18%² and 13%.³ For comparison, there is an estimated 15% to 20% prevalence rate for lower-back pain in this same population.⁴

Most investigations of treatment methods for neck pain have not taken into account the use of complementary methods such as chiropractic. However, a study by Wolsko et al⁵ involving 2055 adults revealed that 54% of persons suffering from neck or back pain sought treatment from complementary health practitioners whereas only 37% saw a conventional provider for treatment. The authors also reported that chiropractic was rated as “very helpful” by 61% of those respondents who received treatment for back or neck pain as compared with only 27% of those who were treated by conventional providers. The authors estimated that approximately one third of all visits (203 million) to complementary health practitioners in 1997 were for the treatment of neck or back pain. They compared the total number of complementary practitioner visits for all conditions, 426 million, with the total of 386 million visits to all primary care physicians for the treatment of any and all conditions. However, Wolsko et al⁵ pointed out several
limitations, including potential recall bias, which may have resulted in an underestimation of the actual number of visits involved, and nonresponse bias, which may have contributed to a distortion of the results.

A meta-analysis of studies that investigated the conservative treatment of neck pain was conducted by Aker et al. They considered treatments such as acupuncture, pharmaceuticals, massage, manipulation, and several others but found a widespread lack of evidence to support the effectiveness of many of the standard methods used in health care to treat neck pain. Treatments that were found to have some early evidence of support for their effectiveness, such as manual methods in combination with other treatments, were thought to be inconclusive because of the small number of trials on which they were based. Their analysis concluded that essentially no form of neck pain treatment has been researched sufficiently to adequately estimate its effectiveness. It should be noted, however, that this meta-analysis was published in 1996, approximately 8 years before this current writing.

### Chiropractic Treatment of NMS Conditions

Doctors of chiropractic (DCs) are trained to treat NMS conditions through procedures such as manipulation, physiotherapy, exercise, and nutrition. Patients with lower-back and neck pain complaints are among those most likely to seek treatment from DCs; many studies have supported the use of chiropractic manipulative therapy (CMT) for these complaints. Furthermore, chiropractic treatment has been shown to be safe and cost-effective for the treatment of such conditions. In a study involving 7527 patients, 46% presented to DCs with complaints of lower-back pain, 12.7% with complaints of neck pain, and the remaining with various complaints such as headaches, allergies, and sinus pain.

Most DCs use a variety of manual therapies, with an emphasis on specific manipulative (adjunctive) techniques applied to the spine. The purpose of CMT techniques is to correct disorders of the NMS system by improving joint alignment, range of motion, and quality of movement. Chiropractic manipulative therapy techniques are the basis of chiropractic practice and are the most focused and important therapy used by chiropractors. The most commonly taught and used manipulative methods in chiropractic are labeled “diversified techniques” and include a number of manipulative approaches that are applied to all spinal and most peripheral joints. Doctors of chiropractic also use supplementary techniques such as physiological therapeutics, exercise, and nutritional counseling, which have been referred to as “complementary chiropractic.”

According to the American Chiropractic Association, there are more than 50,000 DCs currently practicing in the United States, with the average DC administering approximately 115 patient visits per week. Klougart et al reported that cervical CMT is performed during the course of 66% to 69% of chiropractic visits. Using these figures and assuming that the average DC works 50 weeks per year, we approximate that there are 190 to 198 million chiropractic visits involving CMT applied to the cervical spine every year in the United States. Unfortunately, very minimal data have been published to provide evidence for the effectiveness of CMT in treating patients with acute neck pain. In addition, the issue of patient satisfaction with respect to acute neck pain treated by CMT has virtually been ignored in the literature. Accordingly, this article will review the chiropractic and medical literature in an effort to ascertain the current profundity of evidence supporting the use of chiropractic manipulation for the treatment of acute neck pain.

### Methods

A literature search was carried out with the purpose of determining the current level of knowledge regarding the treatment of acute neck pain by the use of CMT. It was also anticipated that the literature search would establish the need for a study of chiropractic patients who were treated for acute neck pain to determine associated relative effectiveness and patient satisfaction. A search of the MEDLINE/PubMed and MANTIS (Manual Alternative and Natural Therapy Index System) databases, extending from 1966 to September 2003, was conducted using the following search terms: “cervical,” “neck,” “chiropractic,” “neck pain,” “patient satisfaction,” and “manipulation.” The inclusion criteria for article selection encompassed all studies dealing with the treatment of neck pain by means of chiropractic manipulation, regardless of the number of subjects involved or whether randomization was implemented.

### Results

Two hundred sixty-seven citations were identified, but after screening, most were eliminated because they either did not specifically deal with the treatment of acute neck pain with CMT or were not written in English. Ultimately, fewer than 10 articles even peripherally dealt with the treatment of acute neck pain with cervical manipulation.

### Discussion

**Chiropractic Treatment of Subacute and Chronic Neck Pain**

Woodward et al reported that 93% of a group of 28 patients with chronic whiplash syndrome, a condition noted for its resistance to improvement from any form of treatment, improved after chiropractic treatment. Patients were randomly selected from referrals to a single chiropractic physician originating from a medical orthopedic practice. No control group was used, but assessment was
blinded before and after treatment. The severity of patients’ symptoms was assessed before and after treatment according to a 4-level grading system that ranged from nil to disabling symptoms. There was improvement of 1 or 2 symptom levels in 26 of 28 cases after treatment.

Parkin-Smith and Penter17 conducted a pilot study investigating the outcome of cervical manipulation alone as contrasted with manipulation of both the cervical and thoracic spine for the treatment of mechanical neck pain. Thirty patients were randomized to the respective groups and then followed over a 3-week period. Both treatment groups experienced similar positive effects, with improvements noted regarding pain levels, Neck Disability Index scores, and cervical range of motion. However, there was no statistical difference noted between groups. A similar study carried out by van Schalkwyk and Parkin-Smith18 compared 2 groups of patients with mechanical neck pain, 1 receiving cervical rotary manipulation on the ipsilateral side of lateral flexion fixation(s) and the other receiving supine lateral break manipulation on the contralateral side of the lateral flexion fixation(s). The results of this investigation concluded that both treatments improved measured outcomes, although they had equal effects.

An 11-point scale was used to measure the intensity of self-reported pain in a study of 119 patients with chronic neck pain that was reported by Jordan et al.19 Chiropractic manipulation was compared with intensive training of the cervical musculature and physiotherapy treatment. No clinical difference was found between the treatments; however, each intervention resulted in significant improvement in all measured outcomes. Another self-reporting scale that consisted of 15 questions was used by these researchers to assess disability, which also failed to differentiate the groups. Nonetheless, there was no significant difference among groups that received intensive training, physiotherapy, or manipulation. The authors did not attempt to rank the satisfaction levels and only indicated that satisfaction was “good.”

A study by McMorland and Suter20 showed that patients with mechanical neck or lower-back pain had a statistically significant decrease in pain-related disability after chiropractic treatment. On the other hand, the researchers only prospectively reviewed files of a single DC and did not contact the involved patients in any way. This weakness severely limits the generalizability of the study’s results.

Bronfort et al21 showed that cervical CMT in combination with strengthening exercise seemed more helpful than spinal manipulation alone for the treatment of chronic neck pain. The authors examined the issue of patient satisfaction, pointing out that patients were more satisfied with spinal manipulative therapy combined with exercise than spinal manipulation alone. Patients’ satisfaction with care was rated using a 7-point scale with choices ranging from completely satisfied (couldn’t be better) to completely dissatisfied (couldn’t be worse). Satisfaction levels were rank transformed to allow better calculation of mean values and standard deviations. Additional data regarding the study were published 1 year later, but there was no difference concerning patients’ perceived satisfaction levels.22

In a study of patients with neck pain receiving manipulation or mobilization treatment at a health maintenance organization, the 11-point numerical rating scale was used to assess before-treatment and after-treatment pain levels.15 The rating scale ranged from 0, representing no pain, to 10, signifying unbearable pain. There was a 3-point reduction of mean pain levels at 6 months for both groups. However, no difference between the effects of manipulation and mobilization was apparent. Before-disability and after-disability status was determined by means of the widely accepted Neck Disability Index, which also did not differentiate the treatment groups. The patients were asked to assess their overall improvement as being either better or a lot better, but patient satisfaction was not specifically addressed. The authors concluded that manipulation was not superior to mobilization for enhancing outcomes in the treatment of neck pain.

The previously mentioned studies that have considered chiropractic manipulation for the treatment of subacute or chronic neck pain are summarized in Table 1.

Case reports illustrating cases of improvement that support the efficacy of CMT for the treatment of neck pain are presented in the literature. Alcantara et al23 described a case of neck pain and left upper extremity radiculopathy after cervical discectomy where CMT resulted in marked improvement of the patient’s symptoms, although there was a history of an unsuccessful cervical spine surgery. The authors also pointed out that there was an associated lessening in chiropractic subluxation findings. Another case report concerning postsurgical neck syndrome showed that the condition may be effectively treated by CMT in certain cases, using mechanical force, manually assisted adjusting procedures.24

Chiropractic Treatment of Acute Neck Pain

The treatment of neck injuries in general has not been investigated with regard to effectiveness and patient satisfaction to the extent of injuries involving the lower back. Nonetheless, CMT has been shown to be advantageous for some patients who have suffered neck injuries, albeit future studies are undeniably needed concerning comparative effectiveness and satisfaction. Specifically focusing on patients with acute neck injury, Osterbauer et al25 reported improvement on pain scores and cervical range of motion in a small nonrandomized group that received short-lever manually assisted manipulation. Based on these findings, they indicated that spinal manipulation may be beneficial and that future studies are warranted.

A systematic review by Gross et al26 identified 20 randomized clinical trials (RCTs) from a possible 173 identified articles that addressed the relationship between...
manual therapy and neck pain. However, only 2 of the RCTs specifically dealt with acute neck pain that was treated by manipulation, 1 of which was written in German. The other study, carried out by Cassidy et al., appears to be the only RCT that included patients with acute neck pain. The remaining studies measured symptomatic changes in patients with neck pain of a subacute or chronic nature or treated test subjects with mobilization techniques rather than with manipulation.

The Cassidy et al. study was designed to determine whether a single cervical manipulation was more effective than mobilization in decreasing neck pain and increasing cervical range of motion. Neck pain was present for less than 1 week in 16 patients and 34 experienced pain for between 1 week and 6 months. The remaining 50 subjects had pain for more than 6 months. The study concluded that a single manipulation was more effective than mobilization in decreasing pain but that both interventions increased range of motion similarly. Altogether, there have only been approximately 50 acute or subacute patients who have participated in RCTs involving cervical manipulation specifically for acute neck pain, half of whom were randomized to receive mobilization. This small sample size consequently provided results with very low statistical power. In addition, only one manipulation was administered to the involved patients, which is in contrast with the approach DCs typically use in practice. In most cases, DCs provide numerous manipulations, sometimes dozens, in the course of treating a single patient’s NMS condition.

Pikula completed a pilot study of patients with acute unilateral neck pain, considering the effectiveness of a single manipulation applied to either side of the neck as

<table>
<thead>
<tr>
<th>Study</th>
<th>n</th>
<th>Design</th>
<th>Interventions</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woodward et al.</td>
<td>28 cases, 0 controls</td>
<td>Descriptive case series</td>
<td>Chiropractic manipulation, neuromuscular facilitation, and cryotherapy</td>
<td>26 patients (93%) improved 1 or 2 symptom levels</td>
</tr>
<tr>
<td>Parkin-Smith and Penter</td>
<td>15 cervical manipulation, 15 cervical and thoracic manipulation</td>
<td>Randomized pilot study</td>
<td>Manipulation over a 3-wk period applied either cervically or both cervically and thoracically</td>
<td>Improvements regarding pain levels, Neck Disability Index scores, and cervical range of motion, with no statistical difference between groups</td>
</tr>
<tr>
<td>van Schalkwyk and Parkin-Smith</td>
<td>15 ipsilateral manipulation, 15 contralateral manipulation</td>
<td>Randomized pilot study</td>
<td>Rotary manipulation on the ipsilateral side of cervical lateral flexion fixation and supine lateral break manipulation on the contralateral side</td>
<td>Both treatments improved measured outcomes, although they had equal effects</td>
</tr>
<tr>
<td>Jordan et al.</td>
<td>40 intensive training, 39 physiotherapy, 40 manipulation</td>
<td>RCT</td>
<td>Intensive training of the cervical musculature, physiotherapy treatment regimen, or chiropractic manipulation twice weekly for 6 wk</td>
<td>Each intervention resulted in significant improvements in measured outcomes; no difference between groups</td>
</tr>
<tr>
<td>McMorland and Suter</td>
<td>119 patients with neck and low-back pain</td>
<td>Retrospective review of chiropractic files</td>
<td>An average of 12 visits with manipulation, soft-tissue techniques, home-care instructions, and ergonomic advice and rehabilitative exercises</td>
<td>Patients with neck pain had an average of 53.8% reduction in pain and 48.4% reduction in disability</td>
</tr>
<tr>
<td>Hurwitz et al.</td>
<td>171 manipulation, 165 mobilization</td>
<td>RCT</td>
<td>Manipulation or mobilization, both coupled with ergonomic and stretching/exercise advice</td>
<td>Both interventions were effective, but there was no significant difference between groups regarding pain and disability through 6 mo</td>
</tr>
<tr>
<td>Bronfort et al.</td>
<td>64 manipulation, 64 manipulation plus exercise, 63 MedX exercise</td>
<td>RCT</td>
<td>Manipulation alone, manipulation plus exercise, or MedX rehabilitative exercises for 11 wk, 20 total visits</td>
<td>Strengthening exercise, combined with manipulation or in the form of a MedX program, was more helpful in patients with chronic neck pain than was manipulation alone</td>
</tr>
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</table>
compared with detuned ultrasound (placebo) on pain reduction and range of motion. Twelve patients were randomly assigned to each of the 3 groups; however, it appears that blinding was not used. Greater improvements concerning pain levels and cervical range of motion were noted in the group where manipulation was applied to the ipsilateral side of pain as compared with the contralateral manipulation or placebo groups.

A recent pilot study carried out by Evans et al\textsuperscript{30} involved patients with acute or subacute neck pain of less than 12 weeks’ duration. Interventions included CMT, prescription medications, and self-care education. Each of the 28 patients was randomly assigned to receive one of these interventions, with 10 being included in the manipulation group. No comparison was made between groups because of the small size of the study. Twenty-three of the patients indicated that they were either “very satisfied” or “completely satisfied” with the care they received. A full study is planned for the future, but it may not accurately represent patients with acute neck pain because all prospective participants will be provided 2 baseline evaluations spaced 1 week apart. Potentially qualifying acute patients may advance to the subacute phase during this time interval.

Table 2 shows a compilation of the studies that have specifically investigated chiropractic manipulation for the treatment of acute neck pain.

### Comments

In view of the fact that there are nearly 200 million chiropractic visits that involve cervical CMT every year in the United States, many of which are for the treatment of acute pain, there are very few studies available on this topic. Those that have been completed involved small samples that yielded low power. Furthermore, the use of a single session of cervical CMT in the Cassidy et al\textsuperscript{27} study did not reflect the conventional treatment patterns used by DCs in this country.

The forthcoming study proposed by Evans et al\textsuperscript{30} is promising, as it includes patients with acute neck pain. They have considered patient satisfaction with respect to the treatment of acute neck pain using chiropractic techniques. This is commendable because very few studies that address the subject are available. On the other hand, the delay related to the 2 baseline evaluations spaced 1 week apart before initiating treatment may move some subjects with acute neck pain into the subacute phase. This may be problematic, given that the acute phase of healing is often described to last only 72 hours, and Gross et al\textsuperscript{26} defined it as less than 30 days.

### CONCLUSION

This literature review has shown that there is a lack of published information regarding the relationship between acute neck pain and treatment by means of CMT. Sigrell\textsuperscript{31} indicated that it is important to evaluate treatment outcome and patient satisfaction levels among chiropractic patients, yet there is minimal research that has investigated the chiropractic treatment of acute neck pain with these variables. Furthermore, there are few studies that peripherally broach the topic of patient satisfaction. Consequently, more data are needed and appropriate studies should be initiated. Such research should be directed toward determining the physical improvements, as well as the cost-effectiveness, of this procedure. Resulting information
may be valuable for potential patients and referring physicians with regard to improved decision making when contemplating the use of CMT for acute neck pain.

ACKNOWLEDGMENTS

The author thanks Julia Watkins, PhD, and David N. Young, DC, PhD, for their assistance in the development of this article.

REFERENCES

MANIPULATION UNDER ANESTHESIA: A REPORT OF FOUR CASES

Edward Cremata, DC, a Stephen Collins, DC, b William Clauson, MD, c Alan B. Solinger, PhD, d and Edward S. Roberts, DC e

Abstract

Objective: To report the results of manipulation under anesthesia (MUA) for 4 patients with chronic spinal, sacroiliac, and/or pelvic and low back pain.

Methods: The treatment group was arbitrarily selected from the chiropractor’s patient base who received the MUA protocol along with a follow-up in-office articular and myofascial release program that mimics the MUA procedures. The chiropractic adjustments and articular and myofascial release procedures were performed in a chiropractic office. The MUA procedures were performed in an outpatient ambulatory surgical center. Patients with chronic pain who had not adequately responded to conservative medical and/or a reasonable trial (4 months minimum) of chiropractic adjustments, and had no contraindications to anesthesia or adjustments, were selected. The 4 patients went through 3 consecutive days of MUA followed by an 8-week protocol of the same procedures plus physiotherapy in-office without anesthesia. Data included pre- and post-MUA passive ranges of motion, changes in the visual analog scale, and neurologic and orthopedic examination findings. The patients had follow-up varying from 9 to 18 months.

Results: Increases in passive ranges of motion, decreases in the visual analog scale rating, and diminishment of subsequent visit frequency were seen in each of the patients.

Conclusion: Manipulation under anesthesia was an effective approach to restoring articular and myofascial movements for these 4 patients who did not adequately respond to either medical and/or in-office conservative chiropractic adjustments and adjunctive techniques. (J Manipulative Physiol Ther 2005;28:526-533)

Key Indexing Terms: Manipulation, Chiropractic; Anesthesia; Manipulation, Spinal; Spine; Sacroiliac Joint; Low Back Pain

The application of chiropractic techniques, including high-velocity low-amplitude (HVLA) chiropractic adjustments, passive stretches, and specific articular and postural kinesthetic integrations, 1,2 combined with the use of general anesthesia or conscious sedation is generally referred to as manipulation under anesthesia (MUA). Manipulation under anesthesia allows chiropractic adjustments to be provided to patients who could not otherwise tolerate, or do not adequately respond to, in-office manual techniques. Anesthesia is used to relieve spinal pain and muscle spasm and to reduce protective guarding that may limit the reduction and/or removal of articular or myofascial adhesions during chiropractic adjustments. 3 Manipulation under anesthesia is a technique available to treat patients with neuromusculoskeletal dysfunction at a greater intensity than is available in the office setting. In 1976, Morey 4 stated, “Before MUA is indicated ask yourself whether the patient can respond to conservative care.”

Early osteopathic case studies showed significant results, but the procedure was risky because of the time the patient was under general anesthesia. 5 In 2002, Kohlbeck and Haldeman 3 summarized the history and current clinical knowledge regarding MUA documented in 49 articles. Current medications and more refined treatment approaches have allowed physicians to provide these procedures with much greater safety. In fact, two large malpractice insurers...
for chiropractors, National Chiropractic Mutual Insurance Company (NCMIC) and Pi Omega Delta, cover MUA practitioners without any additional premium.

Manipulation under anesthesia procedures in the clinical setting are based on the hypothesis that adhesions in the joint capsules and surrounding supportive tissues can be altered by the use of specific chiropractic adjustments and stretching techniques.\(^6\) The increased flexibility of the supportive tissues increases the mobility of the motion segment and associated articulations.\(^6\) Additional suspected mechanisms for the increased motion ranges seen after MUA include the resetting of the Golgi tendon apparatus resting length.

In our experience, a large number of patients exhibit mechanical dysfunctions and persistent myofascial and/or articular motion restrictions, with many unable to perform their usual tasks at work or participate in their normal home and recreational duties. It is the opinion of Francis\(^7\) that approximately 3% to 10% of chiropractic patients may be candidates for these procedures. The purpose of this paper is to present how 4 patients with chronic spinal, sacroiliac, and/or pelvic and low back pain responded to MUA.

**METHODS**

**Indications**

In addition to evaluating whether intravenous (IV) anesthetic can be delivered safely, the indications for this procedure are used as illustrated in **Fig 1.**\(^2\) The MUA procedures may be medically necessary when painful and restricting muscular guarding interferes with the performance of manipulative procedures, mobilizations, and soft tissue release techniques in the patient with acute pain or when fibrosis-maintained articular and myofascial adhesions cannot be adequately released with a reasonable trial of in-office procedures in the patient with chronic pain. Manipulation under anesthesia has been used successfully in treating those patients unresponsive to acute and chronic musculoskeletal conditions for years.\(^8,9\) Specific attention should be given to proper patient selection.\(^2\) Morey\(^4\) reported that approximately 3% of patients who do not adequately respond to standard manipulation would come to require these MUA procedures.

**Contraindications**

Contraindications to MUA procedures may include those contraindications that apply to spinal manipulation procedures for patients who are conscious.\(^7\) In addition, the consulting medical physician must consider anesthesia risks to the patient. Contraindications include, but are not limited to, malignancy with metastasis to bone; tuberculosis of the bone or other infectious disease; recent fractures; acute arthritis; acute gout; uncontrolled diabetic neuropathy; syphilitic articular or periarticular lesions; gonorrheal spinal arthritis; excessive spinal osteoporosis; disk fragmentation; direct nerve root impingement that would contradict spinal manipulative therapy; and evidence of cord or caudal compression by tumor, ankylosis, or other space-occupying lesion. This includes severe spinal canal stenosis from any cause, which is considered to be the primary cause of the patient’s symptoms and disability.\(^10\)

**General Procedures**

Before the decision to perform MUA procedures, the physician and the patient discuss the options and possible outcomes. A 7-minute video presentation familiarizes the patient with the procedures, and typical patient questions are addressed before MUA procedures. This serves as additional informed consent. Risk is minimized by performing all spinal adjustments 3-dimensionally toward the center and opposite radiographically verified misalignments (instabilities). No forces are administered in the direction of instabilities present. Also, all motions are only taken to the expected normal ranges with guidance to the amount of the resistance relative to patient size, to tissue resistance, and to the unaffected side.

There are 3 distinct stages of the actual MUA procedure: (1) sedation of the patient; (2) specific chiropractic adjustments; and (3) passive stretching and traction procedures of the spine, sacroiliac, and pelvis. In the operating room are the anesthesiologist, the operating room nurse, the chiropractor in charge of the procedure (primary chiropractor), and an assistant chiropractor (secondary chiropractor). The patient is brought to the operating room and connected to the appropriate monitoring equipment and the appropriate amount of anesthesia is administered. This typically
includes the anesthesiologist’s choice of propofol (Diprivan), midazolam (Versed), sufentanil, and, occasionally, succinylcholine, through a secured IV in the dorsum of the hand. The patient reaches a deep conscious sedation in which he/she continues to breathe on his/her own and maintain normal oxygenation without the smooth muscle paralysis of full general (surgical) anesthesia patients. The principle drug used, propofol, is short acting and induces sedation and amnesia for the procedure. This drug allows the patient to awaken quickly, within 5 to 10 minutes, and does not require intubation and the associated risks of long-acting paralytics and respiratory depression.

A predetermined set of maneuvers are specified for every MUA patient, based on the areas of complaint and the decreased ranges of motion (ROMs). Maneuvers that may impose a particular risk to a patient, such as forced flexion with combined rotation in a patient with a disk herniation, are either modified or deleted from the protocols. The MUA procedures are typically repeated over the course of 3 days.

Lateral bending stress radiographs are taken before the MUA procedures to help direct treatment specifically at the fixated or hypomobile motion segments. This provides the chiropractor with some specific objective outcome goals, namely, improving ROM, globally and intersegmentally. The lateral bending radiographs are taken again after the second day to aid in planning the last day of the procedure for two reasons. One reason is to determine what effect the first 2 days of the MUA procedure had on the fixated and hypomobile spinal levels. Secondly, this process can help identify secondary problem areas that may be revealed by alleviation of the primary problems. These comparative x-rays allow the physicians to modify the treatment approaches more specifically to the patient’s needs after the first 2 days of MUA.

Lumbar/Sacroiliac Spine Procedure

The lower extremities, lumbar spine, and sacroiliac joints are passively stretched to maximum end ROMs in flexion, lateral bending, distraction, and all rotations. The focus of these multiple maneuvers is to free fibrotic adhesions surrounding the lumbar spine, hip joints, pelvis, and lower extremities. These end-range pressures are sustained for 4 to 6 seconds with slight pressure increases during that period as allowed by the patient’s tissue resistance. The second physician stabilizes the patient and provides counter-resistance to all mobilization maneuvers making the use of these directed forces possible.

The patient is then placed in a side posture position typically used for spinal adjustments with the superior knee flexed and stabilized by the second physician. The lumbar curve is placed in a neutral or slightly extended position. The upper torso is stabilized by cephalic and slight posterior pressure on the chest and shoulder. The lumbar spine is taken to the end ROM removing slack from the surrounding tissues. Selected localization of known restricted segment(s) is performed. The elastic barrier of resistance is found with force delivered 3-dimensionally opposite to the direction of instability derived from the patient’s radiograph. An HVLA thrust is applied and joint cavitation was achieved. The fixated sacroiliac articulation(s) is adjusted to assure optimal mobilization. The patient is then placed on the opposite side and the same procedure was repeated. The second physician provides patient stabilization on the table, assists in turning the patient into the side posture positions, and protects the IV and monitoring lines.

Thoracic Spine Procedure

The thoracic spine and the surrounding tissues are passively stretched in flexion, lateral bending, distraction, and rotation. Scapular distraction is used to release adhesions present in the paravertebral myofascial tissues. These end-range pressures are sustained for 4 to 6 seconds with slight pressure increases during that period as allowed by the patient’s tissue resistance. The second physician stabilizes the patient, guards the IV and monitoring leads, and provides counter-resistance to allow the forces to be directed in a useful fashion.

With the patient lying on the table, the upper extremities were flexed at the elbows and crossed over the chest. Segmental localization of known restricted segment(s) is selected. One hand is placed over the selected thoracic segment and the other hand positioned over the crossed upper extremities. The elastic barrier of resistance is achieved and an HVLA thrust is applied in the direction opposite to the instability and cavitation is achieved, while the second physician sustains a slight caudal traction. The second physician provides assistance during the patient positioning, stabilizes the arms during this procedure, and protects the IV and monitoring lines.

Cervical Spine Procedures

The cervical spine and the surrounding soft tissues are passively stretched to maximum motion ranges in flexion, lateral bending, distraction, rotation, and oblique stretching angles. These end-range pressures are sustained for 4 to 6 seconds with slight pressure increases during that period as allowed by the patient’s tissue resistance. The second physician provides counter-forces, as needed for the different procedures, and stabilizes the patient’s arms to protect the IV and monitoring lines.

Axial traction was manually applied to the cervical spine while the second physician stabilizes the thorax with a slight caudal pressure. The involved cervical segment(s) is localized on one side and the elastic barrier of resistance is found. An HVLA thrust is applied opposite to the
radiographically verified vertebral misalignment and cavitation was achieved. This procedure is repeated on the other side with continued assistance from the second physician.

A more aggressive approach to the most restricted regions is used based on patient tolerance to the MUA procedure after the first day. Spinal motions, which exhibited the most significant motion restrictions, were targeted more aggressively until normal or near normal motion ranges were obtained by the second and third day of the MUA procedures. Restricted articular and myofascial restrictions that were previously resistant released better with subsequent attempts.

After the MUA procedure, the patient is transferred to the recovery area, monitored until consciousness is regained and stability is achieved, and released from the recovery area in satisfactory condition to a responsible party for home transport.

### Post-MUA Follow-up Procedure

The post-MUA follow-up procedures are considered second only to good patient selection as a determinant of a good outcome from MUA. These protocols are important to promote joint stabilization, patient independence, and decreased physician dependence.6 The 8-week, post-MUA, in-office articular and myofascial release procedures were designed to keep the decreased ROM and the intersegmental fixations from returning11 during the healing process. The patient is seen 3 times weekly in the first month and twice weekly in the second month.

The following are components of the follow-up program: in-office spinal adjustments; replication of all traction maneuvers and stretches performed during MUA; cryotherapy; electrical stimulation; and an exercise-based functional restoration program initiated by the third week and continuing until the 8 weeks of the program are completed. This exercise program includes basic conditioning and addresses flexibility, strength, muscular balance, aerobic capacity, and proprioceptive coordination. The patients should continue the exercise conditioning program after the 8 weeks, either in-office or at a home or private gymnasium. Other forms of adjunctive therapies, including myofascial release procedures and physiotherapeutic modalities, may also be used.

### Trial of In-Office Chiropractic Care

It is thought that if the patient can tolerate it, a trial of standard spinal manipulation is warranted before MUA procedures should be performed.7 Rumney12 suggests a trial period from 1 day to 6 weeks, whereas Francis13 recommends 5 to 6 weeks. Kohlbeck and Haldeman3 recommend a 4- to 8-week trial of conservative manipulative therapy before considering the more aggressive MUA approach. Francis and Beckett7 state that a “fair” trial of standard manipulation be given before MUA if acute pain does not prevent such a trial. If the patient does not adequately respond to standard manipulation, the attending clinician must ultimately make the decision to proceed with MUA procedures. Waiting too long to satisfy an arbitrary time requirement may delay the patient’s recovery and allow further soft tissue or joint adhesions to develop.7

### Case 1

A 38-year-old female patient had low back pain at the L4-5 vertebral levels and bilateral leg dysesthesias after referral from another chiropractor after 6 months of spinal adjustments to address her chronic symptoms. Acute episodes regularly occurred. She complained of difficulty sleeping and reported much crying, fear for the future, and increased disability. She stated that she was unable to play with her children and her condition was slowly worsening. She had a prior diagnosis as a “borderline” hypertensive.

Physical examination yielded unexceptional results except that her pulse rate was 99 beats per minute. She appeared her stated height of 5 ft 10 in and her stated weight of 200 pounds. No atrophy was noted in her lower

### Table 1. Pre- and post-MUA ROM measurements

<table>
<thead>
<tr>
<th>Condition</th>
<th>Patient 1</th>
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<th>Patient 2</th>
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<th>Patient 3</th>
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<th>Patient 4</th>
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<tr>
<td></td>
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<td>12°/45°a</td>
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<td>4°c, 5°c</td>
<td>1°ab, b</td>
<td>7°/5°c</td>
<td>1°ab, b</td>
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<td>Lumbar flexion</td>
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- **Note:**
  - a To point of reported pain.
  - b Fingertip inches from the ground.
  - c No associated pain reported.
extremities. Neurologic examination was essentially normal with all deep tendon reflexes symmetrical and within normal limits. All muscle strengths of the lower extremities were normal at +5/5. Sensation of the lower extremities was found to be intact. Orthopedic examination revealed a slightly decreased ROM in forward flexion, right and left bending, and right rotation. Local signs of continued neuromechanical dysfunctions were still present at the L3 through S1 region primarily and secondarily in the lower thoracic spine and lower extremity myofascial tissues. These signs included functional x-ray–verified joint restrictions with pain and protective guarding, bilateral thermal alterations, and paraspinal edema. The lumbar ROMs of this patient on presentation before MUA are presented in Table 1.

Positive orthopedic tests included the straight leg raise (SLR) bilaterally at 85° causing low back pain; Patrick’s FABERE test on the left side causing low back and hip pain; Ely’s on the left side causing low back and hip pain; Hibb’s bilaterally causing low back pain; and Yeoman’s test on the left side causing low back pain. Kemp’s maneuver was performed without leg pain, but with a report of tightness when performed on either side. The patient was able to walk on her toes and heels without difficulty. The sacroiliac compression test and Braggard’s test were performed without symptoms.

Weight-bearing plain film lateral flexion radiographs revealed joint restrictions from L3 through S1 on the right and left sides. A lumbar magnetic resonance imaging (MRI) scan was performed and showed minimal annular disk bulging at L3-4 that did not impinge on the spinal canal or neural foramina. However, the L4-5 disk showed desiccation and loss of height, right paracentral protrusion that effaced the ventral thecal sac, and ligamentum flavum hypertrophy. Also evident were foraminal encroachment and mild spinal stenosis at this level. At the L5-S1 disk level, the MRI showed mild degenerative facet disease and ligamentum flavum hypertrophy.

Two weeks after the MUA procedures were performed, there were improvements in ROMs. Lumbar forward flexion allowed the patient’s fingertips to reach approximately 4 in of reach from the floor. Lumbar rotation increased initially by approximately 15° in both directions and stabilized at 10°, and lateral flexion showed smaller improvements. Thoracic rotation improved from an average of 55° to 80° in each direction. The length of hamstring muscles increased. The patient improved subjectively and was able to participate in activities with her children. Her need for treatment decreased from at least 2 times weekly to approximately twice monthly. These results reflect observations up to 18 months post-MUA.

Case 2
A 28-year-old auto mechanic presented with neck pain, headaches, and low back pain resulting from being hit by a car that was traveling approximately 30 mph. He was taken to an emergency department and referred for medical treatment, which included pain medication and physical therapy. Three months later, he was evaluated and was still on total temporary disability, being unable to perform the bending and lifting required for his essential job duties. He subsequently changed to chiropractic management and eventually was referred to our office. After a reasonable trial of chiropractic and an inadequate plateau being maintained, MUA was selected as an appropriate option.

Neurologic examination of the upper and lower extremities revealed a slight muscle weakness of the right hamstring muscle at +4/5. Deep tendon reflexes were all symmetrical and brisk at +2/5. Pinwheel testing of the upper and lower extremity dermatomes revealed decreased sensation of the right C7 and the right L4 dermatomes. Specific local signs of spinal injury were present at the C3, C7, and L3-5 spinal regions. These signs included paraspinous edema, spinous process tenderness, intersegmental motion restrictions, a sustained hyperemic response after deep digital palpation, and bilateral thermal asymmetries suggesting vertebral subluxations (neuromechanical dysfunctions) at these spinal regions. Weight-bearing plain film lateral bending stress radiographs were negative for fracture or other significant related pathology. Orthopedic examination revealed a slight decrease in ROM and increased pain upon several motions before MUA.

Positive orthopedic tests included the cervical compression on the left side causing neck pain and the shoulder depression test causing bilateral stiffness. Adson’s test did not change the radial pulses. The SLR on the left side caused left calf and leg pain; the Patrick’s FABERE test, when performed on the right side, caused right low back and hip pain. Braggard’s test, when performed on the right side, caused right calf and leg pain. Kemp’s maneuver caused low back and buttock pain when performed on the right side. The patient was able to walk on his toes and heels without difficulty. Ely’s, sacroiliac compression, Hibb’s, and Yeoman’s tests were all performed without a production of symptoms.

Two weeks after the MUA procedures, the patient was nearly asymptomatic with normal ROM. He returned to his previous occupation after 1 month. Subsequently, he was treated with in-office spinal adjustments 1 to 2 times monthly for flare-ups that have not exceeded a 3 on a numeric pain scale (NPS) of maximum 10 intensity. Before the MUA procedure, his symptoms often increased to an NPS of 6 to 9. The patient reported an approximate 80% functional and symptomatic improvement from the treatment provided. These improvements were maintained up to 18 months post-MUA.

Case 3
A 34-year-old woman had cervical and thoracic pain, limited motion, and bilateral upper extremity dysesthesias
secondary to repetitive stress injuries related to her employment. She had been with her employer for 3 years and 2 months at the time of injury. Her duties required computer keyboard and mouse use for periods of time greater than 8 hours per day. The patient noticed a gradual onset of pain in her right forearm, right upper arm, and right shoulder region with pain radiating into her neck on the right side and bilaterally in her upper back. Headaches accompanied her right upper extremity and neck complaints, with symptoms rated at 5 to 7 on an NPS.

Initially upon seeking treatment, the patient had been given a “tennis elbow” brace and a shoulder sling to immobilize her right upper extremity by her medical physician; she was also provided a cortisone injection into her right wrist extensor musculature and Vicodin and ibuprofen for pain. After the medical treatment failed, she was referred for physical therapy with no appreciable response. At that point, the patient sought chiropractic care and was treated 3 times per week for 6 weeks. Treatments included specific intersegmental spinal adjustments, soft tissue mobilization, interferential current, home exercises to increase region and total body flexibility and strength, and ergonomic counseling. After a reexamination, the patient was treated at a frequency of 2 times per week for an additional 8 weeks. However, the patient did not show any significant lasting improvement. Finally, after 11 months from the initial treatment, the patient was referred for evaluation to determine her candidacy for MUA.

The cervical compression test was positive during right and left maximal cervical compression causing neck pain. The shoulder depression test was positive when performed on either side, causing increased neck pain. A modified Spurling’s test was positive on the right and cervical distraction caused increased neck pain. Valsalva’s and George’s tests were negative. Neurologic examination revealed hypertonicity upon palpation of the right and left trapezius muscles, cervical and thoracic paraspinal musculature, right and left levator muscles, and the right and left scalene musculature. Deep tendon reflexes were symmetrical and normal. Upper extremity manual muscle testing was normal at +5/5 bilaterally. All cervical ROMs were decreased with pain provocation reported by the patient prior to the MUA procedures.

Specific signs of spinal intersegmental dysfunction (fixation) were noted at spinal levels C1-2, C5-6, and T6-7. Weight-bearing plain film lateral flexion stress radiographs were interpreted as evidence for abnormal coupling motion at the spinal levels of C1-2, C5-6, and T6-7. A cervical MRI failed to show any significant central canal or intervertebral foramen stenosis. Mild disk bulges were noted at the C5-6 and C6-7 levels.

Post-MUA, all orthopedic tests were negative, except that hypertonicity was noted upon palpation of the right trapezius muscle and pain on left lateral bending. Approximately 9 months post-MUA, at the request of the industrial carrier, the patient was referred to an independent medical examiner for reevaluation. The examiner reported subjective complaints consistent with occasional neck stiffness reported at 1 to 2 on an NPS and virtually no upper back and headache complaints. The patient’s only complaint related to her right upper extremity was intermittent pain localized to the wrist extensor musculature reported at 2 to 3 on an NPS. In comparison with 80 treatments during the prior year, the patient required only 7 chiropractic treatments over 9 months post-MUA.

Case 4

A 31-year-old, 10-year veteran worker at an automobile assembly plant had lumbar pain, limited motion, and bilateral lower extremity dysesthesias specific to the posterior thighs and plantar surfaces of his feet. The patient was injured 3 years prior as a transfer unit moved a vehicle he was working on and his tool gun struck him and threw him to the floor. Immediately after the accident, the patient experienced pain in his lower back, reported at 7 on an NPS, attendant lumbar paraspinal muscle spasm, and bilateral posterior thigh numbness. His employer directed him to seek occupational medicine care, and he was treated with Vicodin, Soma, and Motrin. After 3 weeks with no improvement, the patient underwent an 8-week treatment regimen of ultrasound, electrical muscle stimulation, moist heat, and floor exercises. He failed to improve and was referred for a lumbar MRI, which noted a 5-mm disk protrusion at the L5-S1 level. It was determined at this point that the patient was not a surgical candidate and was referred for a chiropractic evaluation and treatment. The patient continued to be on temporary total disability during 65 chiropractic treatments over the course of 7 months. Although he benefited from this chiropractic treatment, the patient desired further relief and was referred to these authors for the MUA procedure.

The patient’s left SLR was positive at 50° and increased lower back and left lower extremity pain. The sitting SLR on the left increased lower back pain. Braggard’s test was positive on the left and negative on the right. Kemp’s maneuver on the left and right produced lower back and lower extremity pain, the lower extremity pain correlating to the side of the test. Patrick’s FABERE test and Valsalva’s were performed without symptoms. Neurologic examination revealed hypertonicity upon palpation of the paraspinal musculature spanning from T12 to S1, the left and right tensor fascia latae muscles, and the left external hip rotator muscles. Deep tendon reflexes were symmetrical and normal. Upper extremity manual muscle testing was normal at +5/5 bilaterally. Lumbar ROMs were decreased and painful in several planes of motion.

Specific signs of spinal intersegmental dysfunction were noted at T8-9 and L5-S1. Weight-bearing plain film lateral flexion stress radiographs showed abnormal coupling
motion at spinal levels T8-9, T12-L1, and L5-S1. A lumbar MRI revealed no evidence of significant central canal or intervertebral foramen stenosis, but the presence of a 5-mm disk protrusion at the L5-S1 level.

A follow-up examination was performed 12 weeks after the patient’s MUA procedures. The patient reported subjective complaints that were consistent with occasional low back discomfort reported at 2 on an NPS. He further reported complete resolution of his bilateral lower extremity complaints. All orthopedic tests were essentially negative and ROMs were normal. The patient returned to full duty with his original employer, working without restriction on the automobile assembly line. Twelve months later, the patient had received a total of 8 chiropractic treatments on an as-need basis, as compared with 65 treatments received over the 7 months before his MUA.

**DISCUSSION**

The 4 cases presented in this study show an application of MUA to patients who tolerate in-office chiropractic adjustments, but failed to progress to functional and acceptable asymptomatic levels. The patients presented with a diagnosis of vertebral subluxation complex (neuro-mechanical dysfunction) complicated by myofascial and articular fibrosis, although the patient histories, the physical examination findings, and the spinal regions affected with each patient were different.

The authors are not suggesting that the results seen with these patients are representative or predictive of results expected on any individual case in a larger population. Results with more aggressive procedures for chronic spinal pain may be expected to offer help for a lesser percentage of patients because only the most complicated and advanced cases are undergoing these MUA procedures. However, Siehl and Bradford reported that 60% of their 87 MUA patients had good or excellent results. Siehl also reported 71% “good” results in the 723 cases reported in 1963.

The authors have seen very favorable responses with an estimated 10% showing no substantial improvement. Our postprocedure quality assurance telephone calls to patients performed by nurses showed that an estimated 70% were “very satisfied,” consistent with the findings of others in the reported literature. The remaining 20% of favorable responses noted above were described by patients as “satisfied.” No patients seen in our offices reported a worsening of their condition once their expected postprocedure symptoms subsided. We have studied these cases to assist in future improvements in patient selection. Similar to Siehl and Bradford, Vannetiello and Soto reported in an internal retrospective quality review (Bay Area Ambulatory Care Center) using patient questionnaires that approximately 70% of the patients treated with MUA improved substantially with clear and significant pain reduction, functional capacity increases, and disability reductions. This retrospective review also showed that approximately 30% of these 400 patients had results exceeding simple improvements, including some apparent autonomic nerve mediated and general health benefits. In one patient, a long-standing vertigo that caused frequent falls was abolished without return of symptoms on an 11-month follow-up. In another, drug medication was reduced by 75% in a patient with disabling daily headaches. In another, posttraumatic daily headaches were abolished after the second day of these procedures and did not return. Patients on total temporary disability from work for periods of 3 to 50 months returned to work successfully within a 2- to 16-week period. One patient included in these studies went from being totally temporary disabled to playing professional football in a 6-month period. Similarly, West et al reported a very favorable reversal in patients out of work before MUA (68.6%) and those returning to unrestricted activities at 6 months after MUA (64.1%). In addition, perhaps most importantly, functional capacity losses were reduced, allowing patients to return to numerous recreational and family-related activities that improved their lives substantially.

Other studies support the efficacy and safety of the MUA process for properly selected patients over the past several decades. Kohlbeck and Haldeman provide a literature review of MUA (49 articles) that concluded the following: medication-assisted spinal manipulation therapies have a relatively long history of clinical use and have been reported in the literature for more than 70 years. However, evidence for the effectiveness of those protocols remains largely anecdotal, based on a case series mimicking many other surgical and conservative approaches for the treatment of chronic pain syndromes of musculoskeletal origin.

Considering the high cost of managing these patients, the number of patients with this type of complaint, and the resultant negative effects on these patient’s lives, further studies in the area of MUA, such as randomized controlled clinical trials, are recommended.

**CONCLUSIONS**

The 4 patients presented in this series initially failed to show lasting improvement from a trial of typical chiropractic management and conservative medical care; however, they improved with MUA. Manipulation under anesthesia may be an effective option for patients with chronic pain who have not adequately improved with in-office chiropractic or other adjunctive approaches.

**REFERENCES**

11. Roberts ES, Cremata EE, Collins SL. Fibrosis release procedures, including manipulation under anesthesia, a handbook defining the mobilization, myofascial release, and spinal adjutative procedures for the primary and secondary doctor of chiropractic. Fremont (Calif): Fremont Chiropractic Group; 2003.
Objective: To investigate and correlate the anatomy of the gluteal region with the clinical findings of retrotrochanteric and posterior thigh pain, as seen in clinical chiropractic practice, and describe potential treatment options.

Methods: A descriptive gross anatomic study is correlated to a case presentation of a patient with deep persistent aching pain in the retrotrochanteric region of the left hip and upper posterolateral thigh.

Results: The structures that are located in the same location as the retrotrochanteric pain described by the patient are the gemelli–obturator internus muscle complex and associated bursae.

Conclusions: In patients with persistent gluteal and sciatica-like pain, especially when centered in the retrotrochanteric region, the gemelli–obturator internus muscle complex and associated bursae should be considered as a possible source of the pain. (J Manipulative Physiol Ther 2005;28:534-538)

Key Indexing Terms: Gluteal Region; Bursa, Synovial; Sciatica; Manipulation, Chiropractic

The specific pain generators for patients with pain in the gluteal and posterior hip region can be challenging to identify. In clinical practice, the first author sees patients complaining of low back, gluteal, and sciatica-like pain, with the gluteal pain sometimes being the most severe aspect. This type of pain sometimes persists after relief of other back and lower extremity pain after standard spinal manipulation. A case report of such a patient with gluteal pain located in the retrotrochanteric region of the femur that was most intense at the greater trochanteric insertion of the gemelli–obturator internus muscle complex (GOIC) is presented. This clinical finding led the authors to conduct a descriptive gross anatomic study of the gluteal region to identify potential pain generators in this case.

Case Report

A 63-year-old white man with a history of an L5 right hemilaminectomy 22 years prior developed a left L4-L5 disk herniation with left L5 dermatome radiculopathy. After 6 weeks of decompression adjusting of the L4-L5 herniated disk, relief of the left sciatic radicular pain was attained; however, a deep persistent aching pain in the retrotrochanteric region of the left hip and upper posterolateral thigh remained. Stabilization and stretching exercises were continued throughout the care of this patient, but had failed to yield relief of this pain. The persistent left retrotrochanteric and thigh pain was relieved within 1 week by deep goading massage and tetanizing current into the retrotrochanteric area of the hip at the insertion of the GOIC.

Materials and Methods

A dissection of the deep gluteal region in an embalmed cadaver was performed. The gluteus maximus muscle was incised in a superior-to-inferior direction lateral to the route of the posterior femoral cutaneous nerve and folded out of the way. The gluteus medius, piriformis, gemelli, obturator internus, and quadratus femoris muscles/tendons were cleaned, and their relationships to the sciatic nerve were defined. The boundaries of the greater and lesser sciatic foramina were defined. The bursae in the retrotrochanteric region were identified. The trochanteric attachment of the GOIC was cut, and the GOIC folded medially to
show the bursa of the obturator internus located in the region of the lesser sciatic notch.

RESULTS

The deeper structures of the gluteal region are shown in Fig 1A and B. The structures that are at the location of the retrotrochanteric pain described in the case presentation are the distal attachments of the GOIC and associated bursae. A brief review of the components of this complex is presented below.

Superior Gemellus

The superior gemellus originates from the ischial spine and inserts on to the medial aspect of the greater trochanter in union with the tendon of obturator internus. The superior gemellus action is lateral rotation of the thigh; when the hip is flexed, it aids in thigh abduction. A branch from the nerve to the quadratus femoris from the sacral plexus and lumbosacral trunk containing fibers from the L5-S2 spinal nerves provides innervation to the superior gemellus. The superior gemellus may be absent or small or may be doubled and inserted into the hip joint capsule. It may fuse with the piriformis or gluteus minimus muscle.

Inferior Gemellus

The inferior gemellus muscle originates from the ischial tuberosity and also inserts on to the medial aspect of the greater trochanter in union with tendon of obturator internus. Its actions are the same as the superior gemellus. A branch of the nerve to the quadratus femoris from the sacral plexus and lumbosacral trunk containing fibers from the
the L4-S1 spinal nerves innervates the inferior gemellus. The inferior gemellus may be doubled and rarely absent. It may fuse with the quadratus femoris.

**Obturator Internus**

The obturator internus muscle originates from the pelvic surface of the obturator membrane and surrounding bones. It inserts on to the greater trochanter medial surface in union with the gemelli tendons. Its actions are the same as superior gemellus. It is innervated by the nerve to obturator internus from the sacral plexus containing fibers from the L5-S2 spinal nerves. The obturator internus muscle belly is located intrapelvically. It usually turns tendinous as it exits the pelvis through the lesser sciatic foramen.

Although the gemelli superior and inferior and obturator internus muscles are usually described separately, because they have a common insertion, they can be considered 3 heads of a single muscle, similar to the triceps brachii muscle. The GOIC appears to be an anatomically and functionally accurate term.

There are two bursae commonly associated with the GOIC. One of these, usually called the bursa of the obturator internus, is located deep in the obturator internus tendon as it winds around the lesser sciatic notch (Fig 2A and B). Another bursa is sometimes found between the common tendon of the GOIC and the capsule of the hip joint. When present, this bursa usually communicates with the bursa of the obturator internus. This bursa appears to be at the location of the retrotrochanteric pain described in the case report.

Besides those associated with the GOIC, there is another bursa in the retrotrochanteric region. A large bursa separates the portion of the gluteus maximus tendon that inserts into the iliotibial band from the greater trochanter. This bursa is usually called the trochanteric bursa of the gluteus maximus. It covers much of the posterior aspect of the greater trochanter and may have multiple compartments. Sometimes, separate bursae are found in this location. This bursa may be located somewhat lateral to the location of the pain described in the case report but is in the same general area.

There are several other bursae in the deep gluteal region but not specifically in the retrotrochanteric area. Usually, the gluteus maximus has two other bursae associated with it. The first one is between the tendon of the gluteus maximus and that of the vastus medialis known as the gluteofemoral bursa. The other is between the muscle and the ischial tuberosity, which is called the ischiogluteal bursa. In the anterior aspect of the greater trochanter are bursae associated with the tendons of the gluteus medius and minimus muscles, known, respectively, as the trochanteric bursa of the gluteus medius and trochanteric bursa of the gluteus minimus. The bursae associated with the gluteal muscles have been variably described and named, such that there is some confusion as to which terms refer to which bursae.

**Discussion**

The structures located where the patient described his pain in the case report are the insertion of the GOIC and the bursa associated with the insertion of that complex. Inflammation and/or hypertonicity of the GOIC and this bursa are a likely cause of the pain in this patient. The trochanteric bursa of the gluteus maximus is in the same general area but may be somewhat lateral to the center of the pain. Irritation of this bursa may also be involved in this patient’s pain presentation.

The GOIC has been implicated as a possible cause of gluteal and posterior thigh pain but has been largely overlooked. Travell and Simons state that deep tenderness posterior and at the upper one third of the greater trochanter is most likely tenderness of one of the gemelli or obturator internus and quadratus femoris muscles. Furthermore, the sciatic nerve usually emerges through the greater sciatic foramen between the piriformis and superior gemellus muscles and continues its course superficial to the superior gemellus, obturator internus, inferior gemellus, obturator externus, and quadratus femoris muscles.

Pain immediately posterior to the greater trochanter can be the result of entrapment of the nerves to the gemelli, obturator internus, and quadratus femoris muscles. Gluteal muscle nerve entrapment has been listed as a cause of proprioception alteration, arterial and/or venous obstruction, sexual dysfunction, perineal and inguinal pain, as well as pelvic and sciatic pain. Sciatic nerve entrapment can be responsible for the pain and paresthesias projecting to the leg (calf) and often to the foot. Numbness of the foot and loss of position sense producing a broad-based, ataxic gait have also been noted. Kirici reported that entrapment of vessels and nerves in the gluteal area can result in venous congestion, arterial obstruction, erectile dysfunction, and perineal neuralgia. These anomalies of the gluteal region are not only of academic interest but may be of practical importance for surgical intervention in the area.

Meknas et al reported on 6 patients in which the internal obturator muscle was found to be very tense, slightly hyperemic, and pressing on the sciatic nerve. The deep muscle layers encircling the hip joint (gluteus minimus, obturator internus and externus, gemellus superior and inferior, piriformis, quadratus femoris, and capsularis) are hip stabilizers, and alteration of them can lead to proprioceptive feedback alteration and locomotion and posture control difficulties. Arifoglu reported a case with double superior gemellus and double piriformis muscles associated with the sciatic nerve dividing high and passing between the two piriformis muscles.
Obturator internus bursitis has been described as a common, but thus far overlooked, focus of myofascial irritability associated with low back and gluteal pain. Tenderness in the anatomic locus of the obturator internus bursa suggests bursitis. Irritation of the sciatic nerve by the myofascial inflammation of the gemelli, piriformis, or obturator internus muscles and their tendons is suggested. This type of problem could also involve the more lateral bursa associated with GOIC.

Inflammation of the various bursae associated with the gluteal muscles is also recognized. Inflammation of the trochanteric bursa of the gluteus maximus is recognized and can cause a pseudoradiculopathy where there is a sciatica-like pain that radiates into the posterior thigh. Kagan reported that lateral hip pain and weakness on hip
abduction was caused by trochanteric bursitis in 7 patients. Trochanteric bursitis is reported to be common in the fourth to sixth decades of life and is characterized by chronic, intermittent aching pain over the lateral aspect of the hip.\textsuperscript{14,15} The incidence of trochanteric bursitis in chronic low back pain patients is reported as 35%.\textsuperscript{16} Snapping hip syndrome of the iliotibial band was partially relieved in 7 cases by removal of the trochanteric bursa.\textsuperscript{15,17} Swezey\textsuperscript{12} reported trochanteric bursitis is a common complication of lumbosacral strain and accompanies herniated disk patients.

Piriformis muscle syndrome as a cause of sciatic and gluteal pain is controversial.\textsuperscript{18-20} Entrapment of pelvic nerves and vessels by it are reported\textsuperscript{21} and some diagnostic signs suggested.\textsuperscript{22} The piriformis muscle did not appear to be the source of pain in the case reported.

**Treatment of the GOIC**

The following GOIC treatment may accompany any other chiropractic adjustment given to the patient. Pressure point therapy is applied to patient tolerance to the retrotrochanteric region where the obturator internus bursa and the conjoined tendon of the obturator internus, gemellus inferior, and superior and piriformis muscles lie in contact with the sciatic nerve (Fig 3). The tendons of the GOIC feel like firm, rope-like tissues under the palpating fingers when they are painful to the patient. Positive galvanism and tetanizing current are administered to the bursa of the gemelli and the common tendon of the obturator muscles inserting into the greater trochanter posterior to the hip joint (Fig 4). Distraction of the gemelli, piriformis, and obturator tendons is applied, as shown in Fig 5. Travell and Simons\textsuperscript{5} show stretch techniques similar to Fig 6 that are good for the lateral rotators of the thigh. Trigger point injection may be used for patients failing to yield to the conservative measures outlined here. Acupuncture treatment has been reported to be helpful for this pain syndrome.

**CONCLUSION**

A patient with sciatica resulting from an L4-L5 disk herniation received relief from decompression adjusting; however, persistent gluteal and posterior thigh pain continued. Relief of the persistent gluteal and thigh pain was attained within 1 week after the onset of treatment given to the retrotrochanteric region targeting the GOIC. Cadaveric dissection confirmed that the GOIC is at this location. Inflammation and/or hypertonicity of this complex and associated bursae are suggested as possible pain generators of gluteal and thigh pain as described in this case. Further study and implementation of this clinical information is needed to identify clinical relevance of this finding.

**REFERENCES**

MYELOPATHY: A REPORT OF TWO CASES
Sanjay N. Patel, DC,a Norman W. Kettner, DC, b and Corey A. Osbourne, DCc

ABSTRACT

Objective: To present diagnostic imaging findings of two cases of cervical myelopathy, with different etiologies, presenting to a chiropractic office.

Clinical Features: The patient with acute transverse myelitis had neck and upper back pain and nonspecific headaches for 40 years. The patient with posttraumatic syringomyelia experienced intermittent left arm pain starting in the anterolateral shoulder and radiating down the arm into the third, fourth, and fifth digits. Neither of these patients presented with typical myelopathic symptoms.

Intervention and Outcome: Chiropractic spinal manipulative therapy using high-velocity low-amplitude thrusts and concomitant medical management were used for the patient with posttraumatic syringomyelia. The patient with acute transverse myelitis was not treated.

Conclusion: Practitioners should be aware of the etiology, pathophysiology, clinical features, laboratory, diagnostic imaging findings, and treatment options pertaining to patients with cervical myelopathy. (J Manipulative Physiol Ther 2005;28:539-546)

Key Indexing Terms: Myelitis, Transverse; Syringomyelia; Lupus Erythematosus, Systemic; Chiropractic; Myelopathy

Myelopathy (spinal cord disease) is a complex diagnostic problem with many possible causes. The diagnosis rests on the recognition of a constellation of symptoms consistent with central nervous system pathology involving the trunk, arms, and legs; in general, it spares the head. Pain, most common over the site of lesion, is one of the cardinal complaints of patients with spinal cord disease. Complaints of motor abnormalities caused by myelopathy may include sudden weakness and paralysis, clumsiness, fatigability, paresthesias, numbness, dyesthesias, and bladder symptoms. General history and physical examination may point to a systemic disease associated with the myelopathy, such as connective tissue disease, atherosclerosis, and diabetes. A neurologic examination usually excludes intracranial disease. Motor and sensory examinations not only help define the level of the lesion but also the extent of anatomic distribution of the lesion within a given level. Causes of spinal canal lesions that may produce myelopathy are described under 3 different headings according to their location of origin (Table 1).1

We report two patients with cervical myelopathy who presented with complaints of pain. The cases include a diagnosis of acute transverse myelitis (ATM) in a patient with systemic lupus erythematosus (SLE) and posttraumatic syringomyelia.

Case Report

Case 1: Acute Transverse Myelitis with Systemic Lupus Erythematosus

A 54-year-old woman had neck and upper back pain for 40 years. She also had nonspecific headaches. Falls were frequent with no apparent reason. The symptoms of neck and upper back pain were exacerbated by rotation of the head for long periods and flexion or extension of the neck. The symptoms were relieved by rest and occipital traction of the cervical spine. The patient stated that she was diagnosed with and treated for ATM 3 years prior. In addition, she was told that she might be positive for SLE because the antinuclear antibody test was positive. Orthopedic examination of the cervical spine revealed pain on the right side of the neck with Jackson’s compression test to the left side. George’s maneuver was positive with nystagmus and intense headache upon bilateral rotation. Neurologic examination showed normal appearance, behavior, and speech with gross motor and sensory intact. Deep tendon reflexes in the upper and
lower extremities were intact and 2+ bilaterally. A 3-view cervical spine series was performed. She had a magnetic resonance imaging (MRI) examination of her cervical and thoracic spine 3 years prior (Fig 1A, B, and C).

Radiographic examination showed discogenic spondylosis from C3/4 through C6/7 with mild reversal of the cervical sagittal curvature and a posterior shift in the cervical gravity line. The MRI examination of the cervical spine included sagittal (T1 and T2) and axial (T1 and T2 dual echo with and without contrast) images. They showed an intramedullary high signal focus at C2, approximately 1 cm in size. This was consistent with a previous diagnosis of transverse myelitis. In addition, a posterior disk bulge was noted at C4/5, C5/6, T8/9, and T11/12, and an anterior disk bulge with Modic II degenerative changes was present at T12. A Schmorl’s node was noted at T7 and T12. Lastly, osseous hemangiomas were noted at T5 and T11. The option of spinal manipulative therapy without rotational adjustments of the cervical spine was discussed on the first visit, but the patient self-discharged and was lost to follow-up.

Case 2: Posttraumatic Syringomyelia

A 23-year-old woman sustained multiple head traumas with at least one subcutaneous hematoma and one laceration during childhood. Three years before presentation, she underwent lateral posterior meniscal repair to the left knee. The same procedure was performed 18 months later with an epidural administered; the patient expressed that there was difficulty with its administration and with the depth of anesthesia. The patient experienced intermittent left arm pain starting in the anterolateral shoulder with radiation down the arm into the third, fourth, and fifth digits. She reported that the arm pain began after the knee surgery. The pain was described as a constant throbbing with an inability to localize or pinpoint a specific source. The patient denied nausea, headaches, vertigo, palpitations, shortness of breath, tinnitus, and blurred vision.

Full range of motion in the cervical and thoracic spine was noted with active and resisted range of motion producing pain in the area of C5/6. Sensory tests revealed hyperesthesia over most of the arm in a nondermatomal pattern. Sensory tests such as sharp/dull, position sense, hot/cold, and vibratory sense were all intact. Cranial nerves II through XII were intact. Deep tendon reflexes were all +2 with negative Babinski and Hoffman. Muscle tests were performed on the upper left extremity. The antibrachium extenders as a group tested +4/5. The patient related that muscle testing the affected arm significantly exacerbated the arm pain. Thoracic spine midline palpation was extremely tender from T3 through T8.

She had undergone multiplanar pre- and post-IV contrast-enhanced spin echo MRI evaluations of the cervical and thoracic spine, which revealed two syrinxes (Fig 2A, B, and C). The higher of the two measured 7 mm in length and was located posterior to C7 within the central left aspect of the cord. There was a second larger area of signal abnormality at the T5 and T6 level that widened the cord and extended from the T7 level with variable size all the way to C7. There was no evidence of contrast enhancement. Nerve conduction tests of the left upper extremity were normal. The patient was diagnosed with posttraumatic syringomyelia.

Treatment began with oral administration of Topamax, an antiepileptic, and Trileptal (oxcarbazepine), an anticonvulsant used to treat painful neuropathy. She was also placed on an anti-inflammatory diet and a 5-week course of spinal manipulation using high-velocity low-amplitude technique in cervical spine and thoracic spine at C1, C2, C6, and T2-5 levels. Surgery was not considered an option for this patient. The patient began experiencing headaches after starting the oral medications. The Topamax was taken for a period of 4 weeks and was then replaced by the Trileptal. The headaches subjectively worsened after starting the Trileptal. A follow-up MRI evaluation after 5 months showed that the syrinx had significantly reduced in length and width. The length of the syrinx had also reduced, extending from C7 to between T5 and T6 (Fig 3C).

**DISCUSSION**

Diagnostic imaging techniques for the evaluation of the spinal cord include myelography, computed tomography (CT) myelography, and structural MRI. Functional MRI (fMRI) and diffusion-weighted MRI techniques to study the spinal cord are on the horizon.2-7 Myelography is a technique by which contrast material (nonionic) is introduced into the subarachnoid space, usually by lumbar puncture, for the delineation of the dura, spinal cord, and nerve roots. Before the advent of MRI, myelography was

**Table 1. Causes of spinal canal lesions according to their site of origin**

<table>
<thead>
<tr>
<th>Intramedullary, intradural</th>
<th>Extramedullary, extradural</th>
<th>Extramedial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syringomyelia, hydromyelia</td>
<td>Meningioma</td>
<td>Hemiated disk</td>
</tr>
<tr>
<td>Intramedullary tumor (eg, ependymoma, astrocytoma)</td>
<td>Neurofibroma</td>
<td>Spinal stenosis, spondylosis, osteophyte</td>
</tr>
<tr>
<td>Inflammation (eg, abscess, myelitis)</td>
<td>Metastasis (eg, leptomeningeal seeding or hematogenous)</td>
<td>Ligamentum flavum thickening; intraspinal ligament ossification</td>
</tr>
<tr>
<td>Multiple sclerosis</td>
<td>Meningioma</td>
<td>Neurogenic tumor (eg, neurofibroma)</td>
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<td>Metastasis</td>
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- Intramedullary
- Extramedullary
- Extramedial
used routinely to show extradural, intradural, and intramedullary lesions of the spinal cord. This included lesions caused by localized block of the flow of cerebrospinal fluid (CSF) within the spinal canal. Myelography was revolutionized with the introduction of the first low-osmolar, nonionic water-soluble contrast medium, metrizamide. Metrizamide, which was produced as a freeze-dried powder, was later replaced by low-osmolar, nonionic contrast media in ready-to-use solutions (iohexol, iotrolan). Computed tomography myelography is used in conjunction with conventional myelography for the assessment of spinal lesions. Added information may be achieved with the cross-sectional imaging provided by CT because it enhances the specific areas of abnormality shown on conventional myelography. This procedure also requires injection of nonionic contrast material into the spinal subarachnoid space. The quantity of contrast required is less than for conventional myelographic examinations.

Magnetic resonance myelography uses a high T2 contrast sequence such as a T2-weighted RARE pulse sequence or a refocused gradient echo pulse sequence with strong T2 weighting. These sequences provide a high contrast between the “dark” spinal cord and its nerves and the surrounding “bright” CSF. Magnetic resonance contrast media act predominantly on T1 relaxation, which results in signal enhancement and “positive” contrast. These media can also act on T2 relaxation, which results in signal reduction and “negative” contrast. The positive contrast agents are typically small-molecular-weight compounds containing gadolinium, manganese, or iron as the active element. All have unpaired electron spins in their outer shells and long relaxivities, making them good T1 relaxation agents. Magnetic resonance
myelography as part of an entire MR examination has virtually replaced x-ray myelography. Magnetic resonance is the criterion standard today for spinal cord imaging.

Since the early 1990s, fMRI has been used for evaluation of the brain and, recently, the spinal cord. Within the brain, the hemodynamic response to sensory, motor, or cognitive stimuli can be imaged in normal or pathological states. The mechanism of fMRI is based on the Blood Oxygen Level Dependant effect in which differential changes in brain and/or spinal cord perfusion and their resultant effect on the regional distribution of oxyhemoglobin to deoxyhemoglobin are displayed. These changes are reflected in the different “intrinsic contrast media” effects of the two hemoglobin forms. Although it is used more frequently to image the brain, Backes et al used fMRI to display median nerve stimulation in the normal lower cervical spinal cord. The localization of the segmental fMRI activation (C4-T1) was consistent with known functional neuroanatomy. Magnetic resonance diffusion imaging is also an evolving technique with which to increase our understanding of pathological damage to the central nervous system. Diffusion is a physical property of molecules referring to their ability to move randomly in relation to their thermal energy. Molecular motion is referred to as Brownian motion and it is a random translational movement that occurs at the microscopic level. It is measured in terms of the diffusion coefficient, which, in general, increases in more dilute solutions and has a directional component. Because diffusion is a reflection of very small-scale motion, diffusion imaging is very sensitive to motion. The application of diffusion-weighted MRI sequences involves imaging the diffusion of water for the assessment of diseases such as stroke, demyelination disease, and tumors. Diffusion weighting has been shown to improve the sensitivity of imaging in cases of spinal cord myelopathy.

The treatment options for the management of spinal canal lesions producing myelopathy include pharmacologic treatment (ie, myelitis, abscess), surgical treatment (ie, tumor, syrinx, herniated disk, and spinal stenosis), and spinal manipulative therapy (ie, spondylosis, degenerative joint disorders). Pharmacologic treatment includes corticosteroid, immunosuppressive agents, and chemotherapeutic agents. Surgical treatment includes either anterior or posterior approach according to the diagnosis. Surgical treatment can be osteotomy, laminectomy, vertebroplasty, resection and fusion, and shunting. Radiotherapy is also an option for primary and/or secondary malignancies. Spinal manipulative therapy includes a range of approaches including low-velocity high-amplitude techniques, high-velocity low-amplitude techniques, and spinal stretching and manipulation under anesthesia. Radiotherapy is also an option for primary and/or secondary malignancies.
Signs and symptoms of acute myelopathy represent an absolute contraindication to high-velocity low-amplitude thrust manipulation applied to the anatomic site of involvement.\textsuperscript{14,15} Although one of our patients with chronic posttraumatic syringomyelia was comanaged with spinal manipulative therapy along with medical management, no adverse effects were observed and a subsequent reduction in size of the syrinx was observed. This raises the question whether spinal manipulation in chronic myelopathy should be considered a relative contraindication to high-velocity low-amplitude manipulation.\textsuperscript{16,17}

**Myelopathy with Systemic Lupus Erythematosus**

The involvement of the central nervous system in SLE occurs frequently (24%-51% of patients), but one of the least common forms of neurologic complication is ATM. It has a reported incidence of 0.4% to 0.8% in patients with SLE.\textsuperscript{18,19} Acute transverse myelitis is a process involving the entire thickness of the spinal cord and is a rare disorder. Potential causes of ATM include multiple sclerosis, viral infection (herpes simplex, influenza, Epstein-Barr virus), immunizations (smallpox, influenza), and intoxications (baclofen, penicillins, lead).\textsuperscript{20} The pathophysiologic mechanism of ATM in SLE is uncertain, although vasculitis, arterial thrombosis resulting in ischemic cord necrosis, and white matter degeneration have been postulated.\textsuperscript{19-21}

Acute transverse myelitis is typically diagnosed when a patient presents with a sudden onset of spinal cord dysfunction giving rise to motor, sensory, or sphincter disturbances in the absence of structural lesions such as tumor, hematoma, and vertebral compression fractures.\textsuperscript{19} Commonly, ATM involves 1 to 4 spinal segments in the

**Fig 3.** A 5-month follow-up. $T_1$-weighted sagittal (A), $T_2$-weighted sagittal (B), and $T_1$-weighted axial (C) MRI examination of cervical and thoracic spine of the same 23-year-old patient in Fig 2A, B, and C. They show a significant reduction in the size of the syrinx after treatment (arrow).
thoracic or cervical region of the spinal cord. The most common levels of involvement are T5 through T8. Our patient presented with a lesion localized at the level of C2 likely due to resolving disease. Lupus patients with ATM frequently have other neurologic manifestations, in particular, with optic neuritis. This is known as Devic’s syndrome. Approximately 20% to 48% of ATM patients with SLE have optic neuritis suggesting that a pathophysiologic mechanism similar to multiple sclerosis might be involved.

Cerebrospinal fluid analysis and MRI of the spinal cord are performed for the evaluation of patients suspected of ATM. Cerebrospinal fluid analysis usually shows pleocytosis and an increase in protein with depressed glucose levels. Before the advent of MRI, CT myelography was the principal means of neuroradiological evaluation of patients with transverse myelitis of any etiology. Positive findings in transverse myelitis using CT myelography were limited to localized spinal cord enlargement. The MRI demonstration of spinal cord enlargement is accompanied by the prolongation of T1 and T2 time, resulting in low signal intensity on T1 and high signal intensity on T2. T1 and T2 time prolongation is a common finding in transverse myelitis and is related to the inflammatory pathology.

A sagittal and axial T2 MRI examination shows focal high signal intensity at the level of C2 within the spinal cord. This focal high signal intensity shows lack of contrast enhancement on post-gadolinium T1 MRI examination, which is a feature helpful in distinguishing transverse myelitis from a neoplasm. The absence of contrast enhancement during the periods of clinical improvement may reflect disease remission or be secondary to the stabilizing effect of the high-dose corticosteroid treatment. The differential diagnosis for an intramedullary lesion, dark on T1 and bright on T2 without mass effect, includes acute disseminated encephalomyelitis, transverse myelitis, arteriovenous malformations, cord edema, giosis, multiple sclerosis, and subacute infarction.

Treatment regimes available for SLE-related ATM include high-dose corticosteroid and immunosuppressive agents (intravenous pulses of methylprednisolone and cyclophosphamide). They are administered within the first few days after symptom onset. This treatment suppresses the autoimmune response and the inflammation involved in the vasculitic process. An elevated antiphospholipid antibody should alert the clinician to the need for the prompt initiation of adequate anticoagulation because the risk of thrombosis is high. Acute transverse myelitis has long been recognized as having a high rate of mortality. Death occurs in approximately 50% of patients, permanent deficits in approximately 35%, and full recovery in approximately 15%. The most common causes of death are infection, pneumonia, and pulmonary embolism as the result of immobilization and immunosuppressive therapy.

Myelopathy and Syringomyelia

The formation and clinical presentation of syringomyelia is a poorly understood clinical entity. Syringomyelia is a condition consisting of a fluid cavity formed in the central canal of the spinal cord. It was first described by Bastian in 1867. This formation has been associated with trauma, congenital anomalies, tumors (e.g., astrocytoma, hemangioblastoma, ependymoma), and arachnoiditis. Larner et al also reported on the correlation of inflammatory central nervous system diseases and the formation of central canal cavity lesions. One theory, supported by most authors, is that syrinx formation is most likely the result of aberrant flow of CSF.

Most posttraumatic cases involve cerebellar tonsil herniation or Arnold-Chiari malformation type I. It is not always easy to distinguish this condition from the even more frequent mild cerebellar ectopia, a condition in which the tonsils may be positioned low, although by not more than 3 mm, below the inferior border of the foramen magnum. The pointed morphology of the cerebellar tonsils is also helpful in distinguishing Chiari I malformations from low-lying tonsils. In our case, there was syrinx formation without cerebellar tonsil herniation.

The percentage of posttraumatic cases that develop symptoms is 0.3% to 3.2% and Schurch et al reported it as high as 4.45%. The actual period between injury and onset of symptoms may be from months to years with 65% of cases displaying symptoms within the first 5 years. Most of the syrinx formation tends to be in the cervical or thoracic spine or at the cervicothoracic junction. The differential diagnosis for intramedullary lesions with CSF intensity includes hydromyelia, posttraumatic cystic myelomalacia, syringomyelia, and tumor cyst (cystic neoplasm).

Before the advent of CT and the contrast agent metrizamide, the neuroradiological diagnosis of syringomyelia was complicated and often difficult. Pantopaque and air myelography were used. Pantopaque was used initially, and a swollen cord, if present, was shown with head down or more horizontal positioning. Computed tomography in conjunction with intrathecal injected water-soluble contrast materials quickly replaced gas and Pantopaque myelography in the evaluation of syringomyelia. Posttraumatic syringomyelic cavities, which do not communicate with the fourth ventricle, central canal, or subarachnoid space, regularly filled with metrizamide 2 to 5 hours after intrathecal administration, supporting the belief that water-soluble agents slowly diffused through cord parenchyma. Magnetic resonance has proven to be extremely effective in demonstrating syringomyelia and related abnormalities. Because this technique also has the advantage of being noninvasive, it has virtually replaced water-soluble myelography in the evaluation of this group of abnormalities.

The prognosis of syringomyelia is uncertain. It is completely unpredictable characterized by “extreme clinical...
variability.” Syrinx cavities have been reported to undergo spontaneous resolution, no change in cavity size, slow cavity progression, rapid cavity progression, and death. As far as clinical presentation is concerned, patients with syrinx formation may be completely asymptomatic and experience pain, motor deficits, and paralysis. Other clinical findings included spasticity, sensory loss, weakness, bladder and bowel dysfunction, and headaches. Any of these symptoms may be brought on by, and have been associated with, sudden changes in CSF pressures as seen with lifting heavy objects or Valsalva-type maneuvers. In 1997, Kramer reported spasticity as being dominant in his patients, whereas Schurch reported sensory deficits and changes in deep tendon reflexes as most common. In the past, most syrinx cases had to be diagnosed from clinical presentation, but advanced imaging techniques such as the MRI provide the capacity to diagnose this condition earlier and more often. The capacity to more effectively diagnose this condition also correlates with the increased number of reported cases.

One problem encountered with syrinx cases is the lack of consistency in the reporting of percentages relating the variety of different progressive states. The actual pathogenesis of the disease is also still controversial. Several different theories have been debated for quite some time. One theory is foramen magnum obstruction. In this view, a pressure gradient between the intracranial and intraspinal compartments develops, forcing CSF into the central canal of the spinal cord. But, in the case of syrinx formation without cerebellar tonsil herniation, there must be a different mechanism. Lee hypothesized the formation of subarachnoid adhesions formed at the site of trauma leading to obstructed CSF flow. His patient’s improvement was also independent of the amount of change in the size of the central cavity lesion. Several of his cases reported improvement without a change in size of the syrinx cavity. In the case of posttraumatic syrinx, there is often a cystic cavity at the site of injury. It has been hypothesized that the injury site undergoes edema leading to ischemic necrosis and hematoma. The area is then subjected to enzymatic destruction or liquefaction resorption. The syrinx extension or dissection of the cord is a result of continuous venous pulses from the epidural venous system. If there are subarachnoid adhesions at the injury site, it may block the normal flow, sending the venous pulses back into the central spinal canal extending the size of the original cystic cavity.

**CONCLUSION**

Patients may not present with typical myelopathic symptoms. Therefore, practitioners should be aware of the etiology, pathophysiology, clinical features, laboratory, diagnostic imaging findings, and treatment options pertaining to patients with cervical myelopathy.

**REFERENCES**

COMMENTARY

REFLECTIONS ON THE "TYPE O" DISORDER

Henry Pollard, Grad DC, MSportSc, PhD

In 1979, the Royal Commission into Chiropractic in New Zealand popularized a description of musculoskeletal and nonmusculoskeletal injuries presenting to chiropractors. The terms referred to the treatment of "type M" (musculoskeletal) conditions and visceral "type O" (organic) conditions. Although chiropractors are considered to appropriately treat the type M condition, treatment of the type O condition is not considered as appropriate by many inside and outside the profession. Chiropractors usually cite research into the somatovisceral reflex as a mechanism to support their position. Although this research is of high quality, it is lacking in its direct application to chiropractic management strategies.

Chiropractors have been treating visceral conditions since the inception of their profession. This treatment has been diverse in nature, and some have claimed to be treating all manner of visceral dysfunction and disease. Despite the chiropractic profession being approximately 110 years old, very little research into the effect of chiropractic manual therapy has been conducted in this subgroup of the population of patients who the chiropractor treats. In addition, psychosocial issues have been recognized as important to the work of chiropractors for some time; however, their potential role in the generation of type O disorders has not been so recognized. Although there have been a few attempts at investigating treatment of visceral conditions, much of the data are flawed by limited or poor methodology, and many of the conclusions are weak, irrelevant, or negative in nature (Table 1).2-8 Despite this, some small-power studies have shown positive outcomes for such management (Table 2).9-16 Despite these findings, strong claims are made as to the success of manual therapy on visceral function. Many of the claims cite a mechanism that involves the somatovisceral reflex. This article discusses the relevance of the somatovisceral reflex as the main mechanism in the proposed effect by manual therapy on the type O condition and its relevance to potential management and research.

SCOPE OF PRACTICE

Chiropractors primarily treat patients with neuromusculoskeletal conditions.17,18 It is not surprising that their training is focused toward such management.19 However, Hawk et al17 have estimated that approximately 10% of conditions presenting to American chiropractors are of a nonmusculoskeletal nature. European data suggest a similar figure of 10% or less,20 although some jurisdictions are reported to see considerably less (less than 2% in the Netherlands).21 Interestingly, those practices with the highest proportion of nonmusculoskeletal patients in the United States were more likely to be in populations of greater than 100,000; these physicians used common chiropractic spinal manipulative therapy less often than other practitioners and used more nonadjustive techniques (including diet/nutrition counseling, nutritional supplementation, herbal preparations, naturopathy, and homeopathy).17

Although a diversity of treatment options and conditions is important to primary contact practitioners, so is the training to manage the diversity of conditions that is likely to be encountered with such primary contact status. It appears that as long as chiropractors stay within the realm of the type M musculoskeletal presentations, they may be less likely to fall foul of criticism leveled by the medical fraternity22 and others within and outside the chiropractic profession.18 However, strong criticism usually follows those practitioners who choose to manage nonmusculoskeletal conditions. Much of this criticism is centered on the appropriateness of the care that is delivered, as well as the ability of the chiropractor to diagnose the conditions that are potentially being treated.22 Given the nature of most chiropractic education around the globe, some college curricula would be more deserving of this criticism than others.

In contrast, the treatment of the type O condition is often seen by chiropractors to be (1) part of their scope of practice, (2) a right of practice for a primary contact practitioner, and (3) consistent with the foundation principles of chiropractic and the philosophy on which it is based. Interestingly, this approach is collectively applauded and embraced by many in the profession. Therein lies the dilemma for those entering the debate on the treatment of the type O disorder.

In an attempt to justify the treatment of these conditions and numerous anecdotal reports of success with some of
these conditions, chiropractors have sought to explain the mechanism of what they are doing by using well-established neurophysiologic explanations. The somatovisceral reflex is at the core of this explanation.

**THE SOMATOVISCERAL REFLEX**

The somatovisceral or somatoautonomic reflex is thought to result from the stimulation of somatic structures (skin, muscle, ligament, bone, etc.) to cause a reflex change in the efferent output to a visceral or effector organ. 23-26 These spinal reflexes span the visceral organs and have been investigated by many researchers including Sato 27 and others 28-31 Although this work is of good quality, it is not the validation that is often portrayed by many in the chiropractic profession.

These reflexes are short-term in nature. 32,33 The studies on which they are based have largely been conducted using an animal model and have occurred in normal physiological states or after spinal transaction. 34-36 Very little work has been conducted in a pathological state of visceral function that would equate to a disease state; as well, not as much work has investigated the longer-term nature of the reflexes in normal or pathological tissue.

Even less research has focused on the effect of treatment on the reflexes or their longer-term sequelae in normal or pathological states. In addition, those investigating the somatoautonomic reflexes point to the important role that supraspinal influences have on somatic and visceral structures of the body. 30,37-40 These supraspinal centers refer to the combined action of higher brain centers such as the thalamus, reticular formation, cerebellum, cortex, hypothalamus, and limbic system.

Thus, this may be another potential explanation for the anecdotal success of type O treatments reported by so many chiropractors. This explanation is not normally discussed as being a factor in the etiology or treatment of the type O condition.

### Table 1. Studies citing a positive effect on Chiropractic spinal manipulative therapy on visceral function9-16

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Result of study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vernon et al9</td>
<td>Small increase in serum μ-endorphin levels at the 5-min postintervention</td>
</tr>
<tr>
<td>Yates et al10</td>
<td>Improves systolic and diastolic blood pressure, and reduces state anxiety</td>
</tr>
<tr>
<td>Kokjohn et al11</td>
<td>Chiro SMT may be effective for 1st dysmenorrhea</td>
</tr>
<tr>
<td>Brennan et al12</td>
<td>Enhanced phagocytic cell respiratory burst by SMT</td>
</tr>
<tr>
<td>Peterson13</td>
<td>Decreased the intensity of emotional arousal reported by phobic subjects.</td>
</tr>
<tr>
<td>Wiberg et al14</td>
<td>Is effective in relieving infantile colic</td>
</tr>
<tr>
<td>Walsh &amp; Polus15</td>
<td>Symptoms associated with premenstrual syndrome generally reduced by Chiro STM &amp; soft tissue therapy</td>
</tr>
<tr>
<td>Tuchin et al16</td>
<td>Migraine 90% better in 22% of patients</td>
</tr>
</tbody>
</table>

SMT indicates spinal manipulative therapy.

### Table 2. Studies citing a positive effect on chiropractic spinal manipulative therapy on visceral function9-16

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Result of study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leboeuf et al2</td>
<td>No effect on nocturnal enuresis</td>
</tr>
<tr>
<td>Brennan et al3</td>
<td>No change in lymphocyte profile</td>
</tr>
<tr>
<td>Reed et al5</td>
<td>No change in bed wetting</td>
</tr>
<tr>
<td>Nielsen et al3</td>
<td>Objective changes nil</td>
</tr>
<tr>
<td>Subjective changes (patient-rated asthma severity) decreased by 34%</td>
<td></td>
</tr>
<tr>
<td>Olafsdottir et al6</td>
<td>Chiropractic SMT no more effective than placebo in treatment of infantile colic</td>
</tr>
<tr>
<td>Straub et al7</td>
<td>Chiropractic SMT does not reduce effects of jet lag</td>
</tr>
<tr>
<td>Goertz et al8</td>
<td>For patients with high-normal blood pressure or stage I hypertension, chiropractic SMT + dietary modification program no different to diet alone</td>
</tr>
</tbody>
</table>

### Table 3. Studies that have shown positive outcomes for the treatment of chronic spinal pain45-71

<table>
<thead>
<tr>
<th>Authors</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giles &amp; Muller45</td>
<td>Manipulation</td>
</tr>
<tr>
<td>Andersson et al46</td>
<td>Mobilization</td>
</tr>
<tr>
<td>Blomberg et al47</td>
<td>Chiropractic SMT</td>
</tr>
<tr>
<td>Hagen et al48</td>
<td>0.16</td>
</tr>
<tr>
<td>Mannion et al49</td>
<td>Aerobic exercise</td>
</tr>
<tr>
<td>Descarreaux et al50</td>
<td>Exercise</td>
</tr>
<tr>
<td>Rittweger et al53</td>
<td>Chiropractic SMT</td>
</tr>
<tr>
<td>Mullican &amp; Lacy52</td>
<td>Medication</td>
</tr>
<tr>
<td>Hurwitz et al53</td>
<td>Electrotherapy</td>
</tr>
<tr>
<td>Sherry et al54</td>
<td></td>
</tr>
<tr>
<td>Leibling et al55</td>
<td>Acupuncture</td>
</tr>
<tr>
<td>Molsberger et al56</td>
<td></td>
</tr>
<tr>
<td>Rozenberg et al57</td>
<td>Rest</td>
</tr>
<tr>
<td>Holm58</td>
<td>Surgery</td>
</tr>
<tr>
<td>Chrubasik et al59</td>
<td>Nutrition</td>
</tr>
<tr>
<td>Geurts et al60</td>
<td>Radiofrequency</td>
</tr>
<tr>
<td>Stam et al61</td>
<td>Homeopathy</td>
</tr>
<tr>
<td>Constant et al62</td>
<td>Spa therapy</td>
</tr>
<tr>
<td>Ruoff et al63</td>
<td>Analgesics</td>
</tr>
<tr>
<td>Kumar et al64</td>
<td>Other approaches</td>
</tr>
<tr>
<td>Vlaeyen et al65</td>
<td>Printed material changing</td>
</tr>
<tr>
<td>Kovacs et al66</td>
<td>behavior. The printed material is more effective if accompanied by verbal illustration and support and actual physical performance.</td>
</tr>
</tbody>
</table>

SMT indicates spinal manipulative therapy.
Table 4. Factors that do not predict chronic pain outcomes \(^{72-81}\)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valat et al (^{72})</td>
<td>Weight &amp; height</td>
</tr>
<tr>
<td>Hildebrandt et al (^{73})</td>
<td>Physical variables (ie, mobility, strength, endurance, and physical performance) showed limited predictive value</td>
</tr>
<tr>
<td>Matsui et al (^{74})</td>
<td>Light-moderate physical workloads</td>
</tr>
<tr>
<td>Haas et al (^{75})</td>
<td>Early post treatment success</td>
</tr>
<tr>
<td>Toomingas et al (^{76})</td>
<td>Signs of tenderness in the joints, tendons, or muscular insertions or signs in nerve compression tests</td>
</tr>
<tr>
<td>Bigos et al (^{77})</td>
<td>Physical and injury factors</td>
</tr>
<tr>
<td>Bigos et al (^{78})</td>
<td>Pre-employment screening</td>
</tr>
<tr>
<td>Hicks et al (^{79})</td>
<td>Segmental mobility</td>
</tr>
<tr>
<td>Natvig et al (^{80})</td>
<td>Specific low back pain in workers</td>
</tr>
<tr>
<td>Truchon &amp; Fillion (^{81})</td>
<td>Age, sex, ethnicity, education, and work task probably not predictors</td>
</tr>
</tbody>
</table>

Table 5. Yellow flag factor in chronic pain \(^{82-96}\)

<table>
<thead>
<tr>
<th>Author</th>
<th>Yellow flag factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>George et al (^{82})</td>
<td>Fear avoidance behavior</td>
</tr>
<tr>
<td>van den Hout et al (^{83})</td>
<td>Operant-behavioral factors important</td>
</tr>
<tr>
<td>Kole-Snidjers et al (^{84})</td>
<td>High job dissatisfaction</td>
</tr>
<tr>
<td>Bigos et al (^{85})</td>
<td>High perceived exertion at work</td>
</tr>
<tr>
<td>Krause et al (^{86})</td>
<td>Malaise</td>
</tr>
<tr>
<td>Fordyce et al (^{87})</td>
<td>Monotonous tasks, unsatisfactory social contacts outside work</td>
</tr>
<tr>
<td>Thorbjornsson et al (^{88})</td>
<td>Unemployment &amp; compensation</td>
</tr>
<tr>
<td>Sanderson et al (^{89})</td>
<td>Demands</td>
</tr>
<tr>
<td>Linton (^{90})</td>
<td>Locus of control</td>
</tr>
<tr>
<td>Krause et al (^{91})</td>
<td>Belief that work is dangerous catastrophic thoughts</td>
</tr>
<tr>
<td>Severeijn et al (^{92})</td>
<td>Low workplace social support</td>
</tr>
<tr>
<td>Hoogendoorn et al (^{93})</td>
<td>Low job satisfaction job content and job control</td>
</tr>
<tr>
<td>Hagen et al (^{94})</td>
<td>Feeling of being worn out</td>
</tr>
<tr>
<td>Krause et al (^{95})</td>
<td>Coworker support</td>
</tr>
<tr>
<td>Krause et al (^{96})</td>
<td>Low supervisory support at work</td>
</tr>
<tr>
<td>Linton (^{97})</td>
<td>Stress</td>
</tr>
<tr>
<td>Linton (^{98})</td>
<td>Work pace</td>
</tr>
<tr>
<td>Linton (^{99})</td>
<td>Emotional effort at work</td>
</tr>
<tr>
<td>Kerr et al (^{100})</td>
<td>Physically demanding job poor workplace social environment</td>
</tr>
<tr>
<td>Kerr et al (^{101})</td>
<td>Inconsistency between job education level</td>
</tr>
<tr>
<td>Kerr et al (^{102})</td>
<td>Better job satisfaction</td>
</tr>
<tr>
<td>Kerr et al (^{103})</td>
<td>Low job control (borderline association)</td>
</tr>
<tr>
<td>Valat et al (^{104})</td>
<td>Compensation for a spinal condition, receipt of work-related sickness payments, or litigation</td>
</tr>
<tr>
<td>Hagen et al (^{105})</td>
<td>Poor general health</td>
</tr>
</tbody>
</table>

**Type M vs Type O Management**

Chiropractors primarily treat type M or neuromusculoskeletal conditions. \(^{19}\) They are said to show equal skill in managing these conditions as medical practitioners. \(^{22}\) It is also reported that chiropractors deal with chronic spinal pain syndromes and that their case mix of spinal pain and associated mental health is, on average, often more severe than their medical counterparts. \(^{18}\)

In addition to case mix ratio of the type O to type M conditions, chiropractors treat a great deal of chronic spinal musculoskeletal pain \(^{18,22}\); however, chronic pain is associated with emotional or psychological content. \(^{41,42}\)

**Chronic Spinal Pain**

Chronic pain has attracted much interest in recent years because of the cost of its collective management and the association that it shares with the advent and promotion of evidence-based practice. \(^{43,44}\) Many studies have investigated outcomes associated with chronic pain presentations (Table 3). Table 4 highlights that assessment and treatment of type M conditions usually associated with manual therapy are not predictive of long-term outcomes. \(^{72-81}\)

Although spinal manipulative therapy has shown beneficial outcomes in chronic spinal pain, other forms of therapy have also shown positive outcomes (Table 3). However, no one approach has shown mastery over chronic spinal pain. \(^{81}\)

Other studies have determined that the only predictors of chronicity in randomized controlled trials are the yellow flag presentations (Table 5). \(^{42,47}\) Psychosocial variables associated with pain are commonly referred to as yellow flags. \(^{95}\) These yellow flags include several variables related to attitudes and beliefs about pain and behavior associated with pain. They include issues of compensation, diagnosis, treatment factors, analysis, family, and work. \(^{95}\) Despite that the yellow flags are usually used in isolation, red flag and yellow flag conditions are not mutually exclusive. \(^{95}\) Red flag conditions are those that may alert the practitioner to serious and potentially uncommon conditions that require urgent medical management. \(^{97}\)

Yellow flags have been recognized as being important in the chiropractic treatment of low back pain. \(^{1}\) The usual clinical factors are poor or weak predictors of progression of acute pain to a chronic state. \(^{97}\) Chronic progression is generally predicted by yellow flags, and it is highly likely that the yellow flags are etiologic in the progression from acute to chronic pain. \(^{98-100}\)

To date, there has been only one set of yellow flag clinical observations that has been operationally defined. \(^{101}\) The Waddell nonorganic signs (Fig 1) have shown the ability to predict chronicity when a high score on the 7-inventory test is measured. \(^{102}\) The performance of this inventory entails a series of physical examinations that are not expected to aggravate pain. Despite that the authors believe a high score is reflecting fear and or anxiety on the part of the subject, \(^{106}\) many clinicians have incorrectly interpreted this to be indicative of a malingering. \(^{102}\)
YELLOW FLAGS AS THE SUPRASPINAL INFLUENCES IN CHRONIC PAIN?

From a treatment perspective, outcomes in chronic pain have been shown to be improved by analgesics, exercise, and cognitive/behavioral therapies. Colloquially, this translates to patient advice that reads, “Move the injured area, keep a positive mental attitude and if it’s sore, use a pain killer.” Despite that some chiropractors would consider such advice unsavory, there is strong efficacy to such advice. This is true compared with the more customary intervention of chiropractors of manual or electrotherapy options. These interventions have been shown to have mixed evidence as to their efficacy. These interventions have been associated with positive or no effective outcome in controlled studies. This finding is as important as it is surprising for manual therapists. It signals a clear association between cognitive processes and chronic pain. Moreover, it could be argued that as chiropractors treat the chronic pain syndromes successfully, they are also influencing the supraspinal centers as well. This mind-body association leans more toward a vitalistic approach to health care than it does the more common mechanistic approach.

Thus, a potential cause-and-effect mechanism could be proposed for the action of manipulation on the supraspinal centers. This mechanism involves not just local spinal reflexes or reflexes that are primarily mechanonociceptor-based but other supraspinal or psychological reflexes. In addition to the potential supraspinal influence on type M disorders, research has also shown that many type O disorders have a distinct supraspinal component. Furthermore, there is evidence that a reduction of this supraspinal effect may be beneficial to the patient outcome.

TREATMENT OF THE TYPE O CONDITION

Despite anecdotal claims of success with type O conditions, success in management is not guaranteed nor is it predictable. Treatment is at best a trial of therapy rather than a known quantity. Unfortunately, some practitioners are overzealous in their expectation of outcome, and this expectation is conveyed to the patient. Although such a positive expectation can be associated with its own positive outcomes, it is irresponsible to claim a certainty in outcome when none has been established.

Aside from the elucidation of the mechanistic action of the treatment effects of the chiropractic model of type O treatment, the ability of the chiropractor to diagnose specific conditions and, potentially, to refer patients for more appropriate management continues to be a thorn in the side of the profession. I propose that it is for these reasons that chiropractic treatment of the type O condition is often questioned.

DOES MEDICINE CONSIDER THE YELLOW FLAGS IN TYPE O CONDITIONS?

Medicine has traditionally operated in the biomedical model. This model focuses on a tissue in lesion and is both mechanistic and pathological in orientation. This model easily explains the “red flags,” but does not explain the influence of the “yellow flag” psychosocial influences on pain. In the biomedical model, all disease is described for derangement of underlying physiochemical mechanisms. It is reductionist and exclusive and leaves no room for social, psychological, or behavioral dimensions of illness. The biomedical model has been rejected by some in the last 20 years in favor of a biopsychosocial model. The biopsychosocial model is defined as a framework for understanding the integration and interplay of the biologic, psychological, and social dimensions of health, disease, and health care.

The effective integration of the biopsychosocial model requires 3 component parts. These include (1) a stressful event or challenge to the system, for example, an exposure to an infectious agent, loss of a family member, or problems
at work; (2) a physiologic vulnerability, for example, a predisposition to bronchial spasm; and (3) a compromise of one or more pathophysiologic systems: immune, nervous, cardiovascular, and others.

It would appear that allopathic medicine is slowly adapting to the biopsychosocial model and that a whole new area of research referred to as neuropsychoimmunology has developed to investigate the model. To illustrate this adaptation, Katon et al found that patients with chest pain and normal coronary arteriograms had a higher level of anxiety, depression, and panic disorder than those with normal psychosocial characteristics and arteriographic studies that showed coronary stenosis.

Thus, supraspinal influences seem to be operating on visceral structures too. Medicine is recognizing these factors and beginning to act on them to improve patient outcomes. Despite that chiropractors may be aware of the psychosocial aspects of chronic musculoskeletal pain, do they collectively consider similar influences on the visceral structures? Moreover, do they consider the supraspinal influences on both type O and type M conditions to be important in the generation and treatment of these conditions?

Thus, it would be important for the chiropractic profession to consider this potential mechanism for the cause and treatment of not only the type M conditions, but also the type O conditions. This consideration should be undertaken as there appears to be compelling evidence (albeit indirect) that psychovisceral reflexes may be operating at least as much and probably more than the much-vaunted somatovisceral reflex. Chiropractors should consider embracing the role of the supraspinal factors in the etiology and treatment of their patients.

**REFERENCES**


CHANGES IN CEREBELLAR BLOOD FLOW AFTER MANIPULATION OF THE CERVICAL SPINE USING TECHNETIUM TC 99M ETHYL CYSTEINATE DIMER

To the Editor:

Cagnie et al. suggested that there may be a relationship between cervical manipulation and hypoperfusion in the anterior lobe of the cerebellum. However, we consider that other methodologically uncontrolled factors were more likely to have contributed to their findings. Moreover, the authors did not provide enough evidence to single out manipulation and its influence on the vertebral artery (VA), concluding that it may have contributed to the reported cerebellar hypoperfusion.

It does not seem plausible that unilateral hypoperfusion would occur in the anterior lobe of the cerebellum as a result of unilateral VA compromise while sparing the more proximal vessels. If hypoperfusion were to occur as a consequence of unilateral VA compromise, one would expect involvement of the posterior inferior cerebellar artery, which was not reported. Furthermore, if unilateral VA blood flow compromise were to occur, blood from both VAs would be combined while passing through the basilar artery, before reaching the left superior cerebellar artery (SCA). Accordingly, any decreased blood flow emanating from the VAs would be much more likely to affect both SCAs. The authors mentioned this scenario as a limitation of their study but went on to conclude, “...that cerebellar hypoperfusion may occur after the type of cervical manipulation that was used in this study.”

The authors cited two articles that were purported to report infarction in the region supplied by the SCA that was associated with stenosis of the ipsilateral VA. After checking these sources, however, the articles that were referred to did not support a contributing relationship that would be applicable to their findings. The article by Bonkowsky et al. reported a case of infarction in the region supplied by the SCA and concomitant VA stenosis at the C2 level, but they went on to state, “...a thromboembolism of the left SCA is most likely to explain the infarct in our case.” The other article discussed the blood supply of the cerebellum and presented clinical characteristics on 10 patients who experienced cerebellar infarcts. It also mentioned the possibility of artery-to-artery embolization but presented nothing that would support a contributory relationship between stenosis of the VA and unilateral infarction of the SCA territory.

In summary, the authors’ statement that cerebellar hypoperfusion may occur after the type of cervical manipulation that was used in their study is not supported by their data. Cerebellar hypoperfusion may have occurred after several other aspects of the procedure that was used (ie, head positioning or head movements that were associated with the manipulative procedure) or equipment malfunction that may have systematically introduced an artifact simulating hypoperfusion. Inclusion of a nonthrust control group or having some of the participants receive manipulation on the opposite side could have answered some of these questions. As it stands, compromise of the VA blood flow should not have been singled out as the most likely contributing factor of hypoperfusion in the anterior lobe of the cerebellum as was presented.

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DOI of original article 10.1016/j.jmpt.2005.01.005
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REFERENCES

RESPONSE TO THE LETTER TO THE EDITOR BY HANELINE

In Response:

We understand the concerns of the responders; however, because limited literature is available concerning the connection between manipulation and cerebellar perfusion, we can only rely on hypotheses. Until now, predominantly case reports and small case series have linked vertebrobasilar insufficiency to therapeutic neck manipulations. To the best of our knowledge, this is the first study that investigates the connection between manipulation and cerebellar perfusion, which we believe is critical for the development of effective therapeutic and preventive strategies.

Bonkowsky et al. (2005) reported a case of infarction in the region supplied by the SCA and concomitant VA stenosis at the C2 level. They attributed the infarction to a thromboembolism of the left SCA, as no other contributing factors were mentioned. In our study, we did not observe such a scenario and therefore did not report it as a limitation of our study.

The authors cited two articles that were purported to report infarction in the region supplied by the SCA that was associated with stenosis of the ipsilateral VA. However, after checking these sources, we found that the articles did not support a contributing relationship that would be applicable to our findings. The article by Bonkowsky et al. (2005) reported a case of infarction in the region supplied by the SCA and concomitant VA stenosis at the C2 level, but they went on to state, “...a thromboembolism of the left SCA is most likely to explain the infarct in our case.” The other article discussed the blood supply of the cerebellum and presented clinical characteristics on 10 patients who experienced cerebellar infarcts. It also mentioned the possibility of artery-to-artery embolization but presented nothing that would support a contributory relationship between stenosis of the VA and unilateral infarction of the SCA territory.

In summary, the authors’ statement that cerebellar hypoperfusion may occur after the type of cervical manipulation that was used in their study is not supported by their data. Cerebellar hypoperfusion may have occurred after several other aspects of the procedure that was used, such as head positioning or head movements that were associated with the manipulative procedure. Therefore, the assessment of the effect of cervical spine manipulation on blood flow to the hindbrain may be more clinically valid if measurements are made distal to the
believed point of restriction, as is the case in transcranial Doppler sonography or single photon emission computed tomography.

The relation between upper cervical spine manipulation and hypoperfusion in the anterior lobe of the cerebellum remains hypothetical. We expected to find a hypoperfusion in the posterior inferior cerebellar artery (PICA) region but found a decreased perfusion in the superior cerebellar artery (SCA) region. One of the hypotheses may be that end-to-end anastomoses may compensate hypoperfusion in other regions of the cerebellum. End-to-end anastomoses exist between the SCA, PICA, and anterior inferior cerebellar artery (AICA). The most important and constant anastomosis is that between the SCA and the PICA, for which the name of Lazorthes has been proposed. The communicating arteries are normally small and cannot immediately deliver the required amounts of blood if one of the major arteries is suddenly occluded. They can, however, provide alternative sources of blood in the event of a progressively occluded artery. Therefore, we can assume that manipulation induces occlusion of one vertebral artery (left in this case), which results in hypoperfusion in the PICA region and will be compensated, through anastomoses, mainly by the SCA but also by the AICA, which will become hypoperfused. To investigate this hypothesis, injection with $^{99m}$Tc ECD should be given earlier (1-2 minutes before the manipulation) so that what happens with the blood flow can be explored. It should also be interesting to know how the cerebral blood flow is influenced the next 24 hours. This requires the same protocol but with a longer time frame between manipulation and injection. However, because this investigation is quite costly and rather invasive, it is not that easy to do this study over and over again.

According to the responders, cerebellar hypoperfusion may have occurred following several other aspects of the procedure that was used, such as head positioning or movements. The mechanism on how manipulation can influence the cerebellar blood flow is still not known. Manipulation is composed of a head position and a thrust. We think that the hypoperfusion exists as a consequence of neck movements in combination with rapid stretching of the vessel. For certainty, the same study should be redone without the thrust component.

We are convinced that this study contributes to the knowledge of the effect of cervical spine manipulation on cerebellar perfusion. There is a need for further investigations regarding the relationship between both because, until now, minimal fundamental research has been done to prove this link.

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REFERENCES

CHANGES IN CEREBELLAR BLOOD FLOW AFTER MANIPULATION OF THE CERVICAL SPINE USING TECHNETIUM 99M-ETHYL CYSTEINATE DIMER

To the Editor:

Cagnie et al1 made a statement in their article that concerns me: “In this study, a lateral manipulation technique was used, as it was considered unethical to use the rotational technique, in view of the knowledge that this technique may be associated with the highest frequency of adverse responses.” However, evidence that any particular vector is riskier than others is at best scant. Even if there were data showing rotational manipulation to be riskier, then the authors would be guilty of having been “unethical” by their own standards because their maneuver included rotation1: “The head was slightly rotated to the right and laterally flexed to the opposite side...” This is a perfect description of a chiropractic adjunctive procedure known as the “modified rotary break.” One is at a loss to understand why the authors endorse the modified rotary break and yet find rotation unethical, unless they mean to protest highly rotated maneuvers, in which case most would agree. Indeed, it is not a good idea to use excessive force in any direction, which could result in a sprain/strain.

There is some evidence that upper cervical restrictions are best addressed by rotational manipulation.2 Thus, for whatever increased risk that may be posed by rotational procedures (if any), there may be increased benefits in terms of enhanced rotational range of motion. There are data linking automobile accidents to decreased cervical range of motion; thus, more trauma is conceivably avoided using rotation than trauma created using it.3 As always, intelligent clinical decision making depends on careful risk-benefit analysis. Where this amounts to a question mark divided by question mark, as in this case, it is not helpful to toss around the word “unethical,” which tends to close the door to continuing dialogue.
REFERENCES


RESPONSE TO THE LETTER TO THE EDITOR BY COOPERSTEIN

In Response:

The responder’s main concern is the description and use of the manipulation technique.

Because we are not chiropractors but manual therapists, we are not familiar with the kind of terminology the responder uses. However, although the terminology differs, we think the same types of manipulation are used among chiropractors, manual therapists, and osteopaths. The technique we used was a “gapping technique,” such that, as the impulse was directed toward the right shoulder, the prime mover is lateral flexion, not rotation. We speak of a rotational manipulation (translation technique) when the impulse is directed toward the eyes (in cases of cervical spine manipulation). In this case, rotation is the prime mover.

We agree with the responder that the use of the word unethical is exaggerated in this case and only accounts for those techniques where excessive forces and highly rotated maneuvers are used. Today, using excessive forces and movements are inadmissible. We hope these techniques are definitely banished, although we are not quite sure about that. We hope this answer satisfies the responder and further opens the door to continuing dialogue.