Prolonged static work postures and posture constraints imposed by surgical equipment may increase the risk of musculoskeletal pain and discomfort in surgeons. Four surgeons were video recorded performing live microsurgery and a work sampling methodology was used to quantify their upper body postures, investigating the proportion of static and dynamic postures, and compare surgeon postures to the postures found in laboratory studies. Surgeons were found assuming flexed postures in their neck, shoulder, elbow, and back. Most of the procedure consists of static postures where movement greater than 10 degrees per second was not frequently detected in our sampling. Of the four surgeons, one surgeon was found on average to have lower neck flexion than the other three. Further investigation showed the surgeon looking through the microscope at a distance to assume a more upright neutral posture. Identifying surgeon work postures is a key step to understanding how to reduce musculoskeletal pain and discomfort.

INTRODUCTION

Prolong static work postures is a well-known risk factor for neck and upper limb disorders in computer workers due the increase neck flexion while using the monitor (Szeto et al. 2005, Hirms-Ridgal et al. 1986). Similar postural risk factors may be present in surgeons and may contribute to the rising prevalence of discomfort and pain seen in surgeons (Park et al 2010). In particular, surgeons that work with monitors or visual augmentation equipment may be especially at risk due to postural constraints imposed by the equipment (Yu et al. 2011).

In office work, many interventions has been implemented to reduce worker exposures (i.e. Adjustable work stations, ergonomic posters, mandatory breaks); however, unlike office work, similar interventions are difficult to implement in the operating room since they may interrupt workflow or the difficulty due uncontrollable factors like patient characteristics and operating location. More investigation is needed to understand how surgeons interact with their equipment and environment so instrument and workplace designs can be created to reduce musculoskeletal (MS) symptoms and improve surgeon performance.

This study examines surgeon postures in video recordings of live surgery to identify potential posture risk factors that may cause discomfort and MS symptoms in surgeons. Specific aims include: quantifying upper body posture of surgeons and investigating the proportion of static and dynamic postures.

METHODS

To achieve the stated aims, a field observation study was conducted to quantify surgeon postures during microsurgery that requires a use of a microscope. More specifically, microvascular anastomosis microsurgery cases were collected. In microvascular anastomosis, surgeons use a surgical microscope to join blood vessels from transplant tissue to the patient. This surgery usually requires two surgeons operating under the microscope, with a lead surgeon performing series of cut, grasp, and suture actions, while the assistant irrigates and holds the tissue in place. This study focused on microvascular anastomosis because: 1) it is frequently performed at large teaching hospitals, 2) the procedure is performed by many surgical specialties, and 3) the use of microscope equipment may constrain upper body postures and limit natural changes in body postures.

Subjects

A total of eight lead surgeons from a large teaching hospital were recruited for this study. Because microvascular surgery is usually done with an assistant surgeon simultaneously using the microscope, data from a total of sixteen different surgeons were collected. For this pilot study, data from four surgeons were analyzed.

Data Collection

Seventy-three procedures were video recorded using a Sony HD video camera. These recordings and the participation of the surgeons was approved by the Institutional Review Board of the university’s medical school. All participating surgeons and their patients provided consent prior to the recording. In most cases,
the video camera was placed perpendicular to the surgeon’s sagittal plane to record their upper body flexion angles. However, due to operating room constraints and surgical workflow impediments, the angle of the camera with respect to the sagittal plane may deviated up to ± 30 degrees for some cases. The four cases presented in this pilot study were all recorded at angles close to perpendicular to the surgeon.

**Analysis Procedure**

To quantify the postures that surgeons are constrained to during surgery, a work sampling approach was used. The length of the procedures analyzed was between 34 minutes to 113 minutes. Since microsurgery is assumed primarily to be static postures (>95% of the time), a sample size of 100 frames was chosen to achieve at least 95% confidence with 5% accuracy. For each of the four cases, 100 sample frames were randomly selected using Microsoft Excel random number generator.

Dynamic postures and the movements made by the surgeons were also quantified using work sampling. For each of the 100 random frames, the video was played for one second. If a study team member noticed any upper body movement, the frame 1 second after the sampled frame would also be analyzed. If the differences in posture between the two sequential frames is greater than 10° (representing velocity of 10°/second), it is recorded as surgeon movement.

**Data Analysis Software**

Video recordings of the cases were analyzed on a custom Visual Basics software program. The software that allowed the user to upload a video file and play selected frames of the video. The software interface (Figure 1) allows the data analyst to click on any location on the video with a mouse.

Upon clicking the video, x-y coordinates of that location would be recorded in an excel spreadsheet with its respective time-stamps. Six locations (Figure 2) were marked for each sampled frame. The six points include: Iliac Crest of the hip, fifth metacarpal on the hand, styloid process of the ulna, epicondyle of the elbow, acromion of the shoulder, and near the top of the ear on the head. On the occasions when the camera is not perpendicular to the surgeon (when surgeon moves), simulated angles are estimated by the study team member using pictures showing different degrees of arm and upper body flexion. Some frames were skipped when there is a visual obstruction such that even a simulation of angles is not possible.

**RESULTS**

**Flexion Angles Results**

From the random sampling of frames and subsequent calculation of angles, means and standard deviations for neck, shoulder, elbow, and back flexion were found (Table 1). Positive neck flexion angle represents neck flexion between the head-neck link and the body’s vertical axis. The shoulder angle is the angle formed by the hip, shoulder, and elbow. The elbow angle

![Figure 1: Posture sampling software interface](image1)

![Figure 2: Camera view. Red circles indicate marker locations](image2)
is formed by the shoulder, elbow, and wrist. Thus, angles less than 90 degrees represent flexion and angles greater than 90 degrees represent extension. The back angle is the angle formed by hip-shoulder link and the axis perpendicular to the floor. The mean neck flexion and back flexion angles are similar between all surgeons; however, surgeon four on average has less shoulder flexion than the others. Surgeon three on average has more elbow flexion and more shoulder flexion than the other three surgeons.

Table 1: Mean ± SD flexion angles by surgeons in degrees

<table>
<thead>
<tr>
<th>Surgeon</th>
<th>Neck</th>
<th>Shoulder</th>
<th>Elbow</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17±9</td>
<td>23±5</td>
<td>101±11</td>
<td>16±4</td>
</tr>
<tr>
<td>2</td>
<td>25±16</td>
<td>26±16</td>
<td>97±14</td>
<td>14±4</td>
</tr>
<tr>
<td>3</td>
<td>22±8</td>
<td>56±15</td>
<td>57±18</td>
<td>10±4</td>
</tr>
<tr>
<td>4</td>
<td>25±21</td>
<td>8±6</td>
<td>91±12</td>
<td>7±4</td>
</tr>
</tbody>
</table>

To further examine the neck postures of surgeons performing microsurgery work, a bar graph is presented with the average and standard deviation marked (Figure 3). While surgeon 2, 3, and 4 have similar neck flexion while surgeon 1 has much less flexion.

Figure 3: Graphical representation of neck flexion angles for all four surgeons

By compiling the sample points, an estimate of surgeon posture over time can be made and the neck flexion through time for one surgeon (Figure 4). The points are primarily centered around 20 degrees, however, the time plot shows several instances where the surgeon assumes neck postures with flexion as high as 55 degrees and as low as zero degrees. These unique points represent times when surgeons bend down to examine the patient (higher flexion) or when the surgeon moves away from the microscope to rest and assume postures with less neck flexion.

Figure 4: Neck flexion angle by time for one surgeon

Posture Movement Results

Using a sampling methodology, dynamic movements can also be quantified by examining the frames adjacent to the sampled frame. Table 2 shows the number of times when flexion angles between two adjacent frames were greater than 10 degrees. Of the four flexion angles measured, movement in the neck is most common, followed by the elbow. During the surgery, movements more than 10 degrees/second were least common in the shoulder and back. More shoulder movement was found in Surgeon 3.

Table 2: Number of movements found by sampling

<table>
<thead>
<tr>
<th>Surgeon</th>
<th>Neck</th>
<th>Shoulder</th>
<th>Elbow</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
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<tr>
<td>3</td>
<td>15</td>
<td>1</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

To assess the movement of the surgeon in respect to the microscope, the horizontal distance between the head marker and the microscope optics is calculated for each surgeon (Table 3).

Table 3: Horizontal distance between the head and microscope optics (mean ± SD)

<table>
<thead>
<tr>
<th>Surgeon</th>
<th>Distance Head to Microscope (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12.2±8.1</td>
</tr>
<tr>
<td>2</td>
<td>18.8±6.2</td>
</tr>
<tr>
<td>3</td>
<td>7.5±3.3</td>
</tr>
<tr>
<td>4</td>
<td>16.8±4.1</td>
</tr>
</tbody>
</table>

Plotting the distances by time can illustrate how long surgeons spend close to the microscope. In Figure 5, there are thirteen points where the surgeon is not next to the microscope.
DISCUSSION

Investigating the posture exposure of surgeons performing live surgery is a key step to reducing the discomfort and MS symptoms in surgeons. From the flexion results, the average time surgeons spend while working are in postures away from neutral. This is especially pronounced in the neck and shoulders. Average shoulder flexion was seen as high as 56 degrees. Using biomechanics, it can be calculated that shoulder stresses would be much higher in a high flexion posture than when compared to neutral postures. Identifying extreme angles can be important for reducing discomfort and MS symptoms in surgeons.

An interesting finding among the neck flexion angles is that Surgeon 1 assumes postures that on average have less flexion than the other surgeons. A closer examination of Surgeon 1 (Figure 6) reveals a markedly different working method than the other surgeons seen in Figure 3. Unlike the surgeon in Figure 3, Surgeon 1 does not rest his eyes on the microscope optics. Instead, he peers into the scope at a distance. Using this technique this surgeon can assume more neutral neck flexions than what is seen from the other surgeons.

This work presents pilot data towards understanding the surgeon workplace exposure to postural risk factors with the overall aim of understanding MS discomfort and pain in surgeons, in particular, microsurgeons due to constraints imposed by the microscope. More work is needed to link posture exposures to surgeon discomfort and injuries.

References


