

Surgical Ergonomics in Otolaryngology

John P Gleysteen, MD

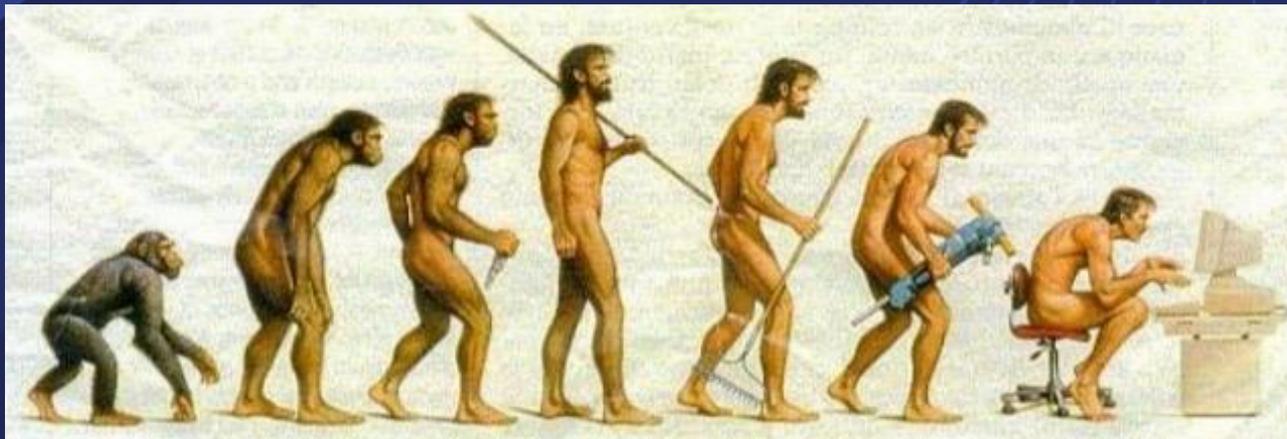
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Outline

- Ergonomics- Definition, History
- What is the problem today?
- Literature review
- Ergonomic considerations for improvement

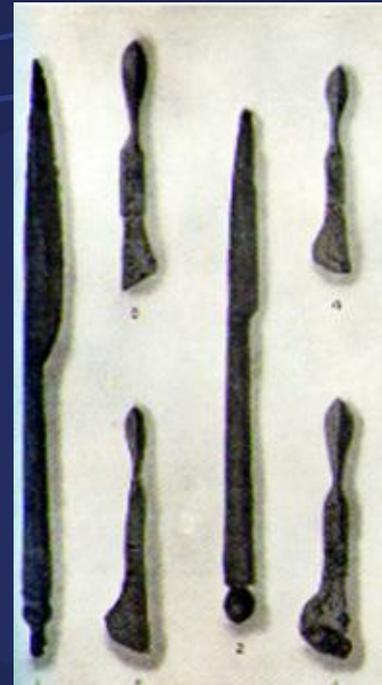
Ergonomics

- In Greek, “Ergo” means work, “Nomos” means natural laws or systems
- Applied science concerned with designing products and procedures for maximum efficiency and safety
- based on anatomy, physiology, psychology, and engineering.
- Modifies tools and tasks to meet the needs of people, rather than forcing people to accommodate the task or tool
- Integrating the surgeon into the working environment, or better yet, accommodating the environment to the surgeon



Ergonomics - Historical Glimpses

- “Let your surgery for cataract be done by the light of the sun at noon”
Arab physician Albucasis, 1000 AD
- Late 1700s- knife handles which had been circular in section became hexagonal for easier grasp
- Early 1800s - development of different types of forceps where handles and jaws could be locked in position by a single gripping movement with one hand
- Modern type of scissors with a hinge at the screw joint began being used in surgery for delicate dissection in late 1800s



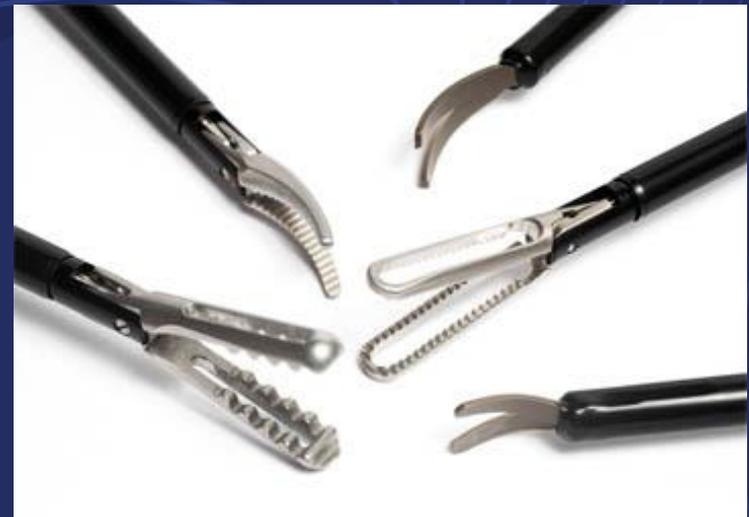
Ergonomics - Modern Advancements

- Microsurgery- beginning in early 70's
 - More accurately see fine detail
 - Control fine movements of hand and tremor
 - Design seating and workplace layout
 - Instrument design



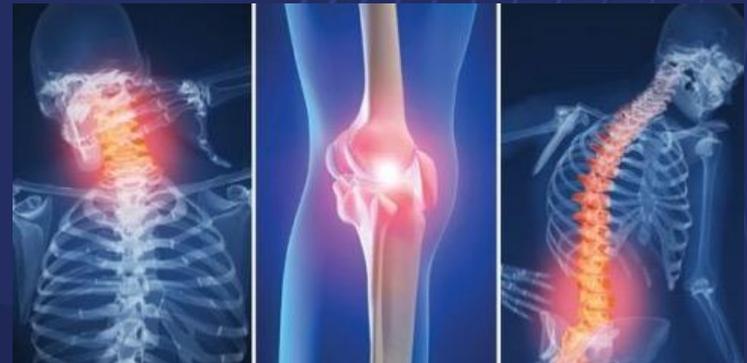
Ergonomics - Modern Advancements

- Microsurgery- beginning in early 70's
 - More accurately see fine detail
 - Control fine movements of hand and tremor
 - Design seating and workplace layout
 - Instrument design
- Laparoscopic surgery- 1990s
 - Hand-eye coordination
 - Long thin instruments with opening jaws/blades, rotation/angulation
 - Interpretation of 3D space from 2D display
 - Integrating complex systems in crowded ORs
- Endoscopic sinus surgery
- Robotic surgery



Ergonomics

- “Looked at from the ergonomic point of view most major operations are, at first sight, a mess”
- Surgical Ergonomics
 - Visualization
 - Manipulation
 - Posture
 - Mental and Physical Workload
 - OR Environment





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“In my day, we didn’t concern ourselves with wimpy notions of workplace ergonomics.”

What is the Issue?

- Surgery may require the adoption of awkward body postures, static muscular loads
 - Increased compressive, shear, and tensile forces on musculoskeletal tissues
- Jobs that require neck flexion greater than 15 to 20 degrees are associated with tension myalgia (Ariens GAM et al. Occup Environ Med. 2001)
- Observational posture studies indicate that surgeons spend >50% of their time in the OR with head in flexion, thus increasing their risk for musculoskeletal disorders of neck (Kant IJ, Int Arch Occup Environ Health, 1992)

What is the Issue?

- Cervical degenerative disc disease

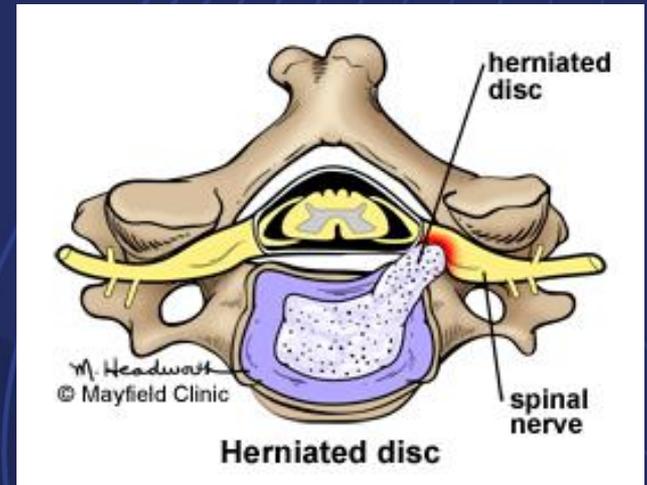
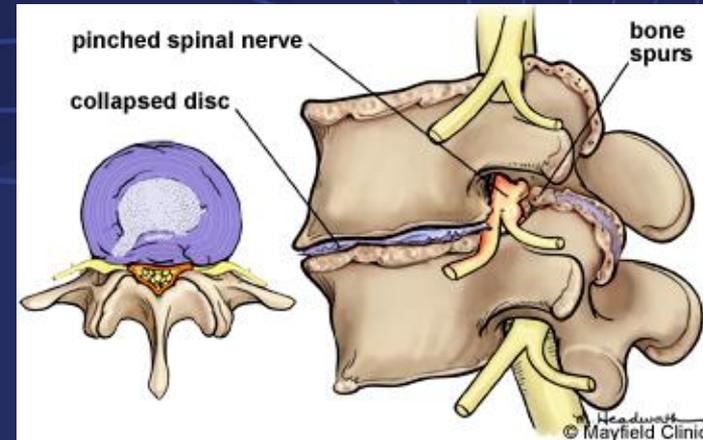
- Discs can dry out and shrink, reducing the disc space between vertebrae. Bone spurs and tears in the annulus may develop which can lead to spinal stenosis and disc herniations, respectively

- Cervical herniated disc

- occurs when the gel-filled nucleus material escapes through a tear in the disc annulus and compresses the spinal nerve

- Cervical radiculopathy

- Term for one or more pinched nerves or nerve roots along the spine. Pressure where the nerve connects to the spine (nerve root) can cause pain, weakness and other symptoms.



What is the Issue?

- General surgeons (Park et al, J Am Coll Surg 2010)
 - Survey of 319 general laparoscopic surgeons showed that 86.9% experience physical discomfort or symptoms directly related to performance of surgery
 - Higher incidences directly associated with frequency of cases performed, unrelated to surgeon age or years in practice
- Dentists (Finsen et al, Appl Ergon 1998)
 - Survey showed symptoms of discomfort for dentists occurred in the wrists/hands (69.5%), neck (68.5%), upper back (67.4%), low back (56.8) and shoulders (60%)

What is the Issue?

- Plastic Surgeons (Capone et al, Plast Reconst Surg 2010)
 - Survey of 339 found that 81.5% complained of musculoskeletal symptoms
 - Microscope usage of 3 or more hours per week was associated with cervical and thoracic pain
 - Sampling appears to suffer more than other labor-intensive populations

What is the Issue?

- Otolaryngologists (Babar Craig et al, JLO 2003)
 - A national survey of 325 otolaryngologists in the UK demonstrated that 72% had back pain and/or neck pain
 - Otology had the highest prevalence of back and neck pain followed by head and neck surgery and rhinology.
 - Two surgeons required operative intervention with ACDF
 - One surgeon required a neck collar on a regular basis for neck pain, another had stopped ear surgery all together due to severe neck pain.
 - Rhinology study (Little et al, Int Forum Allergy Rhinol, 2012)- 77% of respondents experienced physical discomfort or symptoms associated with endoscopic sinus surgery

Is there an Increased Incidence of Cervical Degenerative Disease in Surgeons who use Loupes and a Headlight?

Deshdeepak Sahni¹, Kevin B. James¹, John Hipp², Stephanie Holloway¹, Rex A. W. Marco^{1*}

- Questionnaire distributed to fellowship trained spine surgeons at conferences
- Part one assessed the current level of neck pain compared to prior to residency
 - $\text{Headgear Hours} = \text{Years in practice} * \text{Months/year headgear usage} * \text{Cases/month} * \text{Hours/case}$
- Part two assessed whether a specific diagnosis or treatment associated with neck symptoms rendered
- Placed into two groups for comparison
 - Group A: non- or infrequent users of headgear
 - Group B: frequent users

Is there an Increased Incidence of Cervical Degenerative Disease in Surgeons who use Loupes and a Headlight?

Deshdeepak Sahni¹, Kevin B. James¹, John Hipp², Stephanie Holloway¹, Rex A. W. Marco^{1*}

Groups	Number of Surgeons	Avg. headgear-hrs	Number with an increase in severity of symptoms after headgear usage	Avg. increase in severity of symptoms on VAS	Number with an increase in frequency of symptoms after headgear usage	Avg. increase in frequency of symptoms: scale 1-3	Number of Surgeons receiving treatment
A – use headgear < or = 3x/month	13	1826	5 (38%)	4	3 (23%)	1.5	4 (31%)
B – use headgear > 3x/month	41	10424	28 (68.3%)	4.1	25 (61%)	1.5	24 (58.5%)
			P=0.027		P=0.04		

Table 1: Respondent analysis. Statistical significance at P<0.05.

- No surgeon in group A received any invasive treatment (injection or surgery), none required narcotics
- 2 surgeons in group B received surgery for their pain (ACDF), one is now disabled and unable to operate
- Logistic regression analysis showed that frequent headgear users are 3.8x more likely to have a worsening of symptoms (P=.05)

What is the Issue?

‘Text neck’ is becoming an ‘epidemic’ and could wreck your spine

- “Smartphone users spend an average of two to four hours per day hunched over, reading e-mails, sending texts or checking social media sites. That’s 700 to 1,400 hours per year people are putting stress on their spines, according to the research. And high-schoolers might be the worst. They could conceivably spend an additional 5,000 hours in this position”
- “Over time, researchers say, this poor posture, sometimes called ‘text neck’ can lead to early wear-and-tear on the spine, degeneration and even surgery”

What is the Issue?

‘Text neck’ is becoming an ‘epidemic’ and

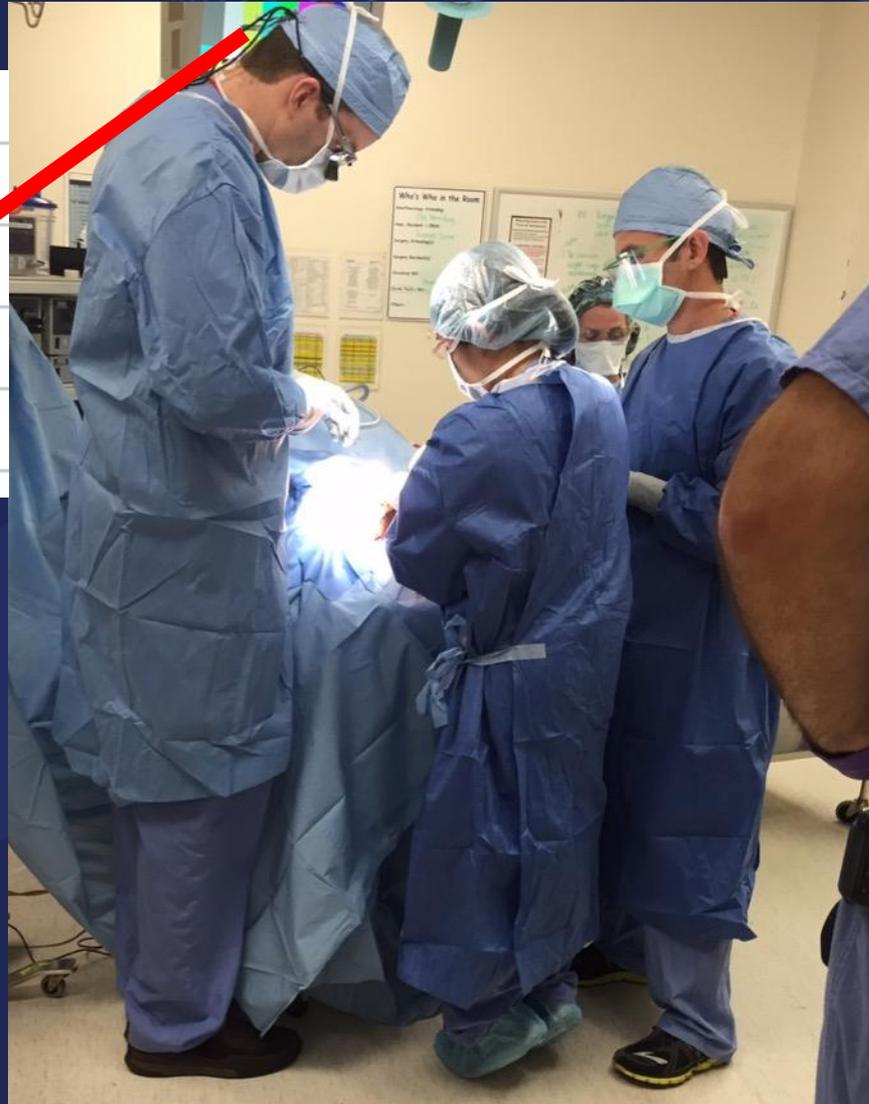
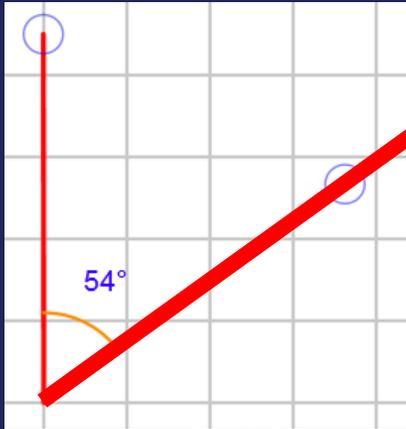


Assessment of Stresses in the Cervical Spine Caused by Posture and Position of the Head



Position	Neutral	15 °	30°	45 °	60 °	90°
Force To Cervical Spine	10-12lbs.	27lbs.	40lbs.	49lbs.	60lbs.	Not Measurable

Figure 1. The weight seen by the spine increases when flexing the neck at varying degrees. An adult head weighs 10-12 pounds in the neutral position. As the head tilts forward the forces seen by the neck surges to 27 pounds at 15 degrees, 40 pounds at 30 degrees, 49 pounds at 45 degrees and 60 pounds at 60 degrees.





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“No wonder your arm aches. Shackles should be placed at eye level. Man, it’s an ergonomic nightmare down here.”

Ergonomic Considerations

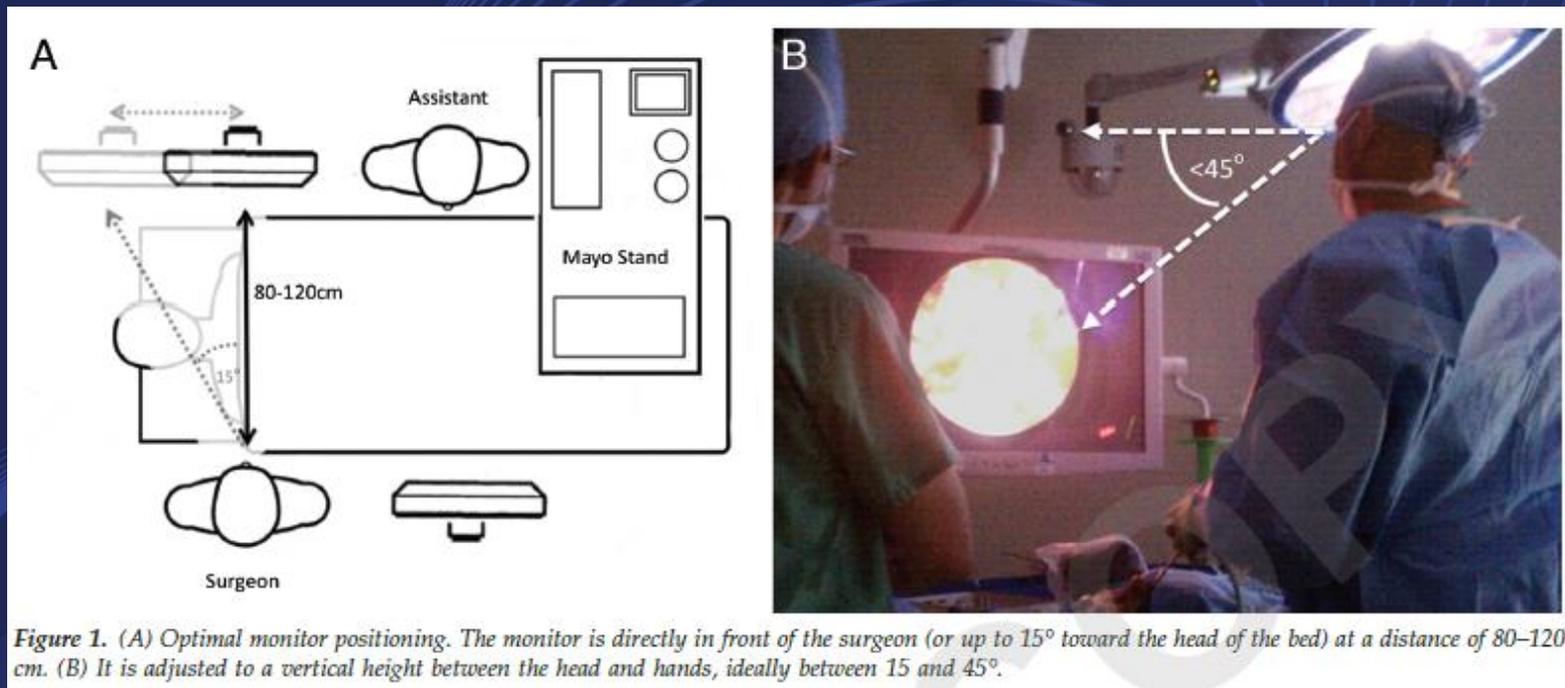
Ergonomic considerations in endoscopic sinus surgery: Lessons learned from laparoscopic surgeons

Vijay R. Ramakrishnan, M.D.,¹ and Paul N. Montero, M.D.²

- Comprehensive review of surgical ergonomics with focus on ergonomics of laparoscopic and endoscopic sinus surgery
- Applicable to other subspecialties
- Monitor position and eye strain, upper body ergonomics, trunk and lower body ergonomics, instrumentation

Ergonomic Considerations

- Monitor position and eye strain



Ergonomic Considerations

- Upper Body Ergonomics
 - Optimal table height generally recommended to position instruments at elbow height
 - Working height of 12.5 cm below to 2.5 cm above elbow height
 - Lower height necessitates trunk and neck flexion, higher causes fatigue of upper extremities
 - In one study, surgeons rated height between 0 and +10 cm of the elbow as more comfortable, but EMG data suggested a preferred height between 0 and -10 cm
 - Videotaped comparison of lap to open surgeries showed that dynamic neck and trunk movements seen more often in open surgeries, static flexion seen in minimally invasive

Ergonomic Considerations

- Trunk and Lower Body Ergonomics
 - Minimizing postural sway, maintaining body position control is important component of movement accuracy in surgery
 - More likely to maintain a static posture during periods of maximal concentration, such as complex endoscopic skull base procedure
 - Can result in lactic acid accumulation in muscles and tendons
 - Recommended to take a postural break every hour and briefly sit and/or stretch the upper body, trunk, and lower body

Ergonomic Considerations

- Trunk and Lower Body Ergonomics
 - Use of a gel mat during laparoscopic procedures was evaluated and found to result in less need for breaks and stretching during the case; less discomfort of the back, knees, and feet; less overall discomfort; and a higher overall level of energy



Ergonomic Considerations

- Trunk and Lower Body Ergonomics
 - Foot pedals frequently obscured from direct vision
 - locate by “feel”
 - Some may maintain the precise location by hovering a foot above it
 - In one study of a single pedal model, 91% of surgeons lost contact with the pedal at some point during case, 36% maintained the same postural position to avoid losing contact with the pedal, 20% frequently looked down at the pedal, 90% found the need to look annoying



Ergonomic Considerations

Table 1 Recommendations for endoscopic sinus and skull base surgery

General	<p>Proper instrument maintenance will keep instruments sharp and lubricated.</p> <p>Sitting does not appear to confer an overall advantage, but may limit trunk/lower body strain; needs further study.</p>
Eye	<p>Appropriate monitor placement: at 80–120 cm directly in front of surgeon, can shift up to 15° laterally or down by ~20°.</p> <p>Limit direct visualization through endoscope lens.</p> <p>Limit time wearing headlight or loupes.</p>
Upper body	<p>Adjust table to keep hand in line with elbow ± 10 cm.</p> <p>Keep arms slightly abducted and internally rotated.</p> <p>Limit wrist flexion, deviation, and rotation to $<15^\circ$.</p> <p>Gently rest shaft of endoscope at superior nasal vestibule when able.</p>
Trunk and lower body	<p>Take periodic breaks to stretch and restore blood flow.</p> <p>Do not “hover” over foot pedals.</p> <p>Minimize unnecessary use of accessory devices requiring foot pedals.</p> <p>Consider use of hand-operated debrider or cautery.</p> <p>Lean slightly against table.*</p> <p>Consider gel mat or ergonomic foot support.*</p>

**For surgeons who stand.*

Ergonomic Considerations

- Not simply for surgeon comfort
- Suboptimal working postures are associated with poor work efficiency, which can impact costs and patient safety
- An optimized surgical setting has been shown to improve task efficiency and performance



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“Your attention to ergonomics is getting out of hand.”

Trunk Muscle Training, Posture Fatigue, and Performance in Laparoscopic Surgery

MICHAEL A. TSE, M.B.A., B.Sc.,¹ R.S.W. MASTERS, D.Phil.,¹
A.M. McMANUS, Ph.D.,¹ C.Y. LO, M.S., FRCS.² and N.G. PATIL, M.S., FRCS (ED)³

- Study to investigate the effect of trunk muscle endurance training on the perception of back postural fatigue and performance of a laparoscopic task
- Thirty one medical students with no surgical experience randomly assigned to either a training group or a control group
 - Training group underwent 6-week, 18-session (45 min/session) trunk endurance training program
 - Control group did not perform specific training regimen, but could continue normal recreation activities
- Performance was assessed on simulated laparoscopic tasks under varying conditions of low back postural fatigue
- Baseline scores were obtained, then randomization into groups was performed, then retested at 6 weeks

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- **Results:**
 - Participants in training group showed significant improvements in trunk endurance after the 6-week training program ($P < .05$), whereas those in the control group did not
 - Improvements in trunk endurance were accompanied by significantly reduced perceptions of discomfort ($P < .001$) and fewer errors during performance of the laparoscopic task ($P < .02$), whereas no significant changes occurred for the control group ($P > .05$)
- Possible that a reduction in fatigue of trunk muscles is associated with reduced tremor of the hands, or that participants with better trunk endurance are less distracted by feelings of discomfort as they perform tasks

ADOPTING THE OPERATING MICROSCOPE IN THYROID SURGERY: SAFETY, EFFICIENCY, AND ERGONOMICS

Bruce J. Davidson, MD, Elizabeth Guardiani, MD, Andrea Wang, MD

- In an effort to reduce static neck flexion during thyroid surgery, began using an operating microscope since 2006
- Retrospective case review comparing thyroidectomies performed using an operating microscope to those using surgical loupes, 2004-2007
 - Only total thyroidectomies were included (+/- central neck dissection)
 - Lobectomy, concomitant lateral neck dissection, or additional procedures (eg parathyroid) were excluded
- Operative times and incidence of complications were compared between techniques

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- Procedure:
 - In both circumstances, the incision length, dissection technique, and sequence were similar
 - Transverse incision, platysma, straps
 - Scope is brought in to perform the thyroid mobilization and dissection



FIGURE 5. With the operating microscope, the surgeon is able to maintain a neutral cervical spine and upright position.

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- Results:
 - 116 procedures, 65 without scope, 51 with
 - Surgical times using scope were longer ($P < .001$)
 - Over the 15 months of using scope, no appreciable trend in surgical procedure time

Table 1. Mean operator time for thyroidectomy with and without microscope.

	Microscope	No microscope	<i>p</i> (<i>t</i> test)
	Min (<i>n</i>)	Min (<i>n</i>)	
All total thyroidectomy cases	189.18 (51)	159.89 (65)	<.001
Total thyroidectomy for benian disease. 60240	168.36 (22)	151.74 (39)	.11
Total thyroidectomy for malignancy with limited neck dissection. 60252	208.60 (20)	153.33 (15)	.02
Substernal total thyroidectomy, 60271	196.89 (9)	197.73 (11)	.72

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- Complications rates were **equivalent** between the two groups
 - 4 (3%) hematomas requiring return to OR- 2 with scope
 - 5 (2% nerves at risk) of temporary RLN paresis- 3 with scope
 - 8 (7%) cases of symptomatic hypocalcemia- 3 with scope

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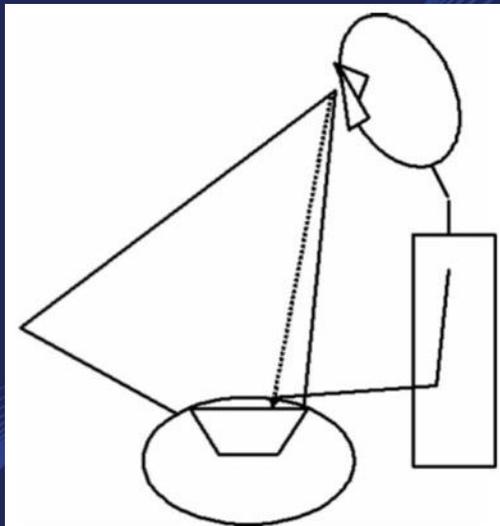


FIGURE 1. Diagram showing posture of surgeons using standard incision and no loupes. 30° neck flexion is required to keep the surgical field in view.

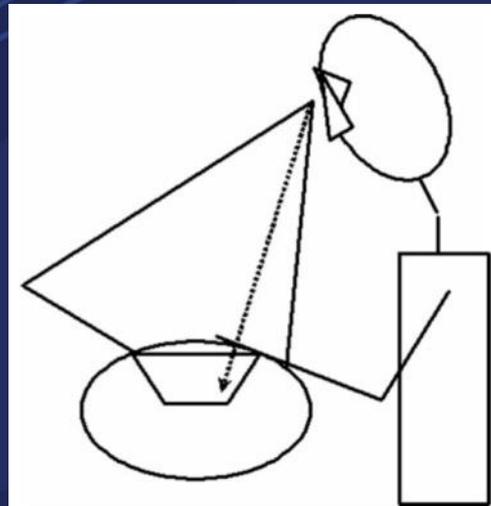


FIGURE 2. Elevation of the position of the patient reduces neck flexion. However, as the height of the bed is raised, it can lead to poor upper extremity positioning and reduced visualization of the surgical field.

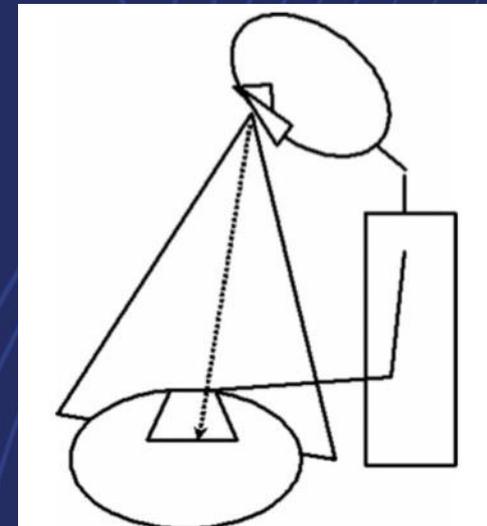


FIGURE 3. Posture of surgeon in thyroidectomy using smaller skin incision. Increased neck flexion (about 45°) is required for surgical field visualization.

ADOPTING THE OPERATING MICROSCOPE IN THYROID SURGERY: SAFETY, EFFICIENCY, AND ERGONOMICS

Bruce J. Davidson, MD, Elizabeth Guardiani, MD, Andrea Wang, MD

- Conclusions
 - Does not add to operative time on cases with benign disease
 - Complication rates are similar
 - Improved teaching
 - Always focused on same area and increased zoom allows demonstration of nuances of thyroid surgery
 - RLN and parathyroid identification is easier
 - Learning curve is rapid
- **No comments on difference in neck discomfort!**



WHAT DOES CARPAL TUNNEL SYNDROME FEEL LIKE?

Emerging Technology

- Storz Vitom Exoscope



Initial Clinical Experience With a High-Definition Exoscope System for Microneurosurgery

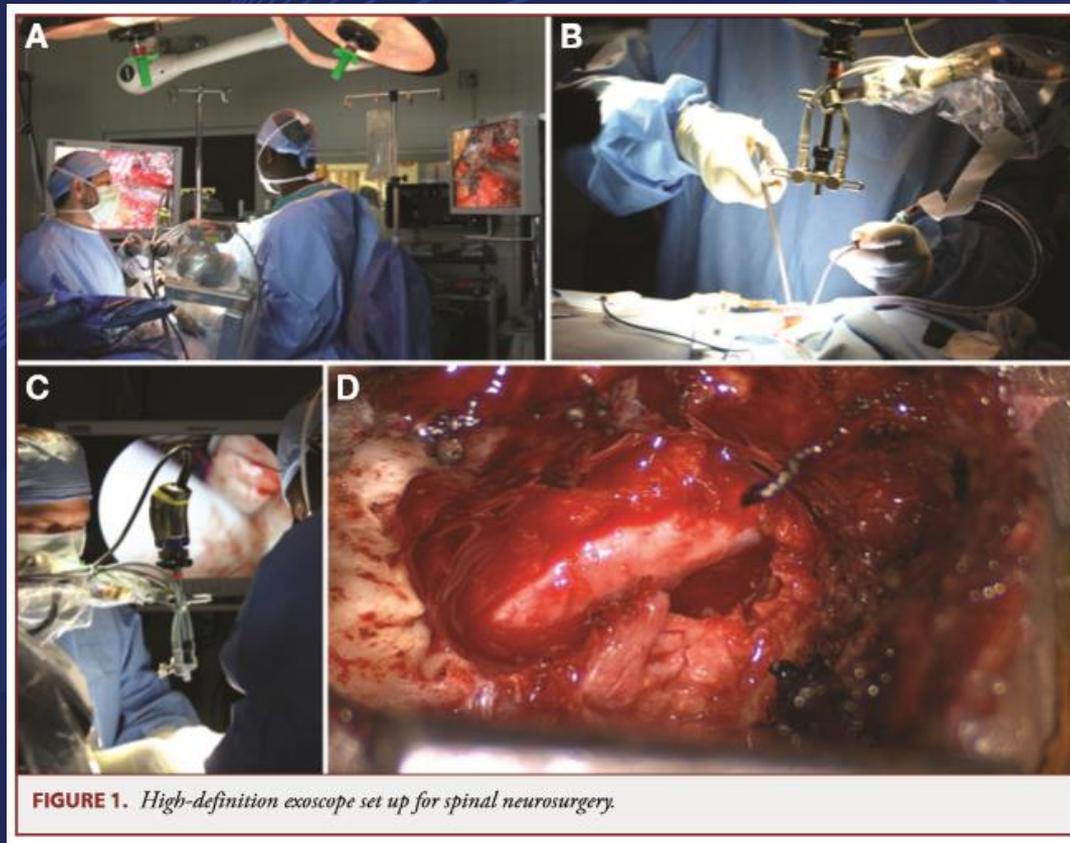
- Objective was to evaluate clinical utility of an exoscope system as an alternative to microscope
- System was used in 16 procedures, optical quality of device was compared with that of an operating microscope during each procedure via a data entry form that evaluated optical quality, ease of manipulation, and overall ability to perform surgery
- Used in 9 craniotomies, 6 spinal procedures, and 1 neurostimulator placement

Initial Clinical Experience With a High-Definition Exoscope System for Microneurosurgery

TABLE. Procedures Performed^a

Case	Procedure	Location	Pathology	Optical Quality	Time Used, %	Ease of Use	Limitation
1	Craniotomy	Left temporal	Glioma	Excellent	85	Good	None
2	Craniotomy	Right frontal	Meningioma	Excellent	100	Good	None
3	Craniotomy	Left occipital	Glioma	Good	100	Good	Light source
4	Craniotomy	Posterior fossa	Hemangioblastoma	Good	30	Poor	Light source/ scope holder
5	Vagus nerve stimulator	Left neck	Epilepsy	Excellent	50	Fair	None
6	Craniotomy	Left supraorbital	Pituitary adenoma	Good	50	Good	Stereopsis/ light source
7	Hemilaminotomy	L5–S1	Epidural abscess	Good	100	Good	Light source
8	Anterior cervical discectomy	C4–C5, C5–C6	Calcified disk	Excellent	100	Excellent	None
9	Anterior cervical discectomy	C5–C6	HNP	Excellent	100	Excellent	None
10	Microdiscectomy	L5–S1	HNP	Excellent	100	Excellent	None
11	Foraminotomies	L4–L5, L5–S1	Foraminal stenosis	Excellent	100	Excellent	None
12	Craniotomy	R temporal	Glioma	Excellent	100	Excellent	None
13	Microdiscectomy	L L5–S1	HNP	Excellent	40	Fair	None
14	Craniotomy	Left parasagittal	Meningioma	Excellent	70	Good	Stereopsis, scope holder
15	Craniotomy	Bifrontal	Meningioma	Excellent	50	Good	Stereopsis, scope holder
16	Craniotomy	Left temporal	Low-grade glioma	Excellent	90	Good	Scope holder

Initial Clinical Experience With a High-Definition Exoscope System for Microneurosurgery



Initial Clinical Experience With a High-Definition Exoscope System for Microneurosurgery

- Image quality was almost equal to that of the operating microscope in all cases.
- Surgeons indicated that surgery with the VITOM-90 was more comfortable than with the microscope, natural position
- Lack of stereopsis was considered a minor drawback.
- Operating room personnel and residents reported improved visualization of the anatomy.
- allowed the surgeon to operate from a comfortable position without increased operative time or complications

Exoscope

- Lots of potential in open head and neck surgery
 - Oral cavity
 - Oropharynx
 - Endocrine
 - Parotid
- Improve teaching opportunities
- Improved ergonomics

Exoscope



A THREE-DIMENSIONAL STEREOSCOPIC MONITOR SYSTEM IN MICROSCOPIC VASCULAR ANASTOMOSIS

HSIU-TING CHENG, M.D.,^{1,2} HSU MA, M.D., Ph.D.,^{1,2} CHAO-HSU TSAI, Ph.D.,³ WEI-LIANG HSU, M.Sc.,³ and TIEN-HSIANG WANG, M.D.^{1,2*}

- Microvascular surgeons need to keep the neck in a fixed flexion posture
- Goal is to develop a 3D monitor system to improve the microsurgery environment
- Transfer the images from microscope onto a monitor located in ergonomic position



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- Two free flaps performed, 3D system used for arterial anastomosis
- Artery anastomosis time for the first patient was 42 min and 32 min for the second patient.
- Both were longer than the mean artery anastomosis time (27 min) of the conventional method performed by the same surgeon
- Surgeon reported less physical restraint and increased comfort level with this system.

The learning rate in three dimensional high definition video assisted microvascular anastomosis in a rat model[☆]

Dimitra Kotsougiani^{a,b}, Caroline A. Hundepool^{a,c},
Liselotte F. Bulstra^{a,c}, Delaney M. Shin^a, Alexander Y. Shin^a,
Allen T. Bishop^{a,★}

- Comparison of 44 arterial anastomoses performed under binocular microscope with 44 performed with 3D system
- 2 novice microsurgeons, 2 experienced microsurgeons
- Patency rates equal, anastomosis times slower with 3D
- All microsurgeons reported improved comfort for the 3D HD video system but found the image quality of the conventional microscope superior, facilitating technical ease

Summary

- Consider ergonomics in your operative setup
 - Monitor placement, bed height, gel pad
- Be aware of the impact of loupes, headlights on your neck
- Consider the use of microscopes, telescopes to relieve static neck flexion
- Be on the lookout for technological improvements
- Exercise/strength training

Thank You!

