Ergonomics of Various Modalities for Middle Ear Surgery

Matthew E. Lin, BS[1]; Sheng Zhou, MD[2]; Seiji Kakeheta, MD PhD[3]; Seiji B. Shibata, MD PhD[2]

[1]Keck School of Medicine, University of Southern California;
[2]Caruso Department of Otolaryngology-Head and Neck Surgery, University of Southern California;
[3]Department of Otolaryngology-Head and Neck Surgery, Yamagata University Faculty of Medicine

INTRODUCTION

- Musculoskeletal disease (MSD) and pain is highly prevalent among otolaryngologists[1,2]
- Otologic surgery includes unique ergonomic challenges such as narrow working spaces and repetitive motions that magnify otologists' ergonomic risk.[3,4]
- These considerations accentuate the importance of investigating surgical modalities to improve the ergonomics of otologic surgery.
- Endoscopes have been shown to have some ergonomic benefits over microscopes in regard to neck and back angles.[5]
- Exoscopes are a new surgical modality used in Asia and Europe that uses three-dimensional cameras to magnify the surgical field.[6]

OBJECTIVES

(1) Characterize the neck, arm, and trunk angles for use of exoscopes, endoscopes, and microscopes in otologic surgery.

(2) Determine the total ergonomic risk score for each modality using the rapid upper limb assessment (RULA).

METHODS

Study Design: Observational study
Study Setting: Two tertiary care centers in Japan and the US.
Population: Fellowship-trained otology attending physicians and otolaryngology residents performing middle ear surgery
Measures:

- Surgeon positioning was photographed at 15-minute intervals using a password-protected high-resolution phone camera.
- Photos were taken parallel to the sagittal plane of the operating surgeon such all extremities on the surgeon's documented side, as well as his or her trunk, hips, head, and neck, were visible.
- Surgeon status, surgical modality, and type of surgery were also separately collected in relation to each photograph taken.

Analysis:

- Intraoperative photographs were analyzed in ImageJ using the validated Rapid Upper Limb Assessment (RULA) Tool.[7,8]
- Descriptive statistics were used to characterize ergonomic scores stratified by surgical modality and RULA subsite.
- ANOVA and unpaired t-tests were used to assess ergonomic differences between surgical modalities
- Multivariable ordinal regression of factors associated with increased MSD risk, as determined by the final RULA score

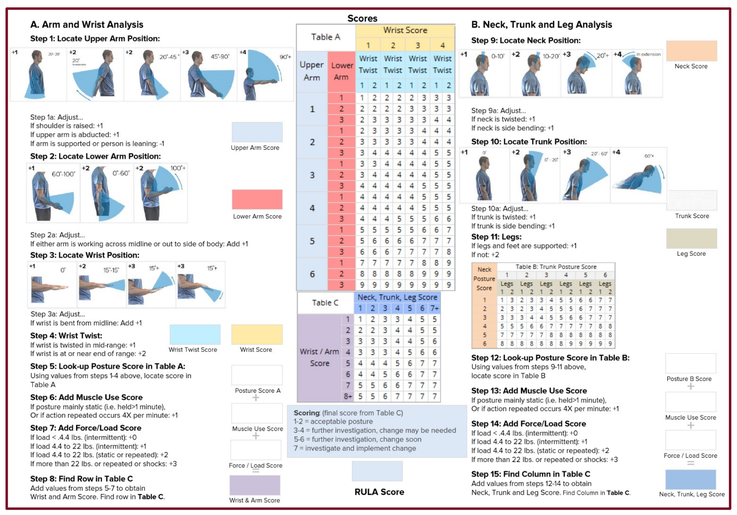


Figure 1. RULA assessment grading breakdown.[8]

RESULTS

Table 1. Characteristics of ergonomic evaluation pictures (n=110).

Characteristic	n (%)
Surgical Modality	
Microscope	52 (47.27)
Endoscope	28 (25.45)
Exoscope	30 (27.27)
Surgeon Experience	
Attending	91 (82.73)
Resident	19 (17.27)
Surgery	
Middle Ear Surgery with Mastoidectomy	66 (60.00)
Middle Ear Surgery Only	44 (40.00)

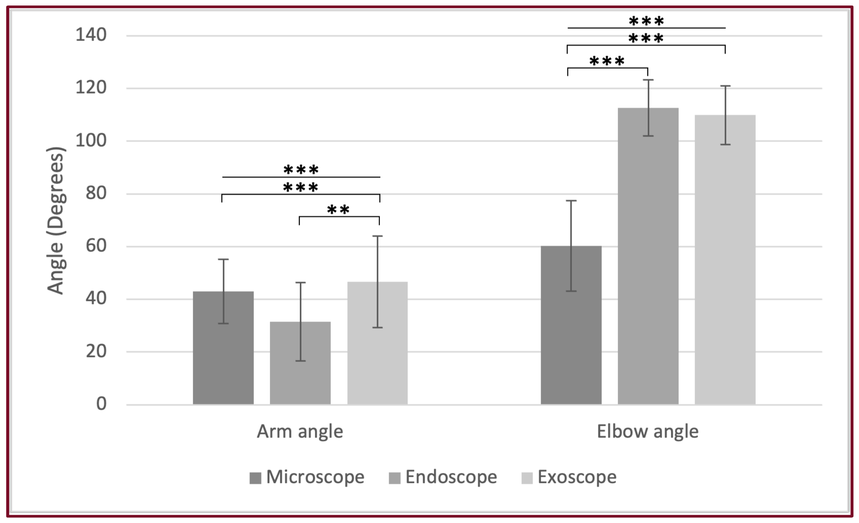


Figure 1. Average surgeon arm and elbow angles stratified by surgical modality. Note: p<0.05 is denoted by " * ", p<0.01 is denoted by " ** ", and p<0.001 is denoted by " *** ".

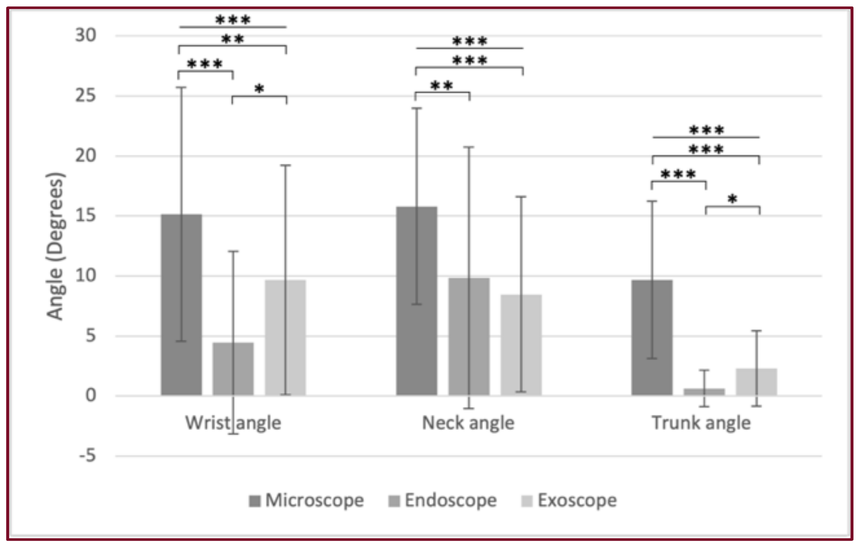
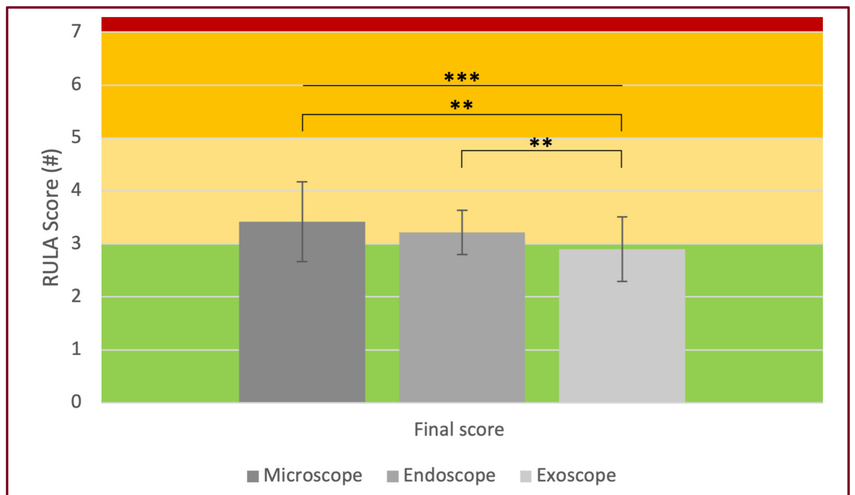


Figure 2. Average surgeon wrist, neck, and trunk angles stratified by surgical modality. Note: p<0.05 is denoted by " * ", p<0.01 is denoted by " ** ", and p<0.001 is denoted by " *** ".



Score	Level of MSD Risk
1-2	Negligible risk with acceptable posture
3-4	Low risk with further investigation as change may be needed
5-6	Moderate with risk further investigation and change soon
7	High risk and need to investigate and implement change

Figure 3. Average surgeon final RULA score stratified by surgical modality.

- Microscopic surgery had significantly higher RULA scores relative to both endoscopic and exoscopic surgery
- **Exoscopic surgery RULA score was significantly lower than that of both microscopic and endoscopic surgery**
- **Average exoscopic surgery RULA score indicated "negligible risk with acceptable posture" on RULA evaluation**
- Average endoscopic and exoscopic RULA score indicated "Low risk with further investigation as change may be needed" on RULA evaluation

Table 2. Multivariable ordinal regression of factors associated with increased RULA score.

- **Relative to microscopic surgery, exoscopic surgery was associated with a significantly lower likelihood of increased RULA score (and thus MSD risk)**
- Endoscopic surgery and surgeon experience were not significantly associated with RULA score.

Characteristic	Odds Ratio	95% CI	p-value
Surgical Modality			
Microscope	Ref	Ref	Ref
Endoscope	0.62	[0.23 - 1.67]	0.343
Exoscope	0.12	[0.03 - 0.43]	**0.001**
Surgeon Experience			
Attending physician	Ref	Ref	Ref
Resident physician	0.77	[0.26 - 2.33]	0.646

CONCLUSIONS

- All three modalities feature low ergonomic risk with exoscopic middle ear surgery demonstrating the lowest risk profile as compared to microscopic and endoscopic ear surgery.
- Exoscopic surgery may offer surgeons improved long-term musculoskeletal health and surgical productivity without compromising patient outcomes.
- Our study is limited by a modest sample size from two institutions
- Further study should be done to assess how to better optimize intraoperative ergonomics to promote surgeon health and longevity.

Contact

Matthew E. Lin, BS
Keck School of Medicine of the University of Southern California
Email: linme@usc.edu

References

1. Bolduc-Bégin J, Prince F, Christopoulos A, Ayad T. Work-related musculoskeletal symptoms amongst Otolaryngologists and Head and Neck surgeons in Canada. *Eur Arch Otorhinolaryngol*. 2018;275(1):261-267. doi:10.1007/s00405-017-4787-1
2. Wong K, Grundfast KM, Levi JR. Assessing work-related musculoskeletal symptoms among otolaryngology residents. *Am J Otolaryngol*. 2017;38(2):213-217. doi:10.1016/j.amjoto.2017.01.013
3. Stern Shavit S, Golub JS, Lustig LR. The Risks of Being Otologist, an Ergonomic and Occupational Hazard Review. *Otol Neurotol Off Publ Am Otol Soc Am Neurotol Soc Eur Acad Otol Neurotol*. 2020;41(9):1182-1189. doi:10.1097/MAO.0000000000002769
4. Varman R, Wang J, Varman A, et al. Comparison of cervical neck strain in common otolaryngology surgeries. *Am J Otolaryngol*. 2022;43(3):103405. doi:10.1016/j.amjoto.2022.103405
5. Arrighi-Allisan AE, Fan CJ, Wong K, et al. Ergonomic Analysis of Otologic Surgery: Comparison of Endoscope and Microscope. *Otol Neurotol*. 2023;44(6):542-548. doi:10.1097/MAO.0000000000003858
6. DeVirgilio A, Spriano G, eds. *Exoscope-Assisted Surgery in Otorhinolaryngology*. Elsevier; 2022.
7. McAtamney L, Nigel Corlett E. RULA: a survey method for the investigation of work-related upper limb disorders. *Appl Ergon*. 1993;24(2):91-99. doi:10.1016/0003-6870(93)90080-s
8. Middlesworth M. A Step-by-Step Guide to the RULA Assessment Tool. ErgoPlus. Published November 6, 2012. Accessed July 22, 2023. https://ergo-plus.com/rula-assessment-tool-guide/