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Ergonomics-based Positioning of the Operating Handle of Surgical Microscopes

Satoru SHIMIZU,[1] Hiroki KURODA,[1] Takahiro MOCHIZUKI,[1] and Toshihiro KUMABE[2]

[1]*Department of Neurosurgery, Yokohama Brain and Spine Center, Yokohama, Kanagawa, Japan;*
[2]*Department of Neurosurgery, Kitasato University School of Medicine, Sagamihara, Kanagawa, Japan*

Abstract

Handling surgical microscopes with one hand requires force, especially when gripping the operating handle (OH) to swing the optic axis toward the surgeon and when moving it laterally or medially. These physical issues may be attributable to the non-ergonomic handling of the OH. To optimize the ease of OH handling, we applied ergonomic criteria to the positioning of the OH, i.e. holding the OH at as little ulnar deviation as possible and at abduction to strengthen the grip and ease arm rotation. Of eight male surgeons holding the OH of a mechanically counterbalanced surgical microscope, the OPMI Neuro/NC4 (Carl Zeiss AG), in ergonomics-based positions, six experienced reduced fatigue in the upper extremity. All reported that their hold on the microscope was firm when it unexpectedly became unbalanced. Ergonomics-based OH positioning, i.e. placing the involved muscles in the optimal length-tension relationship, may generate sufficient force for moving the microscope efficiently and reduce arm fatigue.

Key words: ergonomics, fatigue, operating handle, surgical microscope

Introduction

The application of ergonomics at surgery improves the operator's performance and improves surgical training.[1–3] As physical fatigue and associated physiologic tremors affect the accuracy of microscopic manipulations, factors related to fatigue must be minimized.[1–3] The handling of surgical microscopes may be a fatigue-inducing factor. To change the optic axis of surgical microscopes, the operating handle (OH) is commonly used although current products feature foot switches and/or mouthpiece controls for this maneuver. With the OH, the optic axis can be quickly and widely changed. However, its manipulation with one hand while the other applies suction requires force, especially when the OH is used to swing the optic axis toward the surgeon and when it is moved laterally or medially. These fatigue-inducing physical issues may be elicited by the non-ergonomic handling of the OH, and are apparent in mechanically counterbalanced devices harboring heavy lens tubes. To optimize the ease of OH manipulation we developed ergonomic criteria for the positioning of the OH.

Ergonomics-based Positioning of the OH

Ergonomics-based positioning of the OH aims at strengthening the surgeon's grip and arm rotation when moving the microscope laterally or medially. The grip strength is increased when the wrist is in a less ulnar deviation, in neutral position, and when the tension of the finger flexor muscles and their angle of pull is in balance.[4] Figure 1A demonstrates this ergonomic condition when handling the OH. As the wrist deviates from the neutral position, the grip strength decreases due to excessive extension of the finger flexor muscles whose overlapping myosin- and actin filament layer is less and rubbing of the flexor tendons on the border of the carpal tunnel[5] (Fig. 2A); the grip strength at 30° of ulnar deviation is 9% less than in the neutral position.[4] The torque of external rotation of the arm to move the microscope laterally is greater when the arm is in abduction (Fig. 1B) than when it is not (Fig. 2B). At 45° glenohumeral flexion and 90° elbow flexion, the positions for manipulating the OH, the torque at 45° abduction is 11% higher

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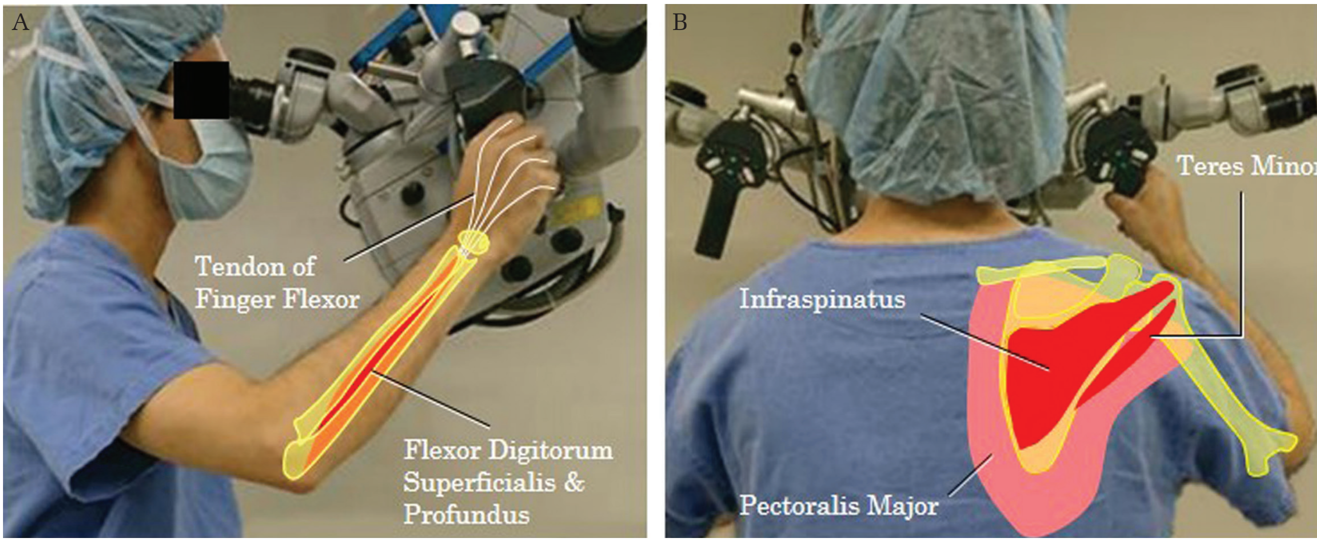

Fig. 1 **Ergonomics-based positioning of operating handle of the surgical microscope. (A) The wrist is in neutral position when the handle is swung away from the surgeon. Grip strength is maintained by the optimum tension of the finger flexor muscles. (B) The surgeon's arm and the handle are in abduction. The muscles for external rotation of the humerus, i.e. the infraspinatus- and the teres minor muscles, and the muscle for internal rotation and adduction of the humerus, i.e. the pectoralis major muscle, are stretched and at optimum for generating force.**

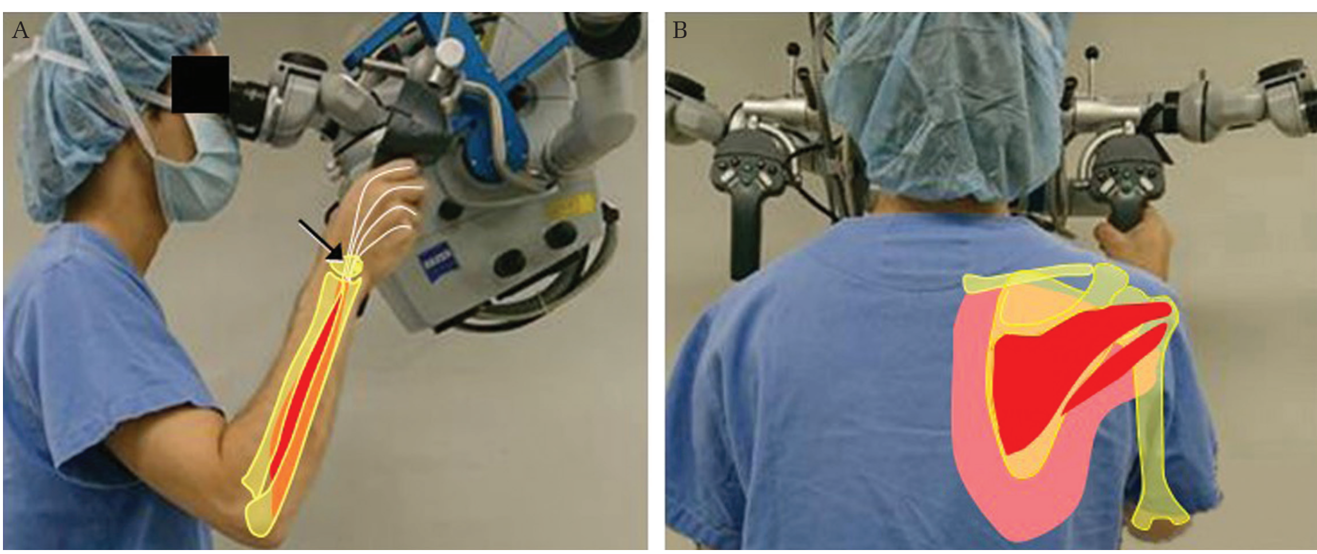

Fig. 2 **Non-ergonomics-based positioning of the operating handle of the surgical microscope. (A) The wrist is forced into ulnar deviation when the handle is swung toward the surgeon. Grip strength is decreased due to excessive extension of the finger flexor muscles and rubbing of the flexor tendons on the border of the carpal tunnel (*arrow*). Swinging the optic axis toward the surgeon weakens the grip strength. (B) The surgeon's arm and the handle are in position without abduction. The tension of muscles for external- and internal rotation of the humerus is too low for the generation of force.**

than without abduction[6] due to the distribution of the infraspinatus- and teres minor muscles.[7] The muscles that connect the posterior aspect of the scapula and the proximal posterolateral aspect of the humerus are stretched and can increase tension when the humerus is in abduction. On the other hand, the torque of internal rotation of the arm to move the microscope medially is not increased when the arm is in abduction.[6] The constant torque of internal rotation in both arm positions may be attributable to the varying directions of muscles that are inserted in the proximal and distal portion of the humerus and engaged in internal rotation, i.e. the pectoralis major, the subscapularis, and the latissimus dorsi muscles.[7] Arm abduction may assist in moving the microscope medially by producing the force of adduction to push the floating OH inferomedially. Therefore, we advise positioning the OH so that the wrist is at less ulnar deviation and the arm is abducted; there is no discomfort in the surgeon's neck and back when the angle of the eyepieces is adjusted as usual during a change in the optic axis. The risk of tenosynovitis associated with ulnar deviation[8,9] may be reduced by this optimal positioning of the OH. In fact, experienced neurosurgeons have demonstrated positioning the OH as we here suggest.[10,11]

The surgeon's habitus, i.e. the arm length and shoulder width, and the design of the microscope, i.e. its height and the width of the OH support rods, must also be taken into account. When the OH and the eyepieces are at the same high level, the wrist tends to be at ulnar deviation which is increased when the surgeon's arms are long; consequently, the grip strength is decreased. When the shoulders are much wider than the OH support rods, the arm is forced into internal rotation; this may affect the usability of the OH.

Use of Ergonomics-based Positioning of the OH

We tested the value of the ergonomics-based positioning of the OH in eight male neuro- and spinal surgeons with 8–20 years of experience (mean 14 years); they had no history of musculoskeletal injuries in the shoulder or upper extremities. They used a mechanically counterbalanced surgical microscope, the OPMI Neuro/NC4 (Carl Zeiss AG, Oberkochen, Germany) and were not aware of being filmed during the surgical procedures. As the microscope featured no power-assisting sensor-servomotor, the electromyographic activity of the upper extremity required for handling was higher than with devices driven by a sensor-servomotor.[12] Also, the microscope tended to become unexpectedly unbalanced upon transposition of accessory scopes.

They held the OH in the right hand at a 0–17° (mean 11.3°) ulnar deviation on the initial optic axis (the principal axis during the procedure), and at –5–20° (mean 7.5°) of abduction (Fig. 3); at –5° abduction, adduction was at 5°. They were instructed to hold the OH at as little ulnar deviation as possible on the initial optic axis, and at more than 10° abduction; all required correction for ulnar deviation and/or abduction. After the procedure they reported their experience when holding the OH as instructed. Correction of the angle of ulnar deviation and abduction ranged from 0° to 9° (mean 4.3°) and from 10° to 22°

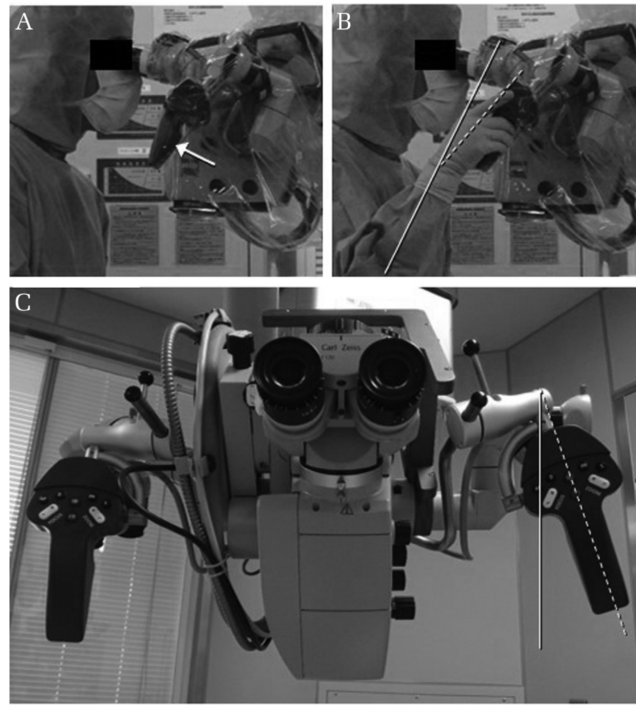

Fig. 3 Examples of the surgeon's preference with respect to the placement of the operating handle of a surgical microscope. (A and B) Side views showing the relationship between the position of the handle (*arrow* in A) and the wrist (B). The wrist is at 15° ulnar deviation when the handle is swung toward the surgeon; this results in insufficient gripping. The *solid* and *dotted lines* are the reference lines (*midline* of the forearm) and the deviation of the third metacarpal shaft, respectively. (C) Front view of the operating microscope. *Note:* 18° Abduction on the right and no abduction on the left. The *solid* and *dotted lines* are the reference lines parallel to the optic axis and the deviation of the operating handle, respectively.

(mean 15.8°), respectively. Of the eight surgeons, six reported a lower degree of arm and shoulder fatigue; one noticed no change and the other was unable to judge. All found that when swinging the optic axis toward the surgeon, difficulty in gripping the OH was reduced, and all reported that their hold on the microscope was firm when it unexpectedly became unbalanced upon transposition of accessory scopes. The six surgeons who judged the ergonomics-based position of the OH to be helpful continued to use the instructed position. The other two decided to continue using their own methods due to the necessity to keep the arm at an uncomfortable height.

Conclusion

We discussed the optimal ergonomics-based positioning of the OH for microsurgery. Although our simple modification of the preoperative surgical microscope setup lessened subjective fatigue in six of eight surgeons, the objective effect remains unknown. Further studies using quantitative measures, e.g. electromyography, a motion-capture system, and a dynamometer, are needed to establish specific ergonomics for the optimal manipulation of the OH during microsurgery. The promulgation of our findings may help to reduce fatigue and improve the performance of surgeons and may even extend their professional career by reducing cumulative musculoskeletal damage. Surgeons with insufficient muscle strength for handling heavy surgical microscopes may benefit from the ergonomic considerations reported here.

Conflicts of Interest Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices in the article. All authors who are members of The Japan Neurosurgical Society (JNS) have registered online Self-reported COI Disclosure Statement Forms through the website for JNS members.

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Address reprint requests to: Satoru Shimizu, MD, Department of Neurosurgery, Yokohama Brain and Spine Center, 1-2-1 Takigashira, Isogo-ku, Yokohama, Kanagawa 235-0012, Japan.
e-mail: Satoru4756@aol.com