Usefulness and limitation of a freely movable armrest in microneurosurgery

Takehiro Yako, M.D.[1,2]
Tetsuya Goto, M.D.[1]
Kazuhiro Hongo, M.D.[1]

ABSTRACT

Neurosurgeons have to perform fine and accurate procedures in microneurosurgery. If supporting places for their hands and arms are prepared adequately, it is possible to stabilize their hands and arms and then to reduce their tremor. To answer to this request, freely movable armrest (FMA) which can follow operator's arm motion has been developed. Although some FMAs have been already commercially available, the FMA has not widely been used yet. We have made an original FMA and investigated the system with basic examinations. The efficacy and the limitation of the system were discussed.

Materials and methods: A FMA, consisted of an arm holder, a flexible holding arm and a stand, was made. It can be freely moved and follow the operator's motion. With a task of stitching an incised vessel model, effect of the FMA was evaluated for three factors: 1) performance time to complete 10-stitch suturing, 2) subjective fatigue and 3) subjective maneuverability. Subjective evaluations were scored in 1-10 scale (1: the least fatigue and the worst to perform, 10: the most fatigue and the best to perform).

Results: The simulated surgery was successfully performed without technical and mechanical errors. Mean performance time with the FMA (790.8 seconds) was significantly shorter than that without the FMA (P=0.038). Mean fatigue score with the FMA (4.33) was smaller than that with the FMA (6.17), and mean maneuverability score with the FMA (6.33) was larger than that without the FMA (4.00).

Conclusions: Installing a freely movable armrest, which can follow the operator's motion, into microneurosurgery has a possibility to reduce operator's fatigue and to improve maneuverability.

Key words: Freely movable armrest, microneurosurgery operator's fatigue

INTRODUCTION

In microneurosurgery, it is important to conduct precise manipulation throughout procedures. In deep and/or narrow operative field surrounded with critical and fragile structures, hand tremor is sometimes remarkably emphasized because of instability of the hand. Some of the procedures limit operators to insert instruments into such operative fields, which forces operators to continue the procedures in unnatural postures. Unnatural posture in difficult situation causes operator's fatigue, and their fatigue may also lead his/her hand tremor. Operators usually try to put their hands and/or arms on patient's head, head frame(1, 2, 3) and various kinds of armrests fixed on head frames(1, 2, 4, 5)

Auther Affiltion [1]Department of Neurosurgery, Shinshu University School of Medicine, Matsumoto, [2]Department of Neurosurgery, Aizawa Hospital, Matsumoto, Japan

Reprints requests: Kazuhiro Hongo, M.D. Address: 3-1-1 Asahi, Matsumoto 390-8621, Japan, Phone: +81-263-37-2690, Fax: +81-263-37-0480, E-mail: khongo@shinshu-u.ac.jp

and operating table[6] and chair[7, 9] to stabilize their hand and arm. However, these conventional hand supporting devices are insufficient to provide suitable hand and arm position in every situations because their hands and arms move dynamically.

If a hand and arm supporting system which can be moved upon operator's wish is developed, the system may be helpful for reducing the operator's hand tremor and fatigue. Ohta et al. has produced such a freely movable armrest (FMA) and reported it's utility in clinical usage[8]. They described that their FMA improved operator's hand stability and reduce operator's fatigue from their own practical impression. However, the FMA has not widely been used yet. We made an original FMA and investigated the system with basic examinations. The efficacy and the limitation of the system were discussed.

MATERIAL AND METHODS

Instrumentation : The original FMA that we have developed consists of three parts: 1) an arm holder, 2) a flexible holding arm, and 3) a stand supporting the flexible holding arm (Fig. 1). The arm holder has a shape of half-tube to hold the forearm and the wrist and also to play a role of handling the flexible holding arms. The Point Setter® (Mitaka Kohki Co., Ltd., Tokyo, Japan), which is widely used as a holding device for endoscopes, is used as the flexible holding arm. It has 5 joints with 11 degrees of freedom, which are fixed by mechanical friction and become free as it is filled with compressed air. The flexible holding arm can be freely moved in three dimensions while the switch, mounted beneath the arm holder, is pressed. The stand, supporting the flexible holding arm, is designed steady enough to withstand even if an operator leans to the arm holder.

Examination : A simulated microsurgery, stitching an incised vessel model, was set up as a task of this examination. A vessel model (Hybridgraft®, 2.0 mm in diameter : ACP JAPAN CO., LTD, Tokyo, Japan) was prepared 3-cm long with a longitudinal 10-mm long linear incision, and was placed on a clay which was modeled as the sylvian fissure of the brain. The clay-brain model was set in the skull model fixed in the Sugita's head frame[1] similar to an actual operation (Fig. 2). The FMA was settled on the right side of an operator's chair (Micro Chair®, Mizuho Ikakogyo Co., Ltd., Tokyo, Japan). It was manually moved by an assistant according to the examiner's orders. Six well-experienced neurosurgeons were registered as examiners. Examiners were assigned to suture the incised vessel model 10 times at a 1-mm interval with 10-0 nylon using an operating microscope. Examiners were allowed to touch or put their hand on any part of the head frame and the skull model during performing the task. They practiced the task adequately beforehand. The task was carried out once with and without the FMA. In each task, performance time to complete 10 suturing was recorded, and two subjective evaluations, examiner's fatigue and impression of maneuverability, were asked to each examiner. Subjective evaluations were scored on a 1-10 scale (where 1 is the least fatigue and the worst to perform, and 10 is the most fatigue and the best to perform). All procedures were recorded on a videotape. With watching the video, the subjective impression of using or not using the FMA was discussed with each examiner.

Statistical analysis: Obtained performance time data were analyzed by paired t-test. Fatigue and maneuverability scores were analyzed with the Wilcoxon signed-ranks test. The statistically significant level was set at $p<0.05$.

RESULTS

All the tasks were successfully performed without mechanical error of the FMA such as an unexpected motion. The results of the performance time and scores of subjective evaluations are summarized in Table and Fig. 3. Five of six examiners showed shorter performance time with the FMA. The performance time with the FMA (mean 790.8 seconds, range 592-1010) was significantly shorter than that without the FMA (mean 873 seconds: range 664-1182) (p=0.039). Five of six examiners gave smaller scores of fatigue when using the FMA (mean score 4.33) than when not using the FMA (mean score 6.17) (p=0.031). The maneuverability score with the FMA (mean score 6.33) was larger than without the FMA (mean score 4.00) (p=0.031). Recorded video showed that hand tremor of each examiner became less and manipulation became more stable when using the FMA than without it. Examiner's posture seemed to be more relax in the shoulder and back (Fig. 4). According to impression of examiners, five felt more comfortable when using the FMA. One examiner who took longer time when using the FMA commented that he could be more carefully because his hand became more stable. Five of six examiners felt easier to perform with the FMA. Some of examiners felt their own arm and hand were fixed by the FMA resulting in restricting of their range of motion. Another examiner commented that it was a hassle to have to move the FMA every time when he wanted to move his arm.

Fig.1: Photograph of the freely movable armrest (FMA)

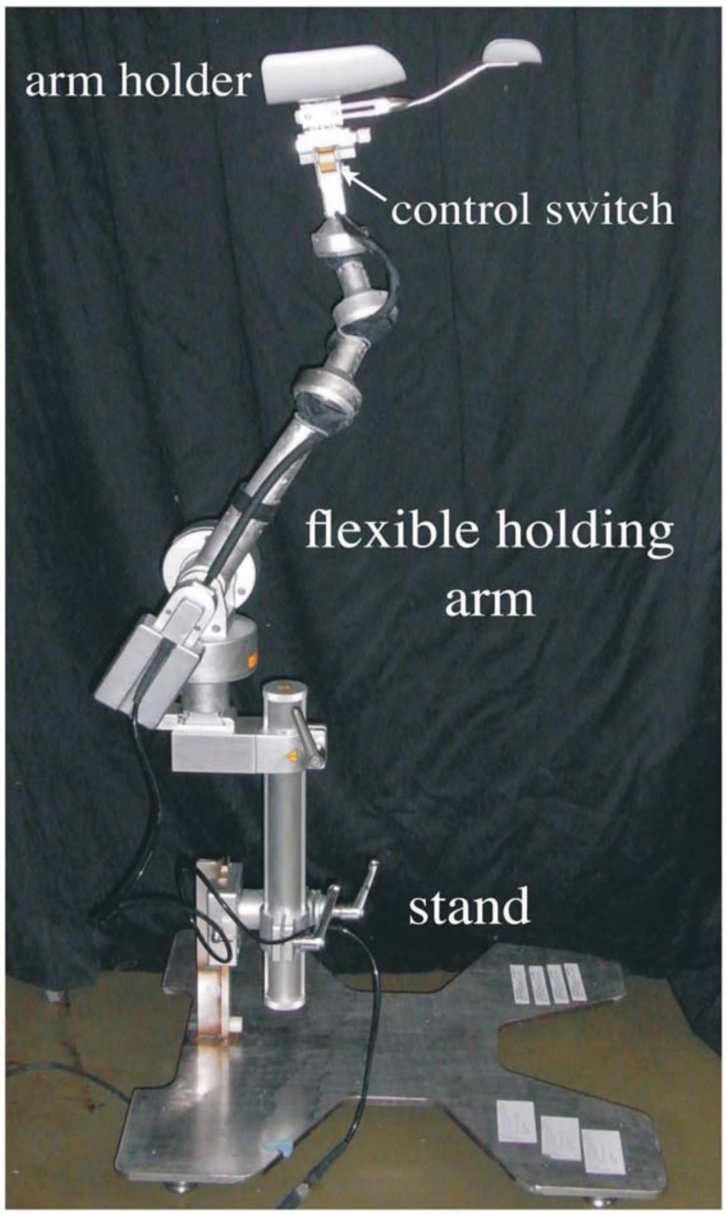

Fig. 2: Photographs of the set-up of the examination. A: An incised vessel model is placed on a clay-brain model in a skull model which is fixed in the Sugita's head frame. B: Scene of stitching the incised vessel model with a 10-0 nylon. C, D: The FMA is settled beside an examiner's chair and supports examiner's forearm and wrist.

Fig. 3: Graph of the result. Fine line means results of each examiner, and a bold line means average. FMA - : without the FMA, FMA + : with the FMA * significant difference

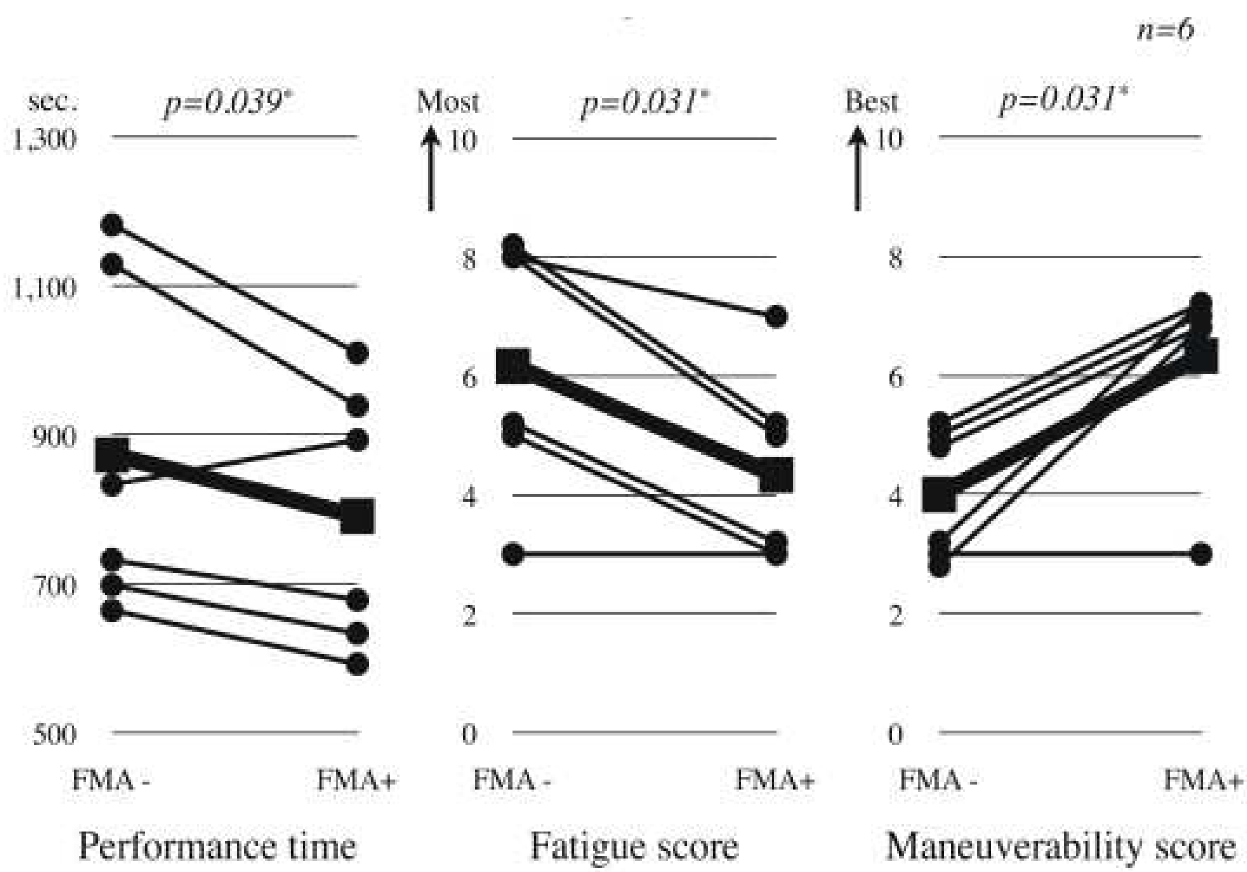

Table : Summary of examination with or without FMA

	Performance time (sec.)		Fatigue Score		Maneuverability Score	
Examiner	FMA* -	FMA +	FMA -	FMA +	FMA -	FMA +
A	633	698	3	3	5	7
B	833	893	8	7	3	3
C	1129	939	8	5	3	7
D	732	678	5	3	5	7
E	664	592	5	3	5	7
F	1182	1010	8	5	3	7

*FMA : freely movable armrest

Fig. 4 Photographs of difference of examiner's posture during the procedure. A and C: without the FMA., B and D: with the FMA.

DISCUSSION

There is no doubt that using the FMA reduces operator's fatigue and improves surgical maneuverability. Our results proved that operator's hand and arm were supported adequately by the FMA. Use of the FMA gave operators more relaxed posture, less muscle stress and hand tremor than use of the conventional armrest system[1, 2]. The FMA can more easily and quickly adjust operator's hand and arm in a suitable position compared to previous armrest systems. Furthermore, the arm holder of our the FMA can support the forearm and the hand more steadily. Continuing accurate procedures with the aid of the FMA may obtain better surgical results. If the FMA has just these advantages; however, the FMA must be used more widely. It is suspected that the use of the FMA has also several disadvantages. Although the FMA turned out to be useful from an aspect of hand supporting device in this study, it should be considered how to control movement of the FMA.

The first point is that the arm holder of the FMA must be moved by an operator or an assistant at present. The microsurgical procedures are interrupted whenever an operator changes the position of the arm holder by himself. He/her then must release an instrument, push the switch, move the arm holder, and take the instrument again. When an assistant moves the arm holder, the position of the arm holder may not be suitable for an operator. Second point is that the position of the operator's arm frequently changes even in the same microsurgical field with using the same instruments. The examiner's hand and arm were moving dynamically while performing the task without the FMA. On the other hand, the examiner's hand and arm looked restricted in the arm holder during the task with the FMA. Such a frequent movement of arm holder is hard to be achieved by the manual operation of the FMA. Majority of examiners felt that it is easy and comfortable with their arm fixed, whereas their fixed arm had often been interfered when handling instruments. A surgeon may feel troublesome to move the FMA whenever he/her has to change a position of the arm holder frequently, even if an assistant does it.

Concept of the FMA has a possibility to raise efficiency of operative manipulation; however, current FMA is not satisfactory for operators' needs. If a control system of FMA movement, such as mechanical and/or computer control, is developed instead of an assistant's help, disadvantages of the FMA will be resolved.

CONCLUSIONS

Installing an FMA, which can follow the operator's motion, into microneurosurgery may have a possibility to reduce operator's fatigue and to improve maneuverability. The FMA will be more satisfactory when an innovative movement control system would be developed.

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