

APPLICATION OF FINGERTIP SUPPORT TECHNIQUE IN MICROSURGERY

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Abstract

Objective

The physiological tremor which may extend up to 0.4–0.6 mm on the instrument tip in case of a well-skilled microsurgeon may cause difficulties in any field of microsurgery, in spite of using different armrests. The limit of correctness of medical robots is about 0.1 mm so far, but the application of these machines is expensive and not convenient for surgeons because the direct touch via microinstruments with living tissues is impossible.

Method

The effectiveness of the fingertip support technique has been proven by randomized analysis by exact measuring of the reduction of tremor.

Results

The 0.1 mm precision could be reached by fingertip support. This extra precise work has not been available by hand so far.

Conclusion

The significant effect of fingertip support technique in neurosurgery has been certified and published by exact measuring and clinical data.

Our hypothesis could be the indication for trials in any microsurgical work.

Keywords: fingertip support technique; micromanipulation; microsurgery; revascularisation

Introduction

The precise microsurgical work can be complicated when more than 5–10× magnification is necessary (microneurosurgery, microvascular procedures in plastic and hand surgery, ret-

ineal surgery in ophthalmology, cardiac surgery, ear surgery). The most obstructive problem is the physiological tremor which expands up to 0.4–0.6 mm even in the case of, well skilled microsurgeons as well^{3,4,5,6} (*Figure 1*).

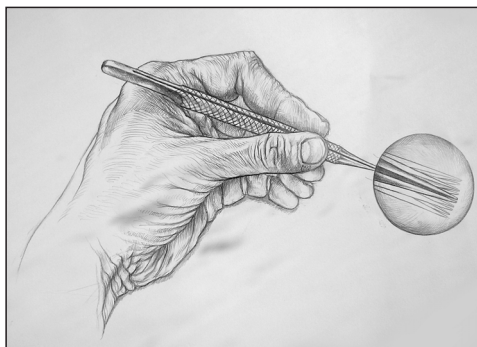


Figure 1. There is a shift caused by the tremor on the end of micro instruments, by the traditional technique



Figure 2. The fingertip support technique reduces the tremor at the end of the instruments

The problems originate from the fact that between the operation point and the last supporting point (end of IV–V fingertip) the carpal joints transmit micro movements (tremors originated neurogenic and mechanical from breathing and heart beat transmitted by circulation to hand) which cause tremors at the end of micro instruments. The fingertip support technique consists of support of I–III fingertip on the crossing bridge (called Bethlehem bridge) above the operating (working) point^{1,2,3,4} (Figure 2).

The end of the bridge rests on the cushions which are fixed on the edge of the exposure. By this technique there are no carpal and finger joints between the last supporting points and the end of instruments which could transmit the tremor. The bridge is necessary because the closest fixed points on the skull or any part of body including the well known armrest devices could be placed so far too far to balance and drive the microinstruments to the operating point only by the fingertip. The fingertip support technique was introduced at different microneurosurgical approaches^{1,2,3,4} (Figure 3) and gives significant reduction of postoperative complications^{3,4}.

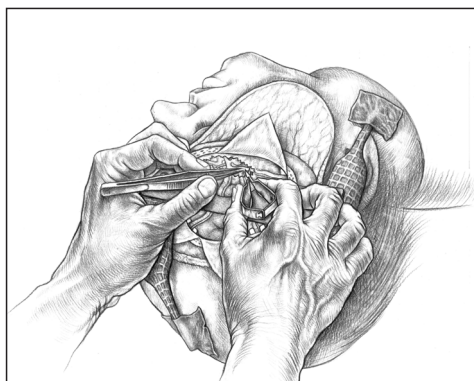


Figure 3. The application of robot hand method in the course of microneurosurgery

Randomized trial of tremor reduction by robot hand technique has not been performed so far. Our hypothesis states that this technique could be introduced in any field of microsurgical approach.

Method

Effectiveness of the fingertip support technique has been proven by randomized analysis by exact measuring of the reduction of tremor. To measure the difference between the traditional and the new method, we used tracking the instrument tip movements in case of 8 microsurgions. (3 neurosurgeons, 3 ophthal-

mologists, 1 hand and plastic surgeon, 1 facial and neck surgeon, (aged 30–50), (male and female ratio (6/2)). The subjects were asked to hold the tip of the instrument above a fixed point with visual control under the microscope with 20× magnification. At a distance of 5 mm from the tip of the instrument an adhesive retroreflective marker (2 mm in diameter) was fixed. The position of the marker was registered in a 100×72 mm field of view in the infrared range with the real-time passive marker-based analyser of movement- PAM⁵ at a sampling rate of 50/s. Coordinates of the marker positions, evaluated from the images were recorded by a two-dimensional analyser⁸.

The digital camcorder was positioned on the axis of the forearm of the subject, the elevation angle was approximately perpendicular to the instrument axis. The markers X and Y position data then were processed with the MATLAB 7.1 (The Math Works, Inc.). The marker trajectories and displacement data were compared, concerning the two methods of holding the instrument. With each method 3 recording were captured from a subject.

	Traditional (mm)	Traditional (mm)	P
Trajectory field horizontal	0.53±0.054	0.15±0.030	0.000
Trajectory field vertical	0.46±0.044	0.13±0.020	0.000
Displacement RMS	0.36±0.046	0.10±0.013	0.001

Table 1. Comparison of measurement data with traditional and fingertip support methods recording of a microsurgeon. The new method resulted highly significant ($P < 0.005$) reduction of vertical and horizontal trajectory field and root-mean-square (RMS) of displacement

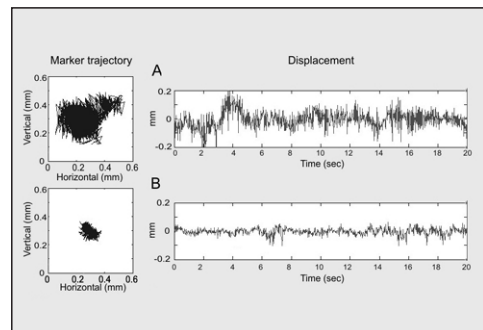
Results

Comparison of marker trajectories showed a significant regress of trajectory field ranges (*Table 1*) with the new instrument holding (fingertip support) technique. The significant reduction of tremor (3,0–4,4) was measured at each subject by fingertip support technique.

The displacement intensity, and the mean displacement values showed significant regress. The maximal displacement with the new method improved from 0.61 mm to 0.27 mm. The most impressive effect was observed in the vertical maximal value with regress from 0.53 mm to 0.18 mm.

Conclusion

The significant reduction of tremor (3.0–4.4) was measured at each subject by fingertip support technique, so we stopped the randomized analysis after the 8 person. The microsurgical work one of the hardest manual work in medicine. Unfortunately microsurgical work practice is hardly affordable in most part of the



Marker trajectories and displacement curves registered with passive marker based analyser of movements with sampling rate of 50 Hz.

The trajectory field and the displacement oscillations with the new method (B) are significantly reduced compared to traditional (A) technique

world. The continuous practice, peaceful spirit helps the surgeon's hand "to stay quiet" during the operations. Even so the tremor may cause difficulties or damages.

There are trials to introduce the medical robots^{7,9} into microsurgery, but their application has not been spread in the microsurgical practice. The preciseness of the most modern robots are 0,1 mm⁹. The preciseness the of fingertip support technique reduces the tremor close to 0,1 mm as well. The manipulation by the surgeons' hand is easier than by the robots.

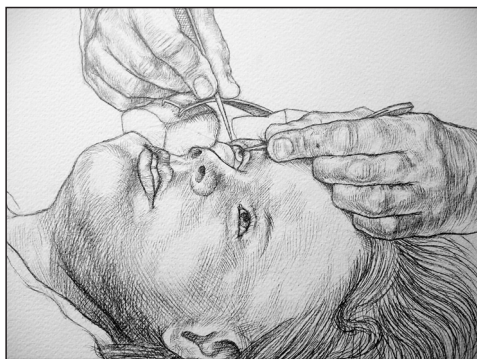


Figure 4. The application of fingertip support method in the course of ophthalmic (retinal) surgery



Figure 6. The application of fingertip support method in the course of finger replantation (revascularization in hand surgery)

The contact of instruments with the living tissues is also very important during surgery. The new technique guarantees it. By fingertip support technique the microsurgical procedures could be available to more surgeons to avoid the postoperative complication. Moreover the mental load on the microsurgeon could be reduced. Our hypothesis suggests the introduction of this technique in any other field of microsurgery (*Figure 4, 5, 6, 7*).



Figure 5. The application of fingertip support method in the course of microrevascularisation of free skin flap transplantation in plastic surgery. The place of Bethlehem bridge is similar in oto surgery (implantation of ear bones)

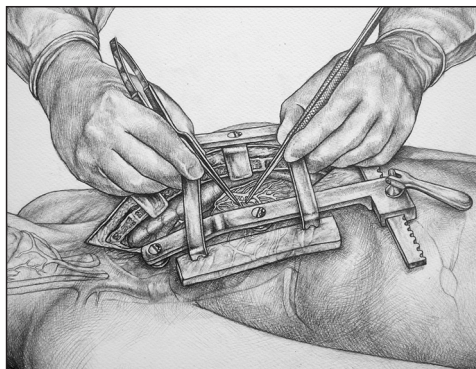


Figure 7. The possible application of robot hand technique in the course of coronary surgery

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