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Endoscopic-assisted microsurgery: microsurgery in the new millennium? A comparative experimental study

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SUMMARY. Endoscopes are already present in almost all plastic surgery departments. The operating microscope is currently an essential piece of equipment for performing microsurgical anastomoses; however, microsurgery could be conducted using other equipment, including the endoscope. By performing 60 vessel and nerve repairs in rats under the operating microscope and the same number using the endoscope as a visual aid, we investigated the technical and clinical differences between the two instruments. We recorded significantly shorter operative, vascular preparation and anastomotic times in the endoscopically assisted group. Based on the data collected during this study, we conclude that microsurgery is possible with the aid of an endoscope. Using the endoscope may make prolonged microvascular procedures shorter and less physically demanding and may increase the comfort level of both the surgeon and the assistant. © 2003 The British Association of Plastics Surgeons. Published by Elsevier Science Ltd. All rights reserved.

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In microvascular surgery, the surgeon must have the best possible view of the operating field. Most major improvements in microvascular surgery in the past 20–30 years have been related to the development of instruments and to the increased understanding of the pathophysiology of transplanted tissues. These developments have led to anastomotic success rates as high as 95%. The operating microscope itself, however, has undergone very few modifications, with the basic mechanical parts remaining much the same as 20–30 years ago.[1]

We still believe that the microscope is the visual aid of choice when performing microsurgical procedures. However, the endoscope provides a similar magnification to the surgical microscope, with the advantage of operating at a distance. To justify adopting this technique, it should lead to a shorter operative time and fewer complications, than have similar success to and cost less than conventional microsurgery. This study examines the efficacy of endoscopically assisted microsurgery (EAM) and compares it with the conventional performance of the operating microscope.

The idea of EAM might be attractive to a new generation of microsurgeons and in special situations.

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Materials and methods

We divided 40 Sprague–Dawley male rats, weighing 250–350 g, into two groups (A and B). The femoral vessels and nerves were sectioned and anastomosed under the operating microscope in 20 animals (group A) and by using an endoscope in the other 20 (group B). The procedures were performed by a single investigator, who had undertaken 6 months of microscopic and endoscopic microsurgical training. Permission for the study was obtained from the concerned animal protection committee of the State of Bavaria, Germany.

The operating microscope used in this project was an OpMi 6-F (Carl Zeiss, Germany), equipped with foot-pedal-controlled zoom and focus and two pairs of eyepieces. The endoscopic unit consisted of a 10 mm 0° endoscope, a Telecam one-chip video camera equipped with zoom and focus functions and a xenon light source (Karl Storz Endoscopy, Tuttlingen, Germany). The endoscope was suspended above the operative field using a standard metal stand (Fig. 1). The images were displayed on a 14-inch Trinitron (Sony) high-resolution colour monitor, which was set up in front of the surgeon.

After ether induction, animals in the two groups were anaesthetised with a mixture of 0.4 ml kg^{-1} midazolam hydrochloride (Dormicum), 0.15 ml kg^{-1} medetomidine hydrochloride (Domitor) and 0.1 ml kg^{-1} fentanyl hydrochloride (Fentanyl) in 4 ml of 0.9% sodium chloride solution administered by intramuscular injection.

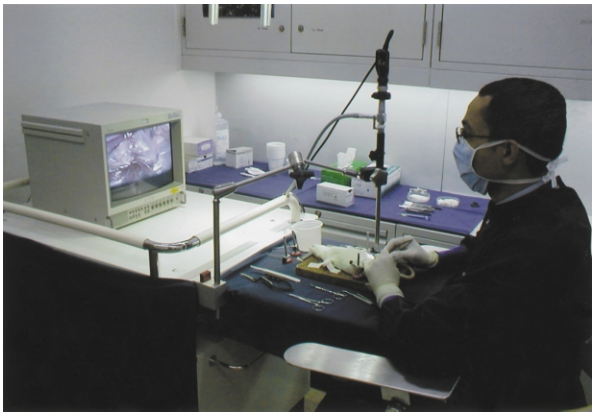

Figure 1—Endoscopic-assisted microsurgery.

All vascular and neural anastomoses were performed as end-to-end anastomoses using 10/0 BV 4 needle Ethilon (Ethicon, Germany). Standard surgical microinstruments were used.

Under the operating microscope in group A and with the visual aid of the endoscope in group B the femoral vessels and nerve were exposed and skeletonised below the inguinal ligament, clamped, divided and the ends flushed with heparinised saline. The adventitia was trimmed, and standard interrupted end-to-end anastomoses were performed. The nerves were sectioned and anastomosed using the periepineural technique. The anastomoses were examined for patency intraoperatively by the milking test in standard fashion. The operative time from skin incision to skin closure and the time required to dissect the vessels and prepare for the anastomoses were recorded. Additionally, the time taken to complete each of the anastomoses was measured from the application of the first suture to the last suture. Other technical aspects, such as handling of the instruments, eye-to-hand coordination, the degree of magnification, the working distance, the depth of focus, the diameter of the operative field, the resolution and quality of the two-dimensional image and the surgeon's physical status were also assessed and compared. The preoperative preparation time, including the pre-anaesthetic medication, anaesthesia and animal preparation for the trial, was neither recorded nor compared. The external wound was closed with simple interrupted sutures. The animals were re-anaesthetised 7 days postoperatively, the anastomoses were clinically examined and a biopsy, including the operated vessels and nerves, was taken for histological assessment and fixed in 10% formal saline (formalin); the animals were then slaughtered.

Statistical analysis, including mean and standard deviation, was performed for both groups. The two groups were compared using the two-way non-paired *t*-test, with the significance (*P* value) reported for each *t*-test.

Results

A technical comparison between the microscope and the endoscope was performed. The 10 mm straight endoscope was well suited to this role. The magnification was inversely proportional to the working distance. The working distance was much shorter when using the endoscope than when using the microscope, and ranged from 1.5 to 2.0 cm with 20 × magnification for the endoscope, compared with 18 cm for the same magnification under the microscope. During special microsurgical steps, such as placing stitches and tying knots, the zoom camera came in very useful for increasing or decreasing the magnification without moving the endoscope. With the one-chip video camera, the quality of the endoscopic two-dimensional image was sufficient to provide a precise view of the microsurgical steps.

Table 1 Time taken for different aspects of femoral vessel and nerve repair in the microscopic (A) and endoscopic (B) groups

	Number performed	Mean time taken (range) (min)	Standard deviation (min)	P
total operative time				
group A	20	200.5 (150–230)	30.6	<0.0001
group B	20	151 (140–180)	8.3	
vessel preparation time				
group A	20	42.2 (28–50)	8.5	<0.0005
group B	20	18.1 (15–25)	3.1	
arterial anastomotic time				
group A	20	36.1 (25–45)	5.7	<0.0005
group B	20	26.3 (22–35)	2.7	
venous anastomotic time				
group A	20	38.5 (25–45)	5.1	<0.0005
group B	20	26.4 (23–35)	2.7	
neural repair time				
group A	20	25.7 (20–40)	7.3	<0.001
group B	20	19.6 (17–25)	1.7	
total anastomotic time				
group A	20	100.4 (75–130)	13.5	<0.0005
group B	20	72.4 (65–90)	5.4	

Analysis of the two groups (Table 1) showed that the mean total times for the whole procedure in the microscopic group (A) and in the endoscopic group (B) were 200.5 and 151 min, respectively ($P < 0.0001$); the mean preparation times for the vessel dissection and preparation for anastomosis were 42.2 and 18.1 min, respectively ($P < 0.0005$); the mean arterial anastomotic times were 36.1 and 26.3 min, respectively ($P < 0.0005$); the mean venous anastomotic times were 38.5 and 26.4 min, respectively ($P < 0.0005$); the mean neural repair times were 25.7 and 19.6 min, respectively ($P < 0.001$); and the mean total times spent on the three repairs

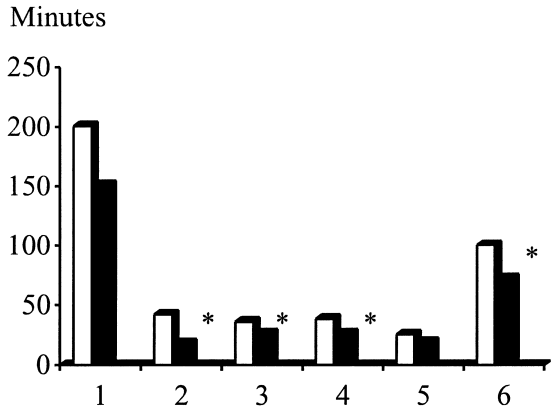

Figure 2—Time taken for the different operative steps of the microscopic (group A; open bars) and endoscopic-assisted (group B; closed bars) anastomoses: 1: total time; 2: vascular preparation time; 3: arterial anastomotic time; 4: venous anastomotic time; 5: neural repair time; and 6: total anastomotic time. *$P < 0.0005$; $n = 20$ for each group.

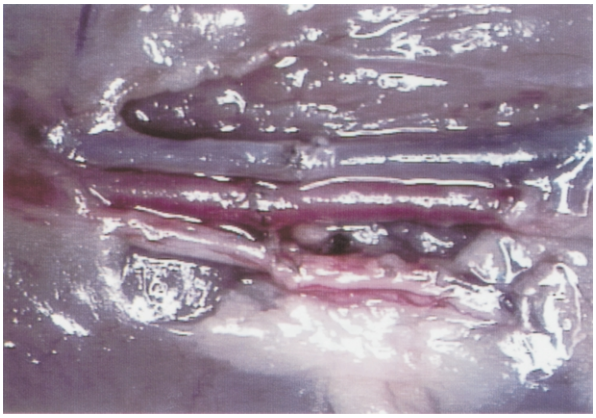

Figure 3—The high-resolution two-dimensional image from the one-chip camera allows clear visualisation of the operative field.

were 100.4 and 72.4 min, respectively ($P < 0.0005$) (Fig. 2). In both groups there was 90% vascular patency and 93.5% accurate neural anastomoses.

Despite the short working distance, all of the steps of the EAM procedures (dissection, clamp application, vascular-end preparation, irrigation and the anastomosis itself) were performed with comfort. The surgeon's physical status was good during the procedures, and visual and physical comfort was excellent compared with the microscope. Handling of the instruments and adjustment of the zoom and focus were not difficult.

Discussion

For good microsurgical performance, the surgeon needs to see the field magnified and at good resolution. These two requirements, together with better physical and visual comfort for the surgeon and his/her team, can be achieved using the endoscope. Many authors have tried experimentally to perform microsurgery without a microscope: Jain et al in six anastomoses,[2] Franken et al in 12 anastomoses,[1] Ramakrishnan et al in 20 anastomoses[3] and Medot et al in clinical and cadaveric human neck dissections.[4] Although their studies involved only a few cases, they all reported that it was possible to perform microsurgery using visual onscreen assistance to disconnect the surgeon from the physically demanding contact with the operating microscope. We have obtained similar results and agree with their reported data.

The 10 mm 0° endoscope was well suited to microsurgery. The two-dimensional endoscopic image was not a constraint to performing the microsurgical procedures. The one-chip camera has a good resolution (450 pixels per image axis) and enabled the investigator to perform the different microsurgical steps with ease, especially fine manoeuvres, such as handling the vascular ends and placing the stitches (Fig. 3). Eye-to-hand coordination, however, was well established only after a few hours' training. The operating microscope has the advantage of a binocular three-dimensional image, and is easier and faster to accommodate to. The large rectangular operative field displayed on the EAM monitor was very helpful and more comfortable than the limited circular field seen under the microscope. The endoscopic working distances with the best magnified images (18 ×) ranged from 1.5 to 2.0 cm, but this was not a limiting factor in manipulating the fine microinstruments and handling the tissues in the operative field under the endoscope. Only one-third of the maximum light intensity was required to illuminate the operative field adequately. With continuous irrigation of the vessels by a physiologic solution, there was no desiccation or heating of the tissues in the operative field.

None of the studies previously mentioned[1–4] compared the operative time when using the microscope and the endoscope. Jain et al found that no endoscopic anastomosis was performed in less than 35 min.[2] In this series, we performed 120 rat femoral vascular and neural repairs using either the operating microscope ($n = 60$) or the visual aid of the endoscope ($n = 60$). Using the endoscope, it took 22–35 min (mean: 26.3 min) for the vascular anastomoses and 17–25 min (mean: 19.6 min) for the neural anastomoses. These times were significantly shorter than those required when using the microscopic, for which mean values of 37.3 and 25.7 min for the vascular and neural repairs, respectively, were recorded. We also found a significant reduction in the total operative time (by about 50 min) and the vessel preparation time (by more than 20 min) in the endoscopically assisted group.

If an endoscopic technique does not achieve a similar success rate to conventional microsurgery, its use is not justified. We consider EAM to be a safe procedure. The success rate depends mainly on the microvascular anastomotic technique. There was no significant difference in the patency rate between the microscopic and the endoscopic groups.

In an era of increasing cost consciousness, surgeons must be aware of the financial impact of a new technical procedure. Endoscopes are now available in most large hospitals at approximately half the cost of a surgical microscope. Reductions in operative time and complication rates may allow further cost savings.

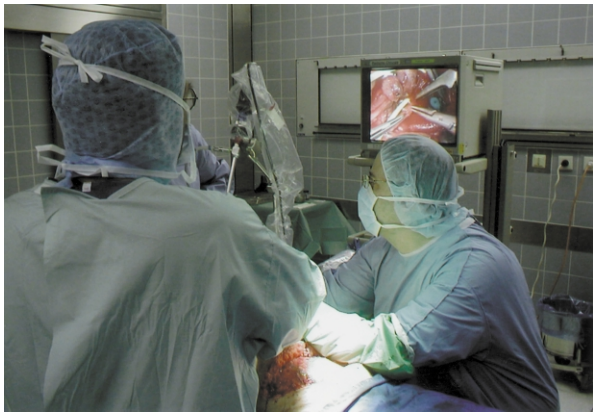

Figure 4—Endoscopic-assisted free TRAM flap transplantation.

The move from experimental to clinical application has already taken place in the field of vascular anastomoses of free flaps (Fig. 4). The surgeon works while watching the monitor, with no need to adjust the focus for each surgeon. Surgeons can feel more comfortable keeping their glasses on while operating than removing them in order to look into the microscope.

Persuading surgeons to change from the microscope to the endoscope will not be easy. Many of them have used the microscope for decades. Our aim was not to replace the operating microscope with the endoscope but to provide an alternative magnification system, which may be preferable in certain operative and financial situations. However, the endoscope has many advantages, and is a new technique in the field of microsurgery, which will be the subject of further research and application by the next generation of surgeons.

References

1. Franken RJ, Gupta SC, Banis JC, et al. Microsurgery without a microscope: laboratory evaluation of a three-dimensional on-screen microsurgical system. Microsurgery 1995;16:746–51.
2. Jain A, Sasaki S, Engeles B, Oldenbeuving B, Poindexter B, Vasconez L. Microvascular surgery utilizing the endoscope as the sole source of visual assistance. Microsurgery 1998;18:86–9.
3. Ramakrishnan V, Villafane O, Southern S. Video microsurgery: a substitute for the operating microscope? Br J Plast Surg 1997;50: 294.
4. Medot M, Nelissen X, Heymans O, Adant J, Fissette J. Video-microsurgery: a new tool in microsurgery. Br J Plast Surg 1999;52: 92–6.

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