Supermicrosurgery

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20.1 Introduction

Microsurgery of free flaps was developed by Harii, Daniel, and Taylor in 1973 [1, 2] and initially involved the use of a groin flap. Since then, many kinds of free flaps have been developed for microsurgery. The vessels supplying these flaps are small and have a diameter of approximately 1 mm or more.

Koshima introduced perforator flaps in microsurgery [3] during the second stage of development of microsurgery. The merits of using these flaps are that they render the surgery less invasive (muscle and other portions that are harvested for other flaps can be preserved) and can be more suitable for the recipient site as they provide the surgeon with flexibility and multiple choices for donor tissue. While using these flaps, smaller vessels, which are branches of main vessels, need to be accurately detected; however, the vessels used for anastomosis are the same as those used for classic flaps.

Some microsurgeons have developed the skills to anastomose very small vessels. This technique is called "supermicrosurgery" and is defined as anastomosis of vessels that have a diameter of less than 0.5 mm. This technique enables unique operations that seemed impossible earlier, such as fingertip replantation (Fig. 20.1), true perforator flaps [4], and lymphaticovenular anastomosis (LVA) [6] (Figs. 20.2 and 20.3). Supermicrosurgery is an ideal technique in this regard but is very difficult to perform.

20.2 Difficulties in Performing Supermicrosurgery

Performing supermicrosurgery is difficult because of mechanical, technical, and environmental problems related with the small diameter of vessels. These vessels have very thin and soft walls. Therefore, after the vessel is cut, its cut edge closes

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P. Liverneaux et al. (eds.), *Telemicrosurgery*,
DOI 10.1007/978-2-8178-0391-3_20,

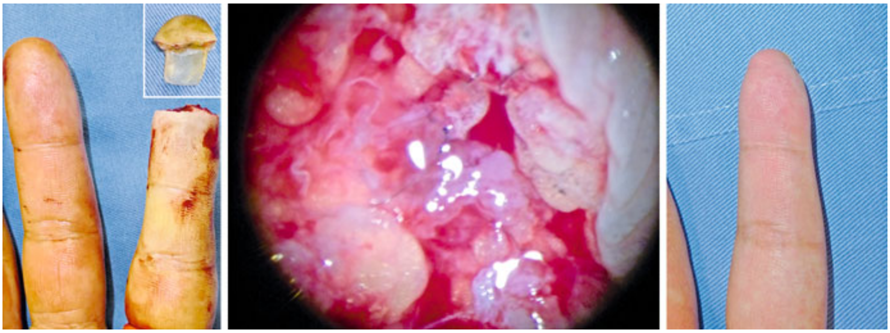

Fig. 20.1 Photographs showing fingertip replantation. *Left*: A palmar view of amputated index fingertip. *Middle*: Arterial anastomosis (the diameters of arteries are 0.3 and 0.45 mm) view under microscope at 20×. *Right*: 6-month follow-up result after reconstruction

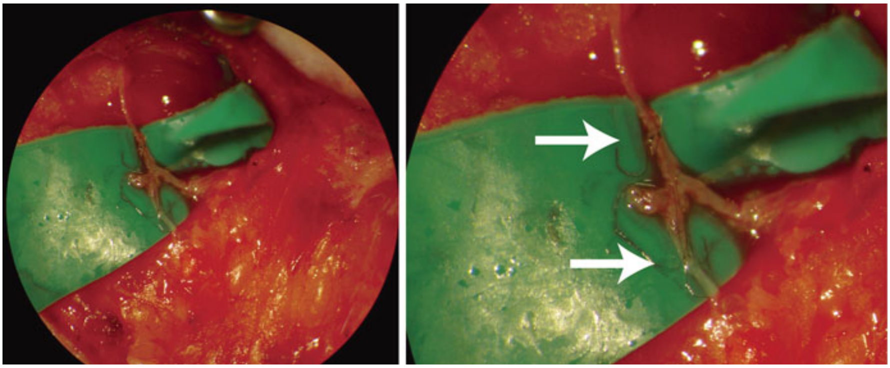

Fig. 20.2 The typical views of LVA. *Left*: A view under microscope at 20×. *Right*: Magnified on computer (*each arrow shows LVA*)

completely, and the intimal edge is often covered with adventitia. Visualizing the inner side of the vessel wall, which faces the lumen, is not difficult, but the inner side can be visualized only for a short period because the walls are soft and cling to each other quickly. In microsurgery, holding the vessel wall from the inner side by using forceps is an essential procedure. However, in supermicrosurgery, it is not possible to insert forceps inside the lumen because of the small diameter of the vessel. Therefore, operators have to penetrate the vessel by using a needle, which is also very small and fragile, without holding the vessel wall from the inner side. The magnification provided by the conventional microscope is not sufficient for supermicrosurgery. Most standard microscopes provide a maximum magnification of 20×. The tubular structure of smaller vessels cannot be seen clearly even at this maximum magnification. When increased magnification is used, operator tremor is more noticeable. This interferes with the very fine aspects of the operation, especially at the stage that the needle is passed through the vessel wall. New techniques

Fig. 20.3 Photographs showing lower extremity lymph edema. *Left*: Preoperative view. *Right*: After performing LVA

and instruments have been invented to overcome these problems, but sufficient progress has not yet been made in this regard.

20.3 Telesupermicrosurgery: The Future Vision of Supermicrosurgery

Telesurgery is used in many fields of surgery and is preferred to traditional surgery in certain fields. Telesurgery is currently not used widely for microsurgery, but the feasibility of telemicrosurgery is being studied. Telesupermicrosurgery may become easier to perform than supermicrosurgery. It has some great advantages that cannot be achieved using manual supermicrosurgery.

One of these is view direction control. The direction of the two vessels that are to be anastomosed is an important factor affecting the ease of anastomosis. In conventional microsurgery, the choice of the vessel from which anastomosis is initiated

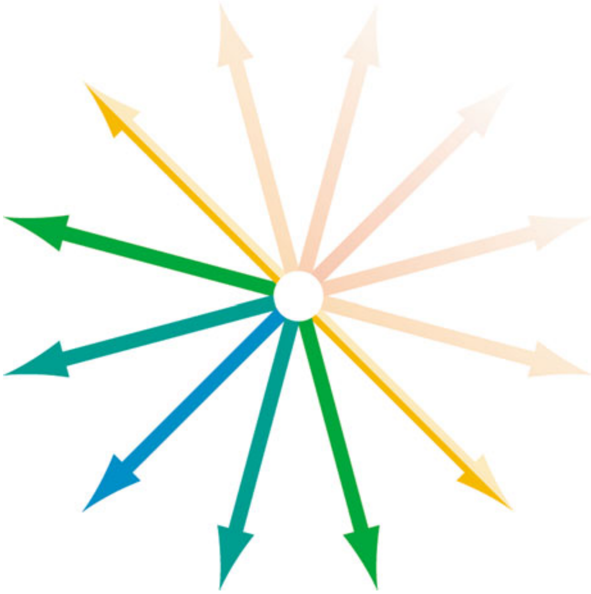

Fig. 20.4 Needle moving direction at microsurgery. *Blue*: easiest direction. *Red*: most difficult direction

has little effect on the results. Therefore, the needle can be moved by almost 180° (Fig. 20.4). In contrast, since the conditions for anastomosis often differ between the vessels during supermicrosurgery, the vessel from which anastomosis is initiated affects ease of performance. Therefore, the needle can be moved in all directions (Fig. 20.5). In telesupermicrosurgery, the field of view can be rotated [5]. Thus, operators can select their consistent and comfortable direction for beginning the anastomosis each time they perform telesupermicrosurgery. Moreover, it is possible to use the mirror view instead of reversing the needle.

Additional advantages of telemicrosurgery are realized through the use of advanced optics. The surgeon benefits from enhancements in magnification and stereoscopic 3D image capture. Limited magnification is obtained with the microscopes commonly used, and only a single image is observed through the eye lens. In supermicrosurgery, greater magnification and quicker image changing between high- and low-power fields are required. In telesupermicrosurgery, increased magnification can be easily achieved using digital zooming because an indirect image is obtained. Using this technology, two images can be reflected in one screen at the same time (Fig. 20.6), similar to that observed with the surgical loupe.

The state of currently available standard manual microsurgical instrumentation confers a limitation to the surgeon. To achieve breakthroughs, finer, more accurate performance and devices are required. Technological advancements in instrumentation for telesupermicrosurgery will improve the facility of performing ultrafine intricate procedures. The surgeon further benefits from the multijoint movement and 6° of freedom associated with the robotic arms and the precision provided by the demultiplication phenomenon described previously in this text.

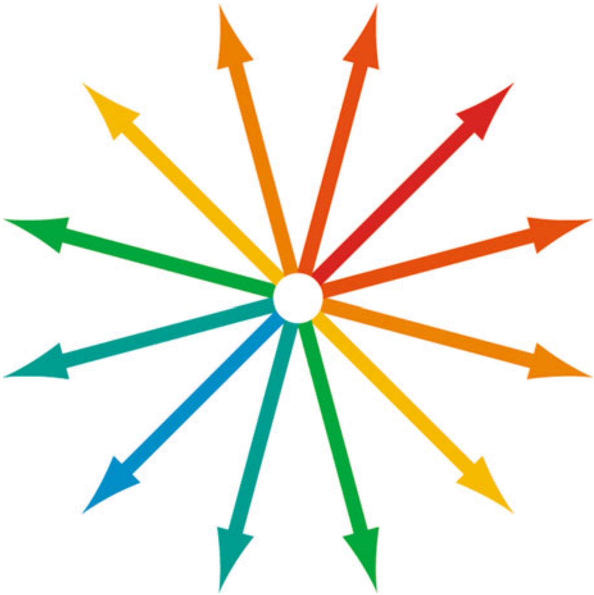

Fig. 20.5 Needle moving direction at supermicrosurgery

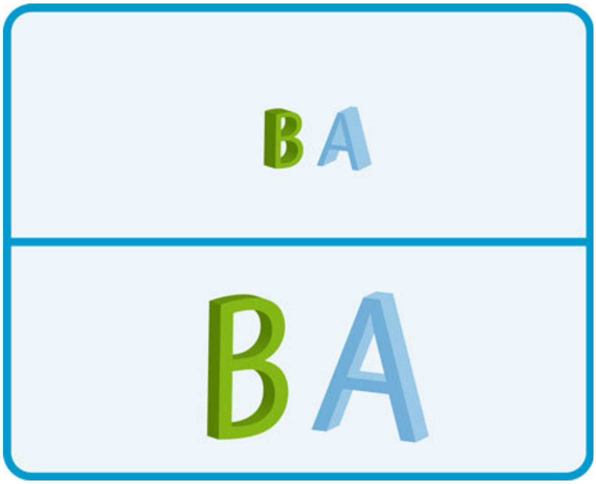

Fig. 20.6 The image of multiple view

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