Performance of Supermicrosurgery Using a Titanium Needle Holder

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Abstract

Development of the supermicrosuture has enabled performance of supermicrosurgery in which microvessels smaller than 0.5 mm in diameter are anastomosed. This surgery has also been facilitated by advances in peripheral equipment, including a needle holder, for accurate handling of the supermicrosuture. However, there are several problems with the stainless steel needle holder, including weight, magnetism and stylized shape, and a new type of needle holder is needed for resolution of these problems. In this context, the EMI Factory Co. used titanium to develop a light, nonmagnetic and convertible needle holder. In this study, we describe a case of pediatric fingertip replantation and we discuss the potential for production of surgical equipment based on a surgical plan, through development of order-specific medical instruments. We suggest that this approach will require close coordination between the medical and industrial fields.

Keywords Supermicrosurgery, Titanium, Needle holder

Introduction

Developments in supermicrosuture and operating microscopes have enabled performance of supermicrosurgery in which anastomosis of capillary vessels of 0.5 mm or less in diameter can be achieved. High-level skills are required for manipulation of the supermicrosuture in supermicrosurgery[1)]. However, these skills take time to acquire, and assistance through refinement of peripheral equipment is important.

Characteristics of the needle holder in current use

The most important peripheral equipment for supermicrosurgery is the needle holder that contacts the suture directly. The needle holder is generally made with stainless steel, but this causes difficulty with manipulation of supermicrosutures due to its heavy weight (20 g) and magnetic properties[2)]. The manufacturing process of the stainless steel needle holder is also not optimal. In this process, the shape of the needle holder is determined by the casting mold, which makes it difficult to improve the fit of the needle holder to the shape of a surgeon's hands and to the purpose and site of surgery.

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Development of a titanium needle holder

To overcome these problems, i) use of a metal that supersedes stainless steel and ii) an order-specific manufacturing method to meet the diversity of operators and surgical methods would be of substantial value[3]. With this background, EMI Factory Co. developed a manufacturing method using titanium to address these problems. Since titanium is lighter than stainless steel (the titanium needle holder is approximately half the weight of the stainless steel holder) and nonmagnetic, the titanium needle holder is suitable for supermicrosurgery in which prolonged, delicate skills are required (Table 1). The new manufacturing process also avoids use of a casting mold. The unique shaving technology enables correction of the shape of the needle holder by 0.2 μm, which permits order-specific manufacturing of needle holders to fit the site and purpose of surgery. Therefore, the titanium needle holder (Figure 1) based on this manufacturing technology is likely to advance the development of supermicrosurgery. In this study, we describe the use of the new needle holder in a case of pediatric fingertip replantation that required anastomosis of peripheral vessels. We discuss the utility of the titanium needle holder and the potential significance of order-specific medical instruments[4].

Case

The patient was a 3-year-old male with complete amputation of his right ring and small fingers at the nail base due to a knife injury (Figure 2). The stump and amputated digit were debrided and fixed with 4-0 Vicryl. One radial artery and one vein of the ring finger were repaired microsurgically with 12-0 nylon utilizing a titanium needle holder. The diameters of the artery and vein were 0.4 mm and 0.7 mm, respectively (Figure 3). The small finger was used for a skin graft (Figure 4). Seven days after the operation, the replanted finger was congestive, but at 14 days postoperatively the color of the replanted finger was good. After a follow-up period of 10 months, the static two-point discrimination value was 6 mm and the range of motion of the interphalangeal joint was 75%.

Table 1. Comparison of stainless steel and titanium needle holders

	Stainless steel	Titanium (EMI Factory)
Weight (standard size)	Approximately 21 g	Approximately 10 g
Corrosion resistance	Corrosion after a long period of use	Highly corrosion resistant
Magnetic property	Magnetic, needle sticks to the tip of the holder	Nonmagnetic
Material	Hard, needle bending occurs because of the concentration of grip force on the holder tip	Flexible, tight grip without any concern of needle bending
Surface coating	i) Blood adherence causes stickiness ii) Reflective under the microscope	Special surface finish: i) Inhibits blood adherence ii) Nonreflective, reduces eye fatigue

Figure 1.
(A) The titanium needle holder developed by EMI Factory Co.
(B) The needle holder improves handling of supermicrosutures and makes it easier to anastomose microtissues of ∼0.5 mm in diameter. The needle holder rests in the hand and is supported by the thenar web.

Figure 2.
Dorsal and thenal views of the amputated right ring and small fingers.

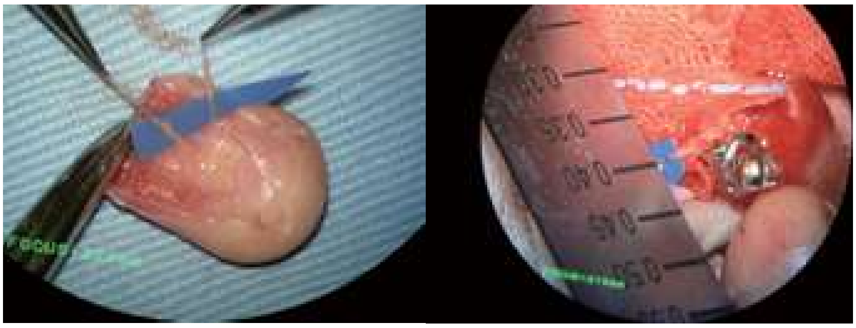

Figure 3.
Vessels of the fingertip. The diameters of the artery and vein were 0.4 mm and 0.7 mm, respectively.

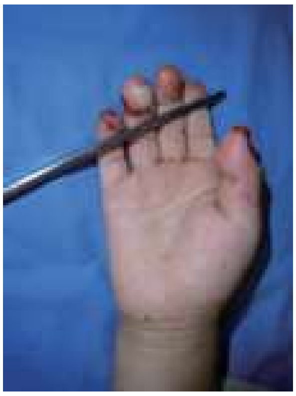

Figure 4.
Dorsal and thenal views of the replanted right ring finger and small finger after the operation.

D iscussion

Discussion

In this study, we used a titanium needle holder in successful replantation of a pediatric fingertip, which required anastomosis of peripheral vessels of ∼0.5 mm in diameter. Compared with the heavy and magnetic stainless steel needle holder, the light and nonmagnetic titanium holder had greatly improved properties for handling of the supermicrosuture, which is extremely brittle and awkward.

An additional advantage of titanium compared with stainless steel is its flexibility, which allows the supermicrosuture to be gripped tightly without needle bending. This property also makes it easy to change the shape of the needle holder, which increase the flexibility of operation planning based on the surgical site. The special surface finish also makes the EMI needle holder resistant to blood, which allows confident use during a long operation. The finish also makes the needle holder nonreflective under the microscope, helping to reduce eye fatigue in a vision-enhanced environment. These improvements in the needle holder have arisen through close coordination between surgeons and the medical industry. This coordination will also improve the developmental environment for order-specific medical instruments and should accelerate technical innovations in supermicrosurgery.

Conclusion

Suturation of tissues is required in many surgeries, including plastic surgery, and is indispensable in modern medicine. Suturation has usually been performed based on knowledge of anatomy, but there is a need for flexibility in addressing individual differences in patients and the types and sites of tissues. Supermicrosurgery based on order-specific medical instruments, as described in this report, can change the paradigm that every surgery must be performed with a few fix-shaped medical instruments. In other words, this approach could permit a shift from the concept of "planning of surgery based on the type of medical instruments" to "the manufacture of medical instruments based on a surgical plan".

Issue 1: Wider use of the new needle holder

Medical instruments for supermicrosurgery such as the supermicrosuture and titanium needle holder are not used widely. Dissemination of information regarding the improved environment for supermicrosurgery produced by use of these instruments is a key issue.

Issue 2: Development of a general-purpose needle holder

Various titanium needle holders are currently manufactured according to the requests of individual surgeons. In the future, the development of a general-purpose needle holder for all situations is desirable through integration of the needs of surgeons.

Issue 3: Expansion of the use of order-specific medical instruments

Order-specific manufacturing of medical instruments, including the needle holder, will accelerate improvements in operator skills. Reinforcement of the cooperative framework between surgeons and companies is needed to establish this system.

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