



The clinical application history of microsurgery

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Abstract

In the 20th century, microsurgery achieved many miracles in the history of surgery. With the development of microsurgery instruments and techniques, the limitations steadily decreased from the time when Dr. Zhong-Wei Chen successfully performed the first replantation of an amputated right forearm in 1963 until super microsurgery today. The developmental history of microsurgery can be divided into 5 parts in chronological order based on significant events in each decade: the feasibility of vascular anastomosis before the 1960s; the successful replantation of amputated extremities worldwide in the 1960s; the foundations of microsurgery societies and publication of literature in the 1970s; the development of various kinds of flaps in the 1980s; and supermicrosurgery today. Arousing the interest of freshmen to participate in the international arena of microsurgery, to discover new facets and to increase the efficiency of multi-disciplinary co-operation will be the future of microsurgery.

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Introduction

Since 1921, when Dr. Carl Olof Nylén [1] introduced the microscope into otology surgery, microsurgery has lasted nearly one hundred years, during which time it thrived and flourished around the world, especially in China. With the development of surgical techniques and various methods of reconstructing various lesions and congenital malformation, the needs of delicate reconstructions have become increasingly important. Today, super microsurgery has opened a new era of traditional microsurgery, and it brings the discipline to a more microscopic world. Vascular anastomosis, a basic element of microsurgery, is regarded as a guide for discussion of the developmental his-

tory of the clinical application of microsurgery in this review; the history will be divided into 5 parts in chronological order based on the significant events in each decade: conception (before the 1960s), foundation (1960s), initiation (1970s), progression (1980s), and expansion (after the 1990s).

Conception

Throughout the process of microsurgery development, undoubtedly, the fundamental techniques of vascular anastomosis and introduction of microscope were indispensably important. In this stage, Lambert [2] sutured an arterial wound in 1762 and J.B. Murphy [3] first performed end-to-end vascular



anastomosis in 1879. Two years later, Jassinowsky [4] repaired a vascular rupture and successfully preserved its patency. These trials demonstrated the feasibility of vascular anastomosis. Subsequently, the Nobel Prize winner, Alexis Carrel [5], reported a technique named “triangulation” for end-to-end anastomosis in 1902, which had a significant impact on vascular anastomosis that is still used in procedures today. Simultaneously, many people placed a great deal of effort into the research of vascular anastomosis after Lowen berg [6,7] reported his results in canines; however, the rate of patency was unsatisfactory without the assistance of a microscope. Microscopy was introduced in the otology surgery by Dr. Carl Olof Nylén [1] in 1921.

Foundation

The exact date of microsurgery foundation can be traced to a company, Zeiss, who put the surgical microscope into mass production in 1953. As the microscope was being used in surgical procedures, Dr. Julius H. Jacobson and Suarez [8,9] successfully performed a canine vessel anastomosis using an operating microscope and achieved a 1.6-3.2 mm diameter vessel anastomosis in 1960, opening a new era of tiny vascular anastomosis and laying the foundation for microsurgery development.

Numerous researchers began a variety of animal experiments at this time, achieving accelerated development of tissue replantation and organ transplantation in the 1960s.

China can be considered a pioneer in microsurgery because Dr. Zhong-Wei Chen [10] successfully performed the first replantation of an amputated right forearm in 1963. In 1964, Dr. Ronald A. Malt [11] reported the case of an amputated right upper arm reunion with the body of a 12-year-old boy performed in 1962. Dr. Gong-Dao Kuang and Dr. Cheng-Da Huang [12] first replanted a right amputated calf in November 1964. Subsequently, many experts tried to perform more complicated surgeries, including those for amputated digits. Dr. Shigeo Komatsu [13] and Dr. Zhong-Wei Chen [14,15] succeeded in replanting amputated digits in 1965 and 1966, respectively. In that same year, Dr. Dong-Yue Yang [16] reconstructed a finger with a second toe-to-hand transplantation.

In addition to replantation of amputated limbs and fingers, many experts successfully performed organ transplantation, including Starzl [17] - homotransplantation of the liver, Hardy [18] - lung homotransplantation in humans in 1963, Lillehei [19] - all transplantation of the pancreas in 1966, and Barnard [20] - human cardiac transplantation in 1967.

Initiation

With the progression of microsurgical suturing and successful cases of reconstruction and transplantation, specialists began considering the establishment of journals and associations for microsurgery for the benefit of academic exchange. This resulted in the formation of the International Microsurgery Society (IMS) in 1970 and the International Society of Reconstructive Microsurgery (ISRM) specific for plastic surgery, orthopaedics and hand surgery in 1972. The best achievement would be “The histopathology of small vessels following microvascular repair” completed by O’Brien in 1972, establishing that accurate apposition of vessel walls and avoidance of excessive medial necrosis by stress were important in vascular anastomosis, a notion that is still influencing the concept of microsurgery today. Moreover, many books, including “Symposium on Microsurgery” by Daniller [21] (1976) and “Microvascular Reconstructive” by O’Brien [22] (1977), were published for propagation and populariza-

tion.

On the other side of the world, the exchange experience and a seminar on digital replantation were held in Guangzhou (China) in 1972. At that time, the reported success rate of amputated arm replantation and the rate of digital replantation were 65.8% and 31.1%, respectively. The first Chinese book about microsurgery, *MICROSURGERY* (Zhong-Wei Chen, et al.), and the Chinese medical journal of *Microsurgery* [23] were published in 1978, and Jia-Kai Zhu of the First Affiliated Hospital of Sun Yat-sen University expanded the vascular anastomosis technique to lymphovenous anastomosis in 1979.

Progression

The skills of microsurgery were advancing with the passage of time. The establishment of “Microsurgery” in 1980 and the “Journal of Reconstructive Microsurgery (JRM)” in 1985 were milestones of microsurgery. In this period, various kinds of flaps were created, which caused the rapid development of microsurgery.

In 1979, Dr. Guo-Fan Yang [24] in China began a study of radial artery forearm flaps and performed 56 cases in 1980. Song [25] and Muhlbauer [26] et al. also reported their successful results for a radial forearm flap. Other axial flaps with main artery in limbs, including the radial artery retrograde island flap, lateral crural flap and dorsalis pedis artery retrograde island flap were subsequently reported (Table 1).

In the late 1980s, the small vascular anastomosis technique became widely accepted, optimizing donor site selection was considered and the concept of the perforator flap was advocated. Dr. Song et al. first introduced the anterolateral thigh flap in 1984 [27], considered for one-stage reconstructions of a variety of defects in various body parts [28-30]. The pioneers, Kojima and Kroll et al., defined it as a type of axial flap supported by small vessels (0.5~0.8 mm). According to the route of the perforator, the flap could be separated into intramuscular and myocutaneous parts. Dr. Koshima [31] also mentioned the idea of a perforated flap and applied it in two patients successfully in 1989.

Expansion

To increase effectiveness and provide platforms for academic exchange, more associations and societies were built successively. In 1990, the European Federation of Societies for Microsurgery (EFSM) [32] was created by a group of countries for the alliance in scientific cooperation.

In 1999, the World Society for Reconstructive Microsurgery (WSRM) [33] was founded following a merger of the International Society for Reconstructive Microsurgery (IRSM) and the International Microsurgical Society (ISM). The goal of WSRM was to stimulate and advance knowledge of the science and art of microsurgery, improving the standards of practice. During this period, *MICROSURGERY* (edited by Jia-Kai Zhu, Chun-Lin Hou, Xiao-Lin Liu, et al) was published, a more comprehensive publication that introduced many new advancements.

Meanwhile, Dr. Koshima et al. first described their technique as “super microsurgery” in a report of the use of the paramedian perforator flap in 1998 [34], clarifying that microsurgery was a technique of nerve and vascular anastomosis of 0.3~0.8 mm at the 2010 conference [35]. Along with the progress of microsurgery instruments and techniques in the last century,

anastomosis of micro vessels with even smaller diameter, such as the proper palmar digital artery (less than 0.5mm), has become feasible today, and successful cases of replantation of fingertips at Zone I in children were reported [36].

To explore more deeply into the microsurgery world, Dr. Koshima and Zengtao Wang established a new platform, the "International Course on Super Microsurgery (ICSM)", for junior doctors with outstanding achievements to share their results and experience. In 2017, the first meeting was held in Jinan, China.

Conclusion

With the contributions of experts around the world during the 20th century, microsurgery has achieved many "first time"

miracles in the history of surgery. From the first case of successful replantation of an amputated forearm with large calibre vessels in 1963 to a tiny digital flap with micro-vessels of less than 1.0 mm today, the limitations of vascular anastomosis with small calibres seem to be no longer considered in the surgical process. Meanwhile, microsurgical techniques are essential in various disciplines, including paediatrics, and heterografts that require precise dissection and micro vascular anastomosis have become an indispensable part of modern surgery and have become more important in various kinds of surgeries. More importantly, inducing freshmen to participate in the international arena of microsurgery to discover the new facets and increasing the efficiency of multidisciplinary cooperation will be the future of microsurgery.

Tables

Table 1: The List of Flaps with Main Arteries Reported in the Literature.

Flap	Reported in Chinese	Reported in English
Radial forearm flap(Chinese flap)	Guo-fan Yang (1981)	Ru-yao Song (1982) Wolfgang Muhlbauer (1982)
Reverse-flow radial artery island flap	Kai-hua Lu (1982) Wei Wang (1982)	Wolfgang Stock (1983) Edgar Biemer (1983)
Reverse-flow posterior tibial artery island flap	Shan-cai Zhang (1984)	Guang-xiang Hong (1989)
Lateral crural flap	Yu-dong Gu (1983)	Mitsuo Yoshimura (1984) Yu-dong Gu (1985)
Reverse-flow ulnar artery island flap	Zhu-tian Li (1985)	D. W. Glasson (1988) J.C. Guimberteau (1988) Zhu-tian Li (1989)
Reverse-flow dorsalis pedis artery island flap	Qing-yuan Yang (1986)	Kozo Ishikawa (1987)
Anteriolateral thigh flap	Li-sheng Luo (1984)	Ye-guang Song (1984)

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