

Microsurgical anatomy in China

S-Z Zhong and J-M Kong

Department of Anatomy, The First Military Medical University Guangzhou, The People's Republic of China

Summary. This is a general review on the recent advances made in China of microsurgical anatomy. In recent years, more than 300 research papers and a number of monographs on microsurgical anatomy have been published in China. In the research of skin and musculocutaneous flaps, much applied anatomical data about more than 30 new donor areas have been collected and the investigations on the patterns of the blood supply of the flaps are instructively significant to clinical practice. New donor areas have also been introduced for scapular, radial, tibial and other bone flaps, and the range of indications for using the periosteal and cartilaginous flaps has been broadened. On the basis of the technique of superficial lymphaticovenous anastomosis, new information for deep lymphaticovenous anastomosis has been provided by clinical anatomists. Through experimental research, the anatomists pointed out that lymphatic vessels with contracting ability should be selected for anastomosis in order to enhance the long term effect of the operation. The successful experiment of bridging the peripheral nerve gap with skeletal muscle, which has been clinically used, has opened up a hopeful prospect for solving the problem of the unavailability of autogenous nerve donors. The iden-

tification of nerve fascicles in the nerve trunk provides a morphological basis for the selection of different suture patterns. In addition, much research work has been done on the transplantation of the suprarenal gland, pancreas, parathyroid gland, testis, kidney of foetus and other small organs.

L'anatomie microchirurgicale en Chine

Résumé. Les auteurs font une revue générale des progrès récents réalisés en anatomie microchirurgicale en Chine. Ces dernières années, plus de 300 publications concernant l'anatomie microchirurgicale ont été publiées en Chine. Dans le cadre de la recherche de lambeaux cutanés et musculo-cutanés, de nombreuses caractéristiques anatomiques concernant plus de 30 nouveaux sites donneurs ont été réunies. Les investigations concernant les modes de vascularisation des lambeaux sont des données fondamentales pour la pratique clinique. De nouveaux sites donneurs ont été découverts pour les cancers osseux à partir de l'omoplate, du radius, du tibia et d'autres os et les indications d'utilisation de lambeaux périostés et cartilagineux ont été élargies. A partir des techniques d'anastomoses lymphatique-veineuses superficielles, de nouvelles données pour les anastomoses lymphatique-veineuses profondes ont été apportées par les anatomistes cliniciens. A travers la

recherche expérimentale, les anatomistes ont insisté sur l'utilisation de vaisseaux lymphatiques contractiles pour accroître les effets de l'intervention. La réparation d'une perte de substance nerveuse par un pontage musculaire a été cliniquement utilisée avec succès, et a ouvert un champ important de possibilités permettant de résoudre les problèmes de réparation nerveuse en l'absence de greffe nerveuse autogène disponible. L'identification des fascicules nerveux dans le tronc nerveux fournit une base morphologique au choix entre différents types de sutures. En outre, de nombreuses recherches ont été réalisées sur les transplantations de glande surrénale, de pancréas, de glande thyroïde, de testicule, de rein, de fœtus et d'autres organes de petites dimensions.

Key words : Microsurgical anatomy — Review

In recent years, a new technique of microsurgery has been expanding very rapidly in China, which has brought about a noteworthy advance in microsurgical anatomy. In order to keep a pace with the development of microsurgery, Chinese clinical anatomists have devoted themselves to anatomical microsurgical research. Working together with clinicians, they have made a great contribution to microsurgery.

The applied anatomy of free skin flap transplantation

In China the early stage of investigation on the applied anatomy of skin flap transplantation was linked with attempts to find new donor sites to provide clinicians with various and optional skin flaps. As a result, many donors for skin transplantation emerged. Donor areas that have been used clinically are from all areas of the body and more than 30 in number, among which the investigations on the fronto-parieto-temporal flap [101], the scapular-dorsal flap [90], the scapular flap [42], the thoraco-umbilical flap [13], the upper lateral branchial flap [52], the forearm flap [47, 89], the anterolateral femoral flap [80, 87], the anterolateral leg flap [96], the lateral pedis flap 5, the scrotal skin flap [104], the scrotal septal flap [61] and the labial flap [62] have proved to be of special clinical importance.

However, recent attention in clinical anatomy of the skin flap has mainly been drawn to the exploration of some rules of regional blood supply rather than the exploration of new donor sites for skin flap transplantation. In the exploration of skin flaps the trend has been "from small to large in number, then large to small" because certain skin flaps have turned out clinically to be not so good for their area, site, texture, neurovascular pedicle, innervation and so on, and have therefore been eliminated [113]. Chinese anatomists have found a few rules of regional blood supply in specific areas such as intermuscular septal a., intermuscular space a. and the marginal branches of musculocutaneous a. and their relationship with the flaps they nourish [105-108, 110]. These are considered to be of instructive significance to the reconstructive operations in microsurgery as well as the anatomical studies of the skin flap.

As the venous return of a skin

flap is of equal importance as the arterial blood supply for the survival of the transplanted flap, the communicating branch between the deep and superficial v. and the venous valve have also drawn the attention of Chinese anatomists. Hou [30-32] observed that the veins over 0.1 mm in diameter in the lower limb may have valves and there were three kinds of communicating branches between the deep and superficial v., namely, those with valves directing the blood flow into the deep v., those with valves directing into the superficial and those without valves [31, 32]. Thus the traditional idea that blood flow in the dorsal pedal v. is only from the deep v. to the superficial veins via the communicating branches may be revised. The communicating branch between the dorsal pedal v. and the dorsal cutaneous venous arch may be absent in 30% of cases in the dorsal pedal flap area. Clinically, it is advisable to anastomose both the deep and the superficial drainage v. during transplantation of the dorsalis pedis flap in case of such absence. Sun [59, 63] explored the anatomical aspect of reverse island flaps of the forearm and shank, and believed that the communicating branches between the two parallel deep v. played an important role in the venous drainage of the flaps [59, 63, 64]. Chen [6] studied the arterialized venous flap and found that the so called arterialized vein was transient and the survival of the transplanted flap largely depended upon the establishment of a new circulation formed by the regeneration of blood vessels from the margin and bed of the recipient area [3].

The applied anatomy of muscle and musculocutaneous flap transplantation

There is considerable anatomical data about the transplantation of muscle and myocutaneous flaps in

the Chinese literature. Nearly all the muscles of the body can be utilized in the clinic and were investigated. Moreover, Li [43] and Chen [2, 3] further investigated the intramuscular distribution of nerves and blood vessels, and suggested that it may be possible to transplant a part of a muscle in accordance with its neuro-muscular distribution [6, 46]. Such extensive anatomical studies have greatly enriched the operative designs. Clinically, the reconstruction of the tongue [2, 15, 83, 93] can be performed by using the forearm flap [6], tensor fasciae latae myocutaneous flap [81-83], infrahyoid myocutaneous flap [15] or sternal head flaps of bilateral sternocleidomastoid muscles [92]. Also, the paralysed muscles resulting from poliomyelitis or other diseases can be reconstructed by either the transposition of adjacent normal m. [30, 56, 92] (such as the latissimus dorsi transfer for reconstruction of the gluteal m., the external oblique m. for the quadriceps femoris and the latissimus dorsi for the deltoid m.) or the semi-transplantation of muscles (with the neural pedicle) (such as the gracilis m. for the contralateral quadriceps femoris and the gastrocnemius for the quadriceps femoris). In addition, Yuan [92] suggested to clinicians a transfer of the temporal myofascial flap to treat cerebral ischemia instead of the intra-extracranial arterial anastomosis [91].

The applied anatomy of bone transplantation

In the early stage there were only a few donor sites such as the fibula and rib for free vascularized bone transplantation. It was the anatomists later on who, on the basis of anatomical studies, discovered certain new donor sites such as the scapula [109], radius [95], tibia [17]. The vascular pedicle for free iliac transplantation expands the use of superior gluteal vessels [14, 26,

27], the ascending branches of lateral circumflex femoral vessels [84], the iliac branches of iliolumbar vessels [51] or the third and fourth lumbar vessels [14, 25, 54, 84] as compared with the deep and superficial circumflex iliac vessels introduced by Taylor in the early days [67, 68]. The vascular pedicles available are so numerous for many bone donor sites that they make the operations flexible.

The anatomical and experimental studies on the blood supply of the periosteum have provided surgeons with a number of optional donor sites for periosteal graft [43, 45]. The donor areas reportedly included the periosteal flaps of the humerus [19, 20], ilium [44], femur [33], tibia [79] and radius and ulna [23].

In transplantation of bone in the child, it is essential to ensure the blood supply of the epiphysis especially so that the graft can still grow long after transplanted. Anatomically, Chinese anatomists investigated the blood supply of the caput fibulae [16, 94] and worked out guidelines for avoiding injury to the blood vessels during the transplantation. Zhong introduced a method of free vascularized costal cartilage transplantation to avoid the absorption of the graft [107]. In recent years, there have been reports of the use of vascularized clavicular transplantation, however, a biomechanical test demonstrated that instability of the shoulder became significant, especially the scope of forward displacement enlarged adduction of the arm after claviculectomy [118].

The microsurgical anatomy of peripheral nerves

The application of microsurgical techniques to the repair of peripheral nerves first introduced by Smith and Nichon [53, 58] demands a better understanding of the internal structures of the peripheral nerve trunk. Zhong and Zhou

produced a topographical diagram of the nerve trunks through the fascicular funicular dissection method with stress on some significant funiculi for surgical match [97, 102, 106, 117]. However, the internal structures of peripheral nerve trunks are so complicated that it is very difficult for the clinician to master them, even with an instructive diagram. Consequently, anatomists working together with surgeons provided the natural fascicular distribution of nerve trunks in the upper [21] and lower [98] limbs, which is much simpler and clearer.

He and Zhong modified the histochemical demonstration of acetylcholinesterase, which was introduced by Karnovsky and Roots in 1964, in the functional identification of nerve fasciculi, shortening the incubation time needed and making it possible to apply this precise method to the operation [26, 27, 28, 37]. A controversial problem about suturing severed peripheral nerve, whether to suture the stumps on the perineurium or on the fascicular membrane, has been solved by Chinese anatomists. Based on techniques for identifying and distinguishing motor, sensory and mixed fasciculi in peripheral nerves, Zhong proposed guidelines for selecting suture methods for nerve repair [114, 115, 116]. Thus, when many mixed fasciculi are known to exist at the nerve lesion, epineural repair is preferable; while fascicular (perineural) repair is more suitable when pure motor and pure sensory fasciculi are clearly recognized. Generally, epineural repair is indicated for more proximal injuries, while fascicular repair is most appropriate for more distal sites. A greater ratio of epineural connective tissue to intrafascicular nervous tissue implies an inclination toward fascicular repair.

There is considerable anatomical data about the cutaneous nerves for free vascularized graft

[12, 34, 35, 36, 72, 99]. With the vascularized transplantation of superficial sural nerve, a 25 cm long defect of the median n. was successfully bridged in the clinic [120]. Some non-cutaneous nerves such as the deep sural nerve have also been employed as donor nerves [57]. As to nerve transposition, a number of new operations have been designed by means of anatomical studies, which include the facio-facial nerve anastomosis, match of musculocutaneous n. with thoracodorsal or lower subscapular n. thoracodorsal with axillary n., and the interosseous n. of the forearm with motor bundles of thenar m. [7, 9, 18, 19, 22].

Bridging gaps between the severed ends of peripheral n. is a difficult problem because for such bridging the most desirable tissue—the readily available donor sensory nerves—is very limited. Through experimental studies, Kong [38-40] evaluated autogenous skeletal m. as a conduit for bridging nerve gaps. Gross appearance, histological examination, histochemical observation and electrophysiological studies confirmed that the nerves did indeed regenerate through the muscular bridge [38, 39, 40]. A long-term observation showed [41] that the muscular fibres in the m. bridge were disorganized and most of them were replaced by the regenerating nerve fibres. The nerve fibres were well myelinated and showed normal AChE histochemical activities. Clinically, Chinese surgeons have performed this operation on patients with ulnar, median and sciatic nerve injuries with satisfactory results [8, 10, 100]. The muscle graft is believed to be a hopeful donor resource for nerve reconstruction.

The microsurgical anatomy of the lymphatic system

With the aid of an operative microscope, lymphatic-venous anastomosis has been successfully

performed in the treatment of obstructive lymphatic edema in the clinic. Since Lymphatic vessels have small calibre and thin walls with colourless contents, their applied anatomical data are in particular demand to the clinicians. Liu [48, 49] observed that in the extremities and external genitalia, the collecting lymphatics, which could be utilized for anastomosis, regularly accompanied superficial vein trunks and provided guidelines for the search of available lymphatics during operation.

Measurements of lymphatic and venous pressures showed that the lymphatic pressure was always lower than the venous pressure under normal conditions, while in chronic lymphedema lymphatic pressure was higher than the venous pressure. Thus, after a lymphatico-venous anastomosis, a pressure gradient reversal exists between the two sides of anastomosis. The high lymphatic pressure gradually drops as the anastomosis becomes patent, and ultimately the venous pressure becomes higher than the lymphatic pressure. Consequently a venous back flow occurs and the resulting thrombosis inevitably obstructs the lymphaticovenous anastomosis [24]. However, through experimental studies, Wang and Zhong [71] demonstrated that the intrinsic contractility of lymphatic vessels was an important determinant of the propulsion of lymph and pointed out that so long as the contractility function of the lymphatic vessel is perfect, the patency of the anastomotic site can be kept long after surgery. They suggested that the clinicians take contractable lymphatics for rejoining, and have obtained

very encouraging results in the treatment of lymphatic edema of the limbs [69, 70, 71].

In addition, Liu [50] provided some anatomical data for lymphatic transplantation. As the autogenous lymphatic graft may result in lymphatic edema of the donor area as demonstrated in experimental animals, Chang [1] proposed to take the autogenous veins to bridge the lymphatic gaps, and Tan [65] gave experimental morphological evidence for this improvement.

The applied anatomy of functional reconstruction of the hand and fingers

With the advancement of microsurgical techniques, the functional reconstruction of the hand has been greatly improved, calling for further relevant anatomical knowledge.

In 1966, Chinese surgeon Yand Dongyue first succeeded in transplanting the vascularized second toe for the reconstruction of the thumb [88]. Though it has widely been adopted all over the world, failures still occur. One of the reasons is that research on the anatomy of the toe, a composite entity for the transplantation, cannot satisfy the surgical demands [119]. This is especially true in the variations of the blood supply of the second toe. For this reason, Wu [74, 75] described the variations of the dorsal pedis and deep plantar a. Sun [60] investigated the second blood supply system of the second toe, which includes the second dorsal metatarsal, the first plantar metatarsal and the second plantar metatarsal a., pointing out that the second dorsal metatarsal a. was the most preferable one in the second

blood supply system and should be utilized in case of abnormal first dorsal metatarsal a. in the first blood supply system. Through extensive anatomical studies, Xu [81] suggested taking the first plantar metatarsal a. for the transplantation of the second toe or the great toe nail flap in case of the variation of the first blood supply system, and has been used in the clinic.

In addition, Xu [82, 85] anatomically investigated the reason for the necrosis of skin on the medial side of the great toe after great toe nail flap transplantation, and gave suggestions for improving the operation. He [29] provided anatomical data for the transplantation of the metatarsophalangeal or interphalangeal joints.

The microsurgical anatomy of the transplantation of small organs

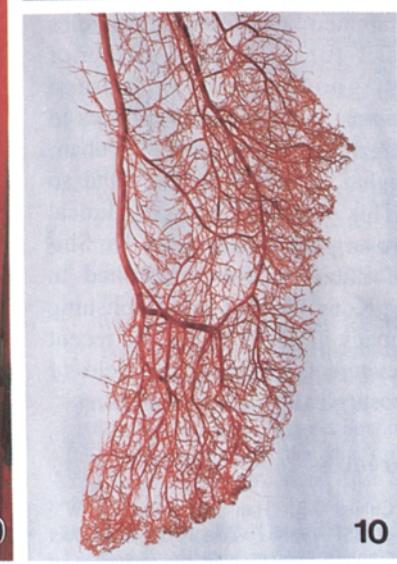
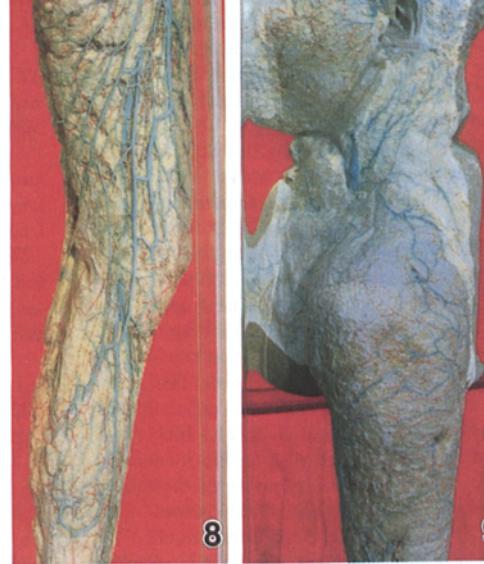
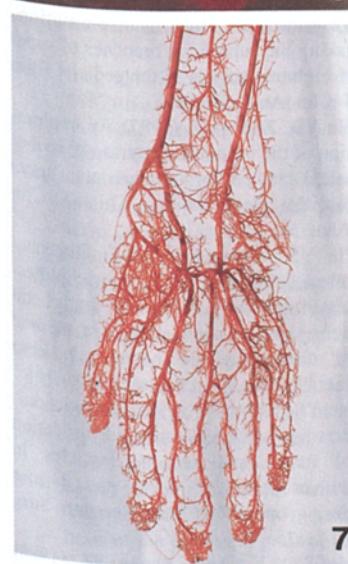
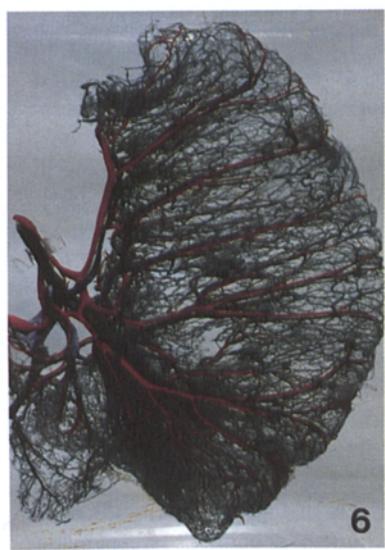
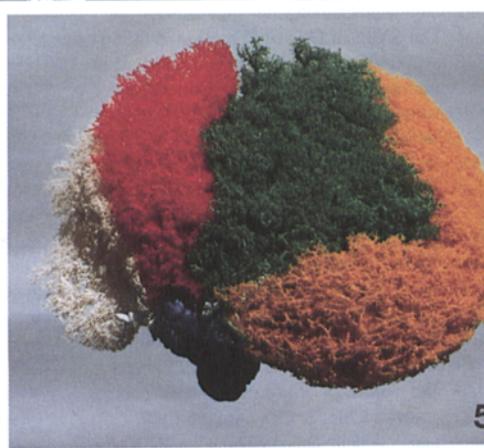
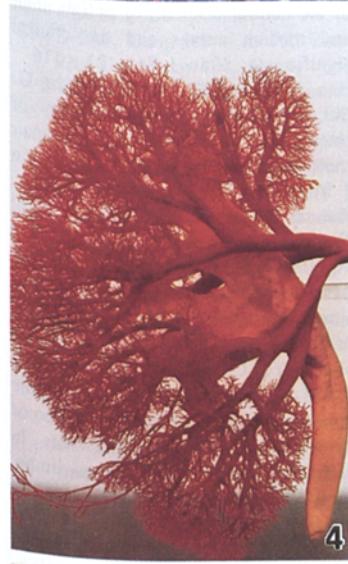
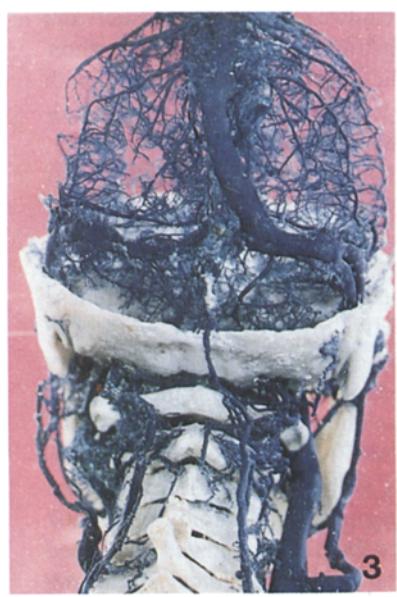
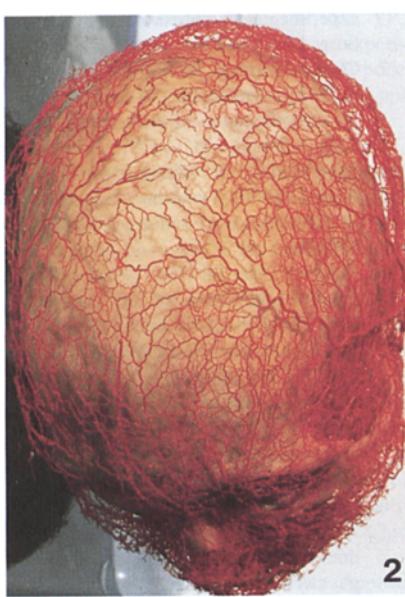
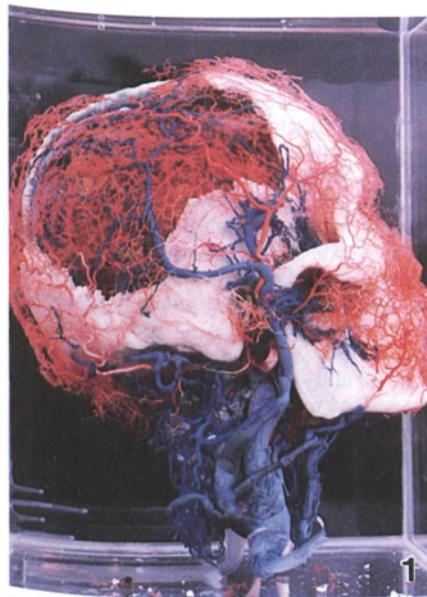
In recent years infant organs have been successfully used as a type of donor for transplantation. Though the transplantation of some large organs of adults is not closely related to the microsurgery, the blood vessels and nerves of infant organs are very delicate and require precise techniques. Diing [11] anatomically evaluated the use of infant kidney as a donor organ for transplantation. Xu [77-79, 86] investigated the infant pancreas, thyroid and parathyroid glands and suprarenal gland with special reference to their clinical application. Moreover, Zhong [103] anatomically introduced a method to repair the urethra with the vermiciform appendix, and this has been successfully used in the clinic.

Microsurgical anatomy has been

Figs. 1-10

1 Cast specimen displaying the intra-extracranial blood vessels 2 arterial network of the scalp 3 the intracranial veins 4 cast specimen illustrating the renal artery and the renal pelvis 5 the segmental vessels of the liver 6 the arteries and veins in the ileocecal region 7 the arteries of the hand 8 the cutaneous arteries and veins of the lower limb 9 the cutaneous blood vessels of the head, neck and shoulder 10 the arteries of the foot

1 Injection-corrosion montrant les vaisseaux extra- et intracrâniens 2 réseau artériel du scalp 3 les veines intracrâniennes 4 injection-corrosion montrant l'a. rénale 5 segmentation vasculaire du foie 6 les artères et les veines de la région iléo-cæcale 7 les artères de la main 8 les artères et les veines cutanées du membre inférieur 9 les vaisseaux cutanés de la tête, du cou et de l'épaule 10 les artères du pied



1

2

3

4

5

6

7

8

9

10

especially related to plastic and reconstructive surgery and orthopaedics. It is also associated with otorhinolaryngology, ophthalmology, obstetrics, gynecology, neurosurgery, cardiovascular surgery, general surgery, and so on. In China, 2 journals, the Chinese Journal of Clinical Anatomy founded in 1983 by the Chinese Society of Anatomy and the Chinese Journal of Microsurgery founded in 1986 by the Chinese Association of Microsurgeons, have provided the Chinese clinical anatomists with a means of publication. Microsurgical Anatomy, a book edited by Dr Zhong and published by the People's Medical Publishing House in China in 1984 and MTP Press Limited in Great Britain in 1985, is considered to be the first monograph in the field of microsurgical anatomy [111, 112]. Later, the Blood Vessels of Skin Flaps in Chinese by Mao and Huang [54], Surgical Anatomy of Bone Transplantation by Wu and Dong [76], Anatomy and Clinical Application of Cutaneous and Myocutaneous Flaps by Chen and Mei [4] were published. In recent years, more than 300 papers on microsurgical anatomy by Chinese anatomists have been published, covering all the fields of the topic. A number of fine human specimens were made for applied microsurgical studies (Figs. 1-10). There are a number of very good human specimen museums in the medical colleges in Guangzhou, Chongqing, Wuhan, Shanghai, Changchun cities and so on. This year, a new book-Clinical Microsurgical Anatomy by Dr Shi-Zhen Zhong will be published in Hong Kong by Med Info Publishing Company and will reflect the recent achievements made in the field of microsurgical anatomy in China.

References

- Chang TS, Han LY, Hwang WY (1985) Venous versus lymphatic duct autotransplantation in the treatment of experimental lymphedema. *Ann Plast Surg* 15 : 296
- Chen BS, Sun H, Wang WC, Jiang SZ (1988) Reconstruction of tongue defect by transplantation of forearm free flap. *Chin J Microsurg* 11 : 77
- Chen EY, Li SR, Zhang FM, Gao CJ, Mi JH (1988) Variation of circulation of the arterialized venous flap. *Chin J Microsurg* 11 : 140
- Chen EY, Mei FR (1987) Anatomy and clinical application of the cutaneous flaps. Publishing House of Chongqing Scientific and Technological Literature, Chongqing
- Chen ZH, Zhong SZ, Liu MZ, Sun B, Wang CQ, Fan QS (1984) Applied anatomy of the lateral pedis flap. *J Clin Appl Anat* 2 : 166
- Chen XX, Xia JL (1988) Studies of arterial distribution of the m. latissimus dorsi, gracilis, tensor fasciae latae, gastrocnemius, soleus. *Acta Anat Sinica* 19 : 225
- Dai SY, Lin DS, Li HY, Han Z (1986) Applied anatomy of the transplantation and anastomosis of thoracodorsal nerve to axillary nerve for the treatment of deltoid muscle paralysis. *Chin J Clin Anat* 4 : 90
- Dai SY, Lin DS, Xing YP, Kong JM, Zhong SZ, Han Z (1987) Skeletal muscle bridge for repair of sciatic nerve defect, a preliminary report of one case. *Chin J Clin Anat* 5 : 231
- Dai SY, Lin DS, Han Z, Zhong SZ, Li HY (1988) Clinical application of transferring the thoracodorsal nerve for the repair of musculocutaneous nerve injury. *Chin J Clin Anat* 6 : 47
- Dai SY, Lin DS, Li SS, Han Z, Kong JM, Shong SZ (1988) A comparison of the early electrophysiological changes between muscle bridging and nerve grafting for the repair of the ulnar nerve. *Chin J Clin Anat* 6 : 174
- Diing ZH, Wei C, Li SC, Li ST, Chen LN (1988) The anatomical main points of fetal renal transplantation. *Chin J Clin Anat* 6 : 107
- Fan PS, Zhou SC, Zhu JL, Dang RS, Ji RM, Huang Y (1982) The blood supply of the lateral femoral cutaneous nerve. *Chin J Anat Bull* 5 : 75
- Fan QS, Liu ZZ, Wang SM, Zhong SZ, Sun B, Yuang L (1987) Anatomical studies and clinical application of thoraco-umbilical skin flap. *Chin J Microsurg* 10 : 129
- Fan YE (1983) Iliac bone free transplantation pedicle by upper gluteal vessels. *Chin J Surg* 21 : 655
- Gao CJ, Zhong SZ (1985) Anatomical study for reconstruction of the tongue with infrahyoid myocutaneous flap. *Chin J Plast Surg Burns* 1 : 12
- Gao CJ, Chen EY (1987) Applied anatomical study of blood supply of the head of fibula. *Chin J Clin Anat* 5 : 159
- Guan GC, Li HY (1986) Tibia bone-cutaneous flap and its applied anatomy. *Chin J Clin Anat* 4 : 33
- Han Z, Zhong SZ, Liu MZ, Sun B, (1983) An anatomical study of the repair of brachial plexus lesion by means of anastomosis between the musculocutaneous nerve and the thoracodorsal or lower subscapular nerves. *J Clin Appl Anat* 1 : 67
- Han Z, Zhong SZ, Sun B, Liu MZ (1984) Applied anatomy of facio-facial nerve anastomosis. *J Clin Appl Anat* 2 : 181
- Han Z, Zhong SZ, Liu MZ, Fu GZ (1984) Applied anatomy of the periosteal graft of humerus by microvascular anastomosis. *J Clin Appl Anat* 2 : 252
- Han Z, Zhong SZ, Sun B, Liu MZ, Shi SD, Xie ZG (1985) Anatomical study of the natural fasciculi of radial, ulnar and median nerves and the clinical significance. *Chin J Surg* 23 : 116
- Han Z, Zhong SZ, Sun B, Huang G, Shi SD (1986) Applied anatomy of interosseous nerve used for repair motor bundles of thenar muscles. *Chin J Microsurg* 9 : 224
- Han Z, Zhong SZ, Sun B, Liu MZ, Wang GY, Shi SD, Zhou J (1987) Applied anatomy of forearm bone or periosteal flaps with pedicle of anterior interosseous vessels. *Chin J Microsurg* 10 : 90
- Han LY, Chang TS, Hwang WY (1985) Experimental model of chronic limb lymphedema and determination of lymphatic and venous pressures in normal and lymphedematous limbs. *Ann Plast Surg* 15 : 303
- He SK, Xu DC, Zhong SZ, Chen ZG, Peng JQ (1987) Applied anatomy of vascularized iliac transplantation, taking the superficial branches of superior gluteal vessels as the pedicle. *Chin J Clin Anat* 5 : 133
- He YS, Zhong SZ (1987) An exploration of the acetylcholinesterase histochemical method for intraoperative nerve fascicle identification. *Chin J Clin Anat* 5 : 13
- He YS, Zhong SY (1987) Histochemical demonstration of acetylcholinesterase activity of human peripheral nerve and its application as a method to distinguish the nature of nerve fascicle. *Acta Anat Sinica* 18 : 7
- He YS, Shong SZ (1988) Acetylcholinesterase : a histochemical identification of motor and sensory fascicles in human peripheral nerve and its use during operation. *Plast Reconstr Surg* 82 : 125
- He SK, Xu DC, Zhong SZ (1988)

- Applied anatomy of transplantation of the second and third metatarsophalangeal joints. *Chin J Clin Anat* 6 : 83
30. Hou SR, Wei St, Lu QQ, Yan SM, Wang TR (1986) Applied anatomy of external oblique muscle transfer for quadriceps paralysis. *Chin J Clin Anat* 4 : 214
31. Hou ZQ, Zhong SZ, Sun B (1986) Relation between orientation of venous valves in communicating branches and dorsalis pedis flap transplantation. *Chin J Clin Anat* 4 : 193
32. Hou ZQ, Zhong SZ, Sun B (1987) Researches on venous valves in leg. *Chin J Microsurg* 10 : 29
33. Hu GZ, Han Z (1985) Applied anatomy of the inferior end of femur grafting by microvascular anastomosis. *J Clin Appl Anat* 3 : 98
34. Huan Y, Wang LW, Dang RS, Ji RM, Fan PS, Zhou SC, Zhu JL (1985) The blood supply of the sural nerve. *Chin J Anat* 8 : 213
35. Ji RM, Dang RS, Fan PS, Zhou SC, Zhu JL, Wang LX, Huang Y (1985) The blood vessels of the medial cutaneous nerves of the forearm. *Chin J Anat* 8 : 314
36. Ji RM, Dang RS, Fan PS, Zhou SC, Zhu JL, Wang LX, Huang Y (1986) The blood supply of the medial cutaneous nerves of the arm. *Chin J Anat* 8 : 132
37. Karnovsky MJ, Roots L (1964) A direct coloring thiococholine method for cholinesterase. *J Histochem Cytochem* 12 : 219
38. Kong JM, Zhong SZ, Sun B, Zhu SX (1986) Experimental study of bridging the peripheral nerve gap with skeletal muscle. *Microsurgery* 7 : 183
39. Kong JM (1987) Preparation and application of an experimental model for guiding nerve regeneration with skeletal muscle. *Chin J Clin Anat* 5 : 17
40. Kong JM, Zhong SZ, Sun B, HE YS (1987) Histochemical evaluation of nervous degeneration and regeneration. *Chin J Clin Anat* 5 : 20
41. Kong JM, Zhong SZ (1988) Long-term observation of bridging the peripheral nerve gap with skeletal muscle. *Chin J Clin Anat* 6 : 76
42. Li GL, Chen DC, Ai RF, Lu KF, Chen SZ (1987) The nerve supply and arterial anastomosis of the scapular free flap. *Chin J Microsurg* 10 : 26
43. Li Hy, Yuan L, He YS, Sun B, Liu MZ, Zhong SZ (1983) The anatomical study of the periosteal graft of tibia. *J Clin Appl Anat* 1 : 31
44. Li HY, Zhong SZ, Liu MZ, Sun B, Yuan L, Xu DC (1984) Anatomical basis of the periosteal graft of iliac ala. *J Clin Appl Anat* 2 : 50
45. Li HY, Yuan L, Cheng JP, Xin YP, Cang ZW, Di SY (1984) An experimental study on the alteration of bone after periosteal resection. *J Clin Appl Anat* 2 : 142
46. Li HY, Gui GC, Lu WF, Cao GY, Chang GZ (1986) Distribution of blood vessels and nerves in latissimus dorsi and ways of dividing this muscle during operation. *Chin J Clin Anat* 4 : 22
47. Li J, Jian SX, Mo YH, He SY, Liu Y (1982) A vascular study of skin flap of forearm. *J Zhongguo Med Coll* 10 : 1
48. Liu MZ, Zhong SZ, Zhu JK (1982) A Study of microsurgical anatomy of the lymphatic system of limbs. *Acta Anat Sinica* 13 : 345
49. Liu MZ, Zhong SZ (1983) A study of microsurgical anatomy of the lymphatic vessels of urogenital system. *Chin Anat Bull* 6 : 28
50. Liu MZ, Zhong SZ (1984) Applied anatomy of lymphatic transplantation. *J Clin Appl Anat* 2 : 236
51. Liu YG, Xu DC, Zhong SZ, Chou SY, Wen JF (1988) Applied anatomy of double-pedicle iliac transplantation for the reconstruction of huge defect of mandible. *Chin J Clin Anat* 6 : 143
52. Luo LS, Zhong SZ, Gao GF, Xu DC, She SB, Sun B, Li YL (1986) Clinical application of the upper lateral brachial flap and deltoid myocutaneous flap. *Chin J Microsurg* 9 : 118
53. Michon J, Masse P (1964) Le mément optimum de la suture nerveuse dans les plaies du membre supérieur. *Rev Chir Orthop* 50 : 205
54. Mao ZR, Huang Y (1984) The blood vessels of skin flaps in China. Shanghai
55. Meng SY, Zhong SZ, Chen ZH, Tan WB (1984) Applied anatomy of gracilis muscle half-transfer for strengthening the contralateral quadriceps femoris. *J Clin Appl Anat* 2 : 213
56. Meng SY, Zhong SZ, Gao CJ, Xu DC, Shao S (1985) Applied anatomy of the latissimus dorsi muscle transfer for reconstruction of the deltoid muscle. *J Microsurg* 6 : 227
57. Meng XY, Zhong SZ, He SK (1988) Applied anatomy of vascularized transplantation of deep peroneal nerve. *Chin J Microsurg* 11 : 223
58. Smith JW (1964) Microsurgery of peripheral nerves. *Plast Reconstr Surg* 33 : 317
59. Sun B, Liu MZ, Yuan L, Ma F, Li HY, Han Z, Zhong SZ (1983) An anatomical study of the venous drainage from tortuous island flaps on the radial side of the forearm. *J Clin Appl Anat* 1 : 8
60. Sun B, Yuan L, Chen CH, Cheng JP, Han Z, Zhong SZ, Gu YD, Yand DY (1984) Study on the second blood supply system of the second toe. *J Clin Appl Anat* 2 : 129
61. Sun B, Meng SH, Cheng JP, Yuan L, Liu MZ, Zhong SZ (1984) Applied anatomy of the scrotal septum flap. *J Clin Appl Anat* 2 : 234
62. Sun B, Chen ZH, Yaun L, Cheng JP, Liu MZ, Zhong SZ (1984) Applied anatomy of labia flap. *J Clin Appl Anat* 2 : 169
63. Sun B, Gao CJ, Chen ZH, Zhong SZ, Yuan L, Xu DC (1985) An anatomical study of the venous drainage from tortuous medial skin flap of leg. *J Clin Appl Anat* 3 : 7
64. Sun B, Zhong SZ, Zhen YM (1985) Experimental study of the venous drainage from tortuous skin flaps of forearm and leg. *J Microsurg* 8 : 148
65. Tang HY, Zhu JK, Yu GZ, Liu JX, Lao ZG, Pan SF (1985) Experimental observation of transplantation of vein graft to lymphatics. *Ann Plast Surg* 15 : 285
66. Tao YS, Zhong SZ (1981) An applied anatomical study of the gastrocnemius semi-transplantation to replace quadriceps femoris. *J Anat Bull* 4 : 231
67. Taylor GI, Waston N (1978) One-stage repair of compound leg defects with free revascularized flaps of groin skin and iliac bone. *Plast Reconstr Surg* 63 : 494
68. Taylor GI, Townsend P, Corlett R (1979) Superiority of the deep circumflex iliac vessels as the supply for free groin flaps. Experimental work. *Plast Reconstr Surg* 64 : 595
69. Wang GY, Zhong SZ (1985) Experimental study of lymphatic contractility and its clinical significance. *Ann Plast Surg* 15 : 278
70. Wang GY, Zhong SZ (1985) A model of experimental study lymphedema in rat's limbs. *Microsurgery* 6 : 204
71. Wang GY, Zhong SZ (1985) Experimental study of lymphatic contractility in lymphedema and its clinical significance. *Microsurgery* 6 : 199
72. Wang LX, Huang Y, Ji RM, Fan PS, Zhou SC, Zhu JL, Dang RS (1986) The blood supply of the superficial branch of the radial nerve. *Chin J Anat* 9 : 271
73. Wang SC, Lu CR, Bai RF (1986) Tibial periosteal graft by microvascular anastomosis. *Chin J Clin Anat* 4 : 104
74. Wu JB, Chen XH, Qin YQ, Wang YZ, Fan LY (1980) The distribution of arteries supplying the dorsum and planta of the foot. *Acta Anat Sinica* 11 : 13
75. Wu JB, Qin YQ, Chen XH, Wang YZ (1984) Distribution and anastomosis of

- the first metatarsal artery. *J Clin Appl Anat* 2 : 6
76. Wu RX, Dong YL (1986) Surgical anatomy of bone transplantation. Publishing House of Anhui Science and Technology, Anhui
77. Xu DC, Zhong SZ, Liu MZ, Tao YS (1982) An applied anatomical study of the pancreatic transplantation by using fetus or newborn as the donor. *Chin Organ Transp* 3 : 32
78. Xu DC, Zhong SZ, Liu MZ, Tao YS (1982) Applied anatomical study of thyroid and parathyroid grafts by using fetus as the donor. *Chin J Organ Transp* 3 : 173
79. Xu DC, Zhong SZ, Tao YS, Liu MZ, Chen CH (1982) Microsurgical anatomy of suprarenal transplantation. *Chin Anat Bull* 5 : 91
80. Xu DC, Zhong SZ, Liu MZ, Li ZF, Sun B, Meng SY (1984) Anatomy of the anterolateral femoral flap. *J Clin Appl Anat* 2 : 158
81. Xu DC, Zhong SZ, Gao CJ, Liu MZ, Sun B (1986) Surgical anatomy of the first plantar metatarsal artery. *Chin J Clin Anat* 4 : 65
82. Xu DC, Zhong SZ, Liu MZ, Sun B, Wang GY (1986) anatomical analysis on the cause of skin necrosis of great toe nail flap. *Chin J Clin Anat* 4 : 137
83. Xu DC, Zhong SZ, Gu YD, Liu MZ, Sun B (1986) Anatomical basis for reconstruction of the tongue with tensor fasciae latae myocutaneous flap. *J Microsurg Med* 9 : 39
84. Xu DC, Zhong SZ, Sun B, Liu MZ (1985) Applied anatomy of the iliac bone transplantation with microvascularized of the ascending branch of the lateral circumflex femoral vessels. *J Microsurg Med* 8 : 96
85. Xu DC, Wang GY, Liu MZ, Sun B, Zhong SZ (1987) Anatomical analysis of the cause of skin necrosis of the great toe after transplantation of the great toe nail flap. *Br J Plast Surg* 40 : 283
86. Xu DC, Zhong SZ (1988) Applied anatomy of the adrenal transplantation with simultaneous arterialized vein. *Chin J Organ Transpl* 9 : 68
87. Xu DC, Zhong SZ, Kong JM, Wang GY, Liu MZ, Luo LS, Gao JH (1988) Applied anatomy of the femoral anterolateral flap. *Plast Reconstr Surg* 82 : 305
88. Yang DY, Gu YD (1979) The thumb reconstruction by second digital free transfer : report of 40 cases. *Chin J Surg* 15 : 13
89. Yang GF, Chen BJ, Gao YC, Liu SY (1981) Forearm free skin flap transplantation. *Natl Med J China* 61 : 139
90. Yan L, Sun B (1984) Applied anatomy of tortuous cutaneous flaps in the back and shoulder regions. *J Clin Appl Anat* 2 : 164
91. Yuan L, Zhong SZ, Tan ZS (1986) An applied anatomical study of temporal myofascial flap. *Chin J Neurosurg* 2 : 97
92. Yuan L, Sun B, Zhong SZ, Liu MZ, Su B (1986) An applied anatomical study and mechanical analysis of the latissimus dorsi muscle transfer for reconstruction of the gluteal muscle. *Chin J Clin Anat* 4 : 84
93. Yuang L, Zhong SZ, Sun B, Kong JM (1988) Anatomical basis of tongue reconstruction by myocutaneous flaps with sternal head of bilateral sternocleidomastoid. *Chin J Microsurg* 11 : 92
94. Zhang FH, Li FH, Chen SC, Han DT, Li GY (1988) Applied anatomy of fibular transplantation with the proximal epiphysis. *Chin J Clin Anat* 6 : 79
95. Zhang FH, Li FH, Liu SH (1983) Applied anatomy of one stage thumb reconstruction by forearm flaps with radius piece. *J Clin Appl Anat* 1 : 87
96. Zhou CM, Zhong SZ, Liu MZ (1983) Anatomy of the anterolateral leg flap, providing a new flap. *J Clin Appl Anat* 1 : 97
97. Zhou CM (1984) A study of the microsurgical anatomy of the sciatic nerve. *Acta Anat Sinica* 15 : 118
98. Zhou CM, Shi SD, Zhong SZ, She ZG (1987) Anatomical study of the natural fasciculi of sciatic nerve. *Chin J Orthop Surg* 7 : 55
99. Zhou SC, Zhu JL, Dang RS, Ji RM, Fan PS, Wang LX, Huang Y (1985) The blood supply of the lateral antebrachial cutaneous nerve. *Chin J Anat* 8 : 221
100. Zhu SX, Song LF, Liu ZS, Liu SC, Zhong SZ (1988) The preliminary study of repairing peripheral nerve gap with muscle bridge (four clinical cases). *Chin J Microsurg* 11 : 65
101. Zhu XH, He GC, Liu ZJ, Chen EY (1986) The macro-microanatomy of the vessels of the skin flap in the fronto-parito-temporal region. *Acta Anat Sinica* 17 : 119
102. Zhong SZ, Liu MZ, Zhu JK (1980) A study of the microsurgical anatomy of the median nerve. *Acta Anat Sinica* 11 : 337
103. Zhong SZ, Tao YS (1981) Anatomical study of repairing urethra with vermiform appendix. *Chin J Urol Surg* 2 : 129
104. Zhong SH, Tao YS (1981) Microsurgical anatomy of the scrotal skin flap. *Chin Anat Bull* 4 : 228
105. Zhong SZ, Tao YS, Liu MZ, Xu DC (1982) An anatomical study of free skin flaps supplied by intermuscular septal vessels. *Acta Anat Sinica* 13 : 230
106. Zhong SZ, Liu MZ, Zhou CM, Tao YS (1983) A study of the microsurgical anatomy of the radial nerve. *Acta Anat Sinica* 14 : 1
107. Zhong SZ, Chen ZH, Li HY, Liu MZ, Xu DC, Sun B (1983) An applied anatomical study of the costal cartilage grafts by microvascular anastomosis. *J Clin Appl Anat* 1 : 91
108. Zhong SZ, Sun B, Liu MZ, Xu DC, Tao YS, Cheng JP (1984) An anatomical study of vascularized skin flaps in intermuscular space. *Chin J Surg* 21 : 596
109. Zhong SZ, Chen ZH, Li HY, Liu MZ, Sun B, Yang LM (1983) Applied anatomy of the scapular graft by microvascular anastomosis. *J Clin Appl Anat* 1 : 3
110. Zhong SZ, Xu DC, Liu MZ, Sun B, Meng SY (1984) Clinical significance of the marginal branches in tensor fasciae latae myocutaneous flap. *J Clin Appl Anat* 2 : 153
111. Zhong SZ (1984) Microsurgical Anatomy. The People's Med Publishing House, Beijing
112. Zhong SZ, Han YG, Yen WC (1985) Microsurgical anatomy. MTP Press, Lancaster/Boston
113. Zhong SZ, Sun B, Meng SY (1986) Recent microsurgical anatomy in China. *Chin Clin Anat* 4 : 129
114. Zhong SZ, He YS, Han Z, Liu MZ, Sun B, Shi SD, Zhu JK (1986) Anatomical basis of selection in different types of nerve repair. *Chin J Clin Anat* 4 : 3
115. Zhong SZ, He YS, Sun B, Wang GY (1987) Relation between structural features of nerve trunk and suture methods. *Chin J Microsurg* 10 : 158
116. Zhong SZ, Wang GY, He YS, Sun B (1988) The relationship between structures of peripheral nerves and suture methods for nerve repair. *Microsurgery* 9 : 181
117. Zhong SZ, Liu MZ, Tao YS (1981) A study of the microsurgical anatomy of the ulnar nerve. *Acta Anat Sinica* 12 : 346
118. Zhong SZ, Li HY, Zhu CA (1988) The biomechanical test and analysis of claviclectomy. *J Clin Appl Anat* 2 : 136
119. Zhong SZ, Sun B, Gu YD (1984) Advances of the hand reconstruction and their applied anatomy. *J Clin Appl Anat* 2 : 201
120. Zhong HZ, Zhou CM, Xing YP, Gao JH, Liu MZ, Zhong SZ (1983) 25 cm defects in the median nerve had been repaired with free vascularized superficial peroneal nerve graft. *J Clin Appl Anat* 1 : 21