

# Special Type of Finger Replantation

Techniques and Cases

Jian Lin  
He-Ping Zheng  
Yong-Qing Xu  
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## Content Summary

*Special Types of Finger Replantation* is a monograph of clinical cases and pictures. The authors have referred to the latest international literature, combined with their own valuable clinical experience and research results. The book consists of more than 200,000 words and includes more than 150 color pictures and drawings and over 500 photos of clinical surgery. The book is divided into two parts. One is the pandect part of finger replantation, mainly referring to the development of the history of replantation, hand anatomy, commonly used equipment and materials, frequently used medicines, preoperative treatment, selection of anesthesia, regular replantation methods, post-operative treatment and management, and methods of functional recovery after finger replantation. The other part focuses on the concepts of 13 special types of finger replantation, case introductions, surgical key points and precautions, etc., along with more than 60 representative cases including photos. Compared with similar books published all over the world, this book focuses more on the combination of systematic and thematic, basic theory and clinical practice, case photos and text description.

This book is rich in illustrations, suitable for hand surgeons, foot surgeons, micro- and reconstructive surgeons, trauma surgeons, orthopedic surgeons, and plastic surgeons to read, follow, and carry out. We hope that this book promotes the technology of finger replantation.

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## Preface

The human hands are the most valuable and a universal tool of labor. They are very easily damaged in everyday life, study, and work. The most serious damage to the hands is the severances. Without timely and effective treatment of replantation or reconstruction of the hand function, especially the special types of replantation, life-long harm to the patients may be caused. Thus, referring to the latest literature at home and abroad, combined with our own long years of clinical experience and research results, we have written this monograph, *Special Types of Finger Replantation*. We hope that this book plays a role in promoting this technology.

*Special Types of Finger Replantation* consists of more than 200,000 words, more than 150 specimens, and over 500 photos of clinical surgery. The book is divided into two parts. The first part is general, introducing the history of the development of finger replantation; the anatomy of the hands; commonly used drugs, equipment, and materials; relevant matters of replantation before treatment; selection of anesthesia; routine replantation methods; treatment and management after replantation surgery; and postoperative functional rehabilitation methods and their significance. The second part focuses on the thirteen special types of replantation concepts, case introductions, and surgical key points and precautions. We try do our best to achieve a systematic and thematic combination of basic theory and clinical practice as well as sample photos and text descriptions.

The book is rich in content and illustrations; it is suitable for surgeons who specialize in hand surgery, microsurgery, trauma surgery, orthopedics, plastic surgery, etc. It is a valuable reference book for finger replantation and research. Because of our limited level of English, mistakes and errors in this book are inevitable. Please let us know of any such errors, so that they can be further corrected.

As soon as the idea of a “special type” of replantation was put forward, it was supported and guided by Professor Hou Chunlin, who is the director of Chinese rehabilitation medicine and reconstructive surgery and director of the Chinese Medical Association. Famous clinical anatomist and Chinese academician, Professor Zhong Shizhen; the hand surgery expert

and academician at the Chinese Academy of Engineering, Professor Gu Yudong; and the chief editor of the *Chinese Journal of Clinical Anatomy*, Professor Xu Chuanda, carefully reviewed and revised the manuscript.

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# Finger Replantation

Finger transection is the most serious trauma to the hands. Finger replantation after hand injury is the most difficult but effective treatment, during which the surgeons perform a sophisticated and technically difficult operation using microscopy and microscopic equipment. At the same time, the surgeons perform a complete debridement for completely or incompletely severed fingers from the hand, the bone, and carry out re-anastomosis of the injured nerves, tendons, skin resurrection, and blood vessels. After the surgery, all aspects of comprehensive treatment are necessary. The purpose is to repair the tissues from the severely wounded finger and enhance the functional reconstruction, save the injured and transected fingers, and to restore function as far as possible. With the continuous improvement in microsurgical techniques and the continuous efforts of microsurgical surgeons, the finger replantation technique has evolved from simple and general finger replantation to a serious and complex special type of replantation for use after finger tissue damage.



# The History of the Replantation of Amputated Fingers

1

The hand is an organ related to labor and beauty that distinguishes humans from other animals. As human civilization progresses, the hands play an irreplaceable role in the process when human activities shift from handicraft to light industry, heavy industry, and electronic technology information. Hands are most susceptible to damage during daily life and work. During industrial production in particular, with relatively low automaticity, it is not uncommon for severe traumas caused by high energy damage in hands to result in finger mutilation, leading to life-long disability. Surgeons face the arduous task of attempting to repair and reconstruct the injuries, reduce the patient's disability and improve their quality of life. Human efforts to carry out studies of hand trauma have never ceased, whether the study be fundamental or clinical. The simple trauma care of hand injuries has been directed to evolve toward the complicated replantation of mutilated fingers and the recovery of hand functions. Long-term clinical practice has demonstrated that patient cooperation and reasonable functional exercise is also of vital significance during the treatment of hand trauma, in addition to the doctor's accurate judgment, skill proficiency, and proper management. Satisfying results can be achieved in the recovery of hand trauma only after the joint efforts of both doctors and patients.

**Replantation of amputated fingers** is a difficult technique that is performed by surgeons under a surgical microscope using microscopic

instruments. Its aim is to repair the tissues and reconstruct the functions of severely traumatized fingers. Its development involves four stages, namely the starting stage (1960s), the growing stage (1970s), the fruiting stage (1980s), and the stage of improving functional recovery (1990s). The earliest replantation work was published by Hopfner in 1903 (Chen, 1997) tried limb replantation in animals that did survive for a short period of time. Thereafter, with the further exploration and improvement of surgical methods, an increasing number of successful cases have been reported that constantly improve and enrich our recognition of replantation. In China, Zhixian Wang (1960) and Kaiyuan Tu (1963) were the first to begin replantation in animals. Professor Tu's successful replantation of a dog's amputated leg set a precedent. In 1963, Zhongwei Chen et al. first reported successful replantation in a patient who underwent complete amputation because of forearm trauma and achieved reliable function. It was recognized worldwide as the first successful replantation, starting a new chapter of clinical study of replantation. In 1964, Shuhuan Wang et al. became the first surgeon in the world to complete the replantation of amputated fingers under a microscope, during which they replanted a rabbit's ear successfully under a magnifying glass; in May of the same year, he successfully replanted a child's finger that had been completely amputated. In 1965, Komatsu and Tanlai first successfully replanted a completely amputated

thumb. At the same time, Zhongwei Chen et al. (Shanghai Sixth People's Hospital) were the first in China to replant an amputated limb under a magnifying glass. Later, there were reports of success from Shanghai Ninth People's Hospital, the First Affiliated Hospital of Zhongshan Medical College, Beijing Jishuitan Hospital, the First Affiliated Hospital of Shanxi Medical University, PLA No. 89 Hospital and No. 401 hospital, which made China the leading country in this field in both quality and quantity. With the constant development of the microsurgical technique and the great effort made by microsurgeons, the replantation of amputated fingers has evolved from simple replantation to the complex and special replantation of the multiple fingers that often cause serious vascular injuries, etc.

Starting in the 1980s, China's special amputated finger replantation is the cutting-edge tech-

nique that has been developed from the simple normal amputated finger replantation with its further evolution and innovation. After 30 years of endeavor, special amputated finger replantation has achieved remarkable progress in treatment, in-depth development, and eye-catching accomplishments, which is evidence for the continuous improvement in comprehensive capacity of Chinese microsurgery and in the skill level of Chinese surgeons.

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## 2.1 Holistic View

### 2.1.1 Hand Surface Landmarks

Hand surface landmarks include skin landmarks, bony landmarks, and tendon (muscle) landmarks. These landmarks are exposed to varying extents when the hand has different statuses. Therefore, they can appear more apparent when moving different joints during clinical applications.

#### 2.1.1.1 Skin Landmarks (Fig. 2.1)

1. Palmar creases: The skin of the palmar surface has a proximal palmar crease, a middle palmar crease, and a distal palmar crease.

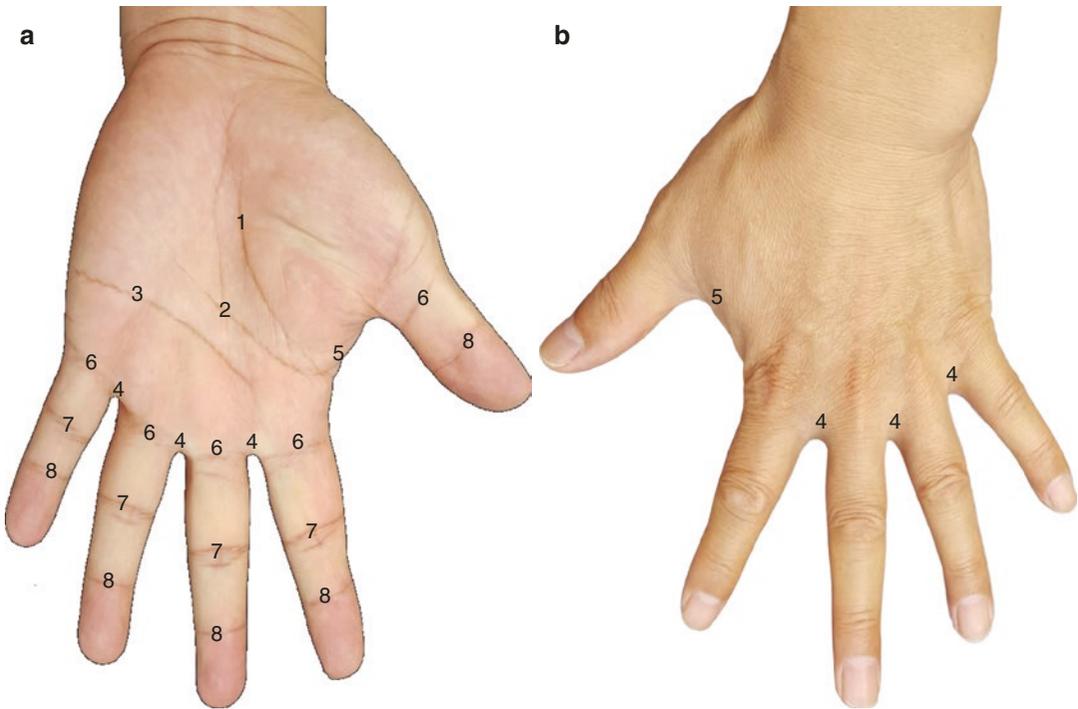
Proximal palmar crease: Also called a thenar pattern, it is located at the ulnar side of the thenar; obliquely running toward the outer and lower direction, it almost circulates transversely at the distal end and reaches the radial margin of the palm, and its deep surface corresponds to the second metacarpal bone. This crease caters for the thumb's need to engage in separate activities.

Middle palmar crease: This crease overlaps with the thenar pattern at the distal end, extends to the ulnar side of the palm, and inserts at the lateral border of the hypothenar; it mainly caters for the need of the index finger to engage in activities.

Distal palmar crease: Starting from the site 1.5 cm away from the proximal side of the

second finger web, it circulates transversely inward until the palmar ulnar margin is reached; this transverse crease corresponds to the third to fifth metacarpophalangeal joint lines and is located at a site about 2 cm away from the proximal side of the palm/finger crease. It caters for the needs of the middle finger, ring finger, and little finger to engage in activities. Under normal circumstances, the distal end of the finger pulp can touch the palmar distal transverse crease in the case of finger flexion, which can clinically serve as a simple method of measuring the degree of finger flexion.

2. Finger palmar crease: The proximal transverse crease, middle transverse crease (the thumb lacks of the middle transverse crease), and the distal transverse crease can be found at the palmar surface of the finger, and they are generated to cater for the finger's need to engage in activities. All transverse creases are attached to the deep sheath, so they move less; they become accumulated into a deep groove in the case of finger flexion, so it can serve as a body surface landmark and the mark for surgical incision. The two ends of the transverse creases reach the dorsoventral boundaries of the hands (i.e., the juncture between the finger palmar side and the dorsal side). The distal transverse crease is parallel and level to the finger-web margin; the middle transverse crease directly faces the proximal interphalan-



**Fig. 2.1** Hand surface landmarks. (a) Palmar surface view. (b) Dorsal surface view. 1 Proximal palmar crease. 2 Middle palmar crease. 3 Distal palmar crease. 4 Finger

web. 5 First web space. 6 Proximal transverse crease. 7 Middle transverse crease. 8 Distal transverse crease

geal joint line; the distal transverse crease is located in the position slightly above the distal interphalangeal joint line.

3. Finger dorsal crease: Several transverse creases and annular eminences can be found at the proximal side of the finger's dorsal surface and the distal interphalangeal joint because this can cater for the dorsal extension of the interphalangeal joint.
4. Finger web: Finger web refers to the skin fold formed by the mutual migration of the palmar and dorsal skin between the adjacent finger roots at the distal end of the palm, and it is level with the middle part of the proximal phalanx. The margins of the finger webs are in the same plane as the hand's palmar skin, and it is connected to the dorsal skin to form an inclined plane. The finger web between the thumb and index finger is the largest, and is called the first web space. Under normal circumstances, the angle of the first web space is maximally greater than  $90^\circ$  when the thumb is

fully abducted. In the case of the deformity of scarring and contracture in the first web space, this angle shrinks to varying degrees, having an impact on the thumb function; therefore, repair and reconstruction must be performed.

5. Finger nail: Located at the dorsal side of the fingertip, this refers to a derived structure of skin at the digital dorsum, which is generated because of the thickening of the dermis (Fig. 2.2). The exposed part of the nail is called the nail body and is connected to the deep skin, and there is a white half moon region at its basal part, called the lunula of the nail. The part in which the proximal end of the nail body is hidden below the skin is called the nail root, and the skin germinal layer of the nail root is the growing point of the finger nail, which should be protected during surgery. The periungual skin fold is called the nail fold. The horny layer of the nail root extends toward the distal end into a thin layer of epidermal fold, which is called the



**Fig. 2.2** Nail appearance: 1 Nail body. 2 Lunula of the nail. 3 Nail fold. 4 Eponychium. 5 Nail groove. 6 Hyponychium

eponychium. The groove between the nail lateral margin and the nail fold is called the nail groove. The hyponychial dermis is called the nail bed. The horny layer of the epidermis below the nail's free margin is very thick, and the part that is extended to the subungual region is called the hyponychium. The finger nail has the role of supporting the distal pulp space and also beautifying the finger; however, it is the most vulnerable part.

### 2.1.1.2 Bony Landmarks

The tubercle of the scaphoid bone is palpable at the lateral side of the distal transverse crease of the wrist, and at the slightly distal end of the tubercle of the scaphoid bone is the tubercle of the trapezium bone. They constitute the radial eminence of the wrist. Lenticiform bone is palpable at the medial side of the distal transverse crease, and at the slightly distal end of the lenticiform bone is the hook of hamate bone. Together,

they constitute the ulnar eminence of the wrist. At the bilateral margins of the carpal canal, the radial eminence and the ulnar eminence, with the wrist transverse ligament and carpal canal groove, constitute the carpal canal.

At the hand's dorsal surface, the metacarpus and phalange are located subcutaneously and are easily palpable; in the case of flexion of the metacarpophalangeal joint, the metacarpal bone is obviously visible.

### 2.1.1.3 Muscle (Tendon) Landmarks

(Fig. 2.3)

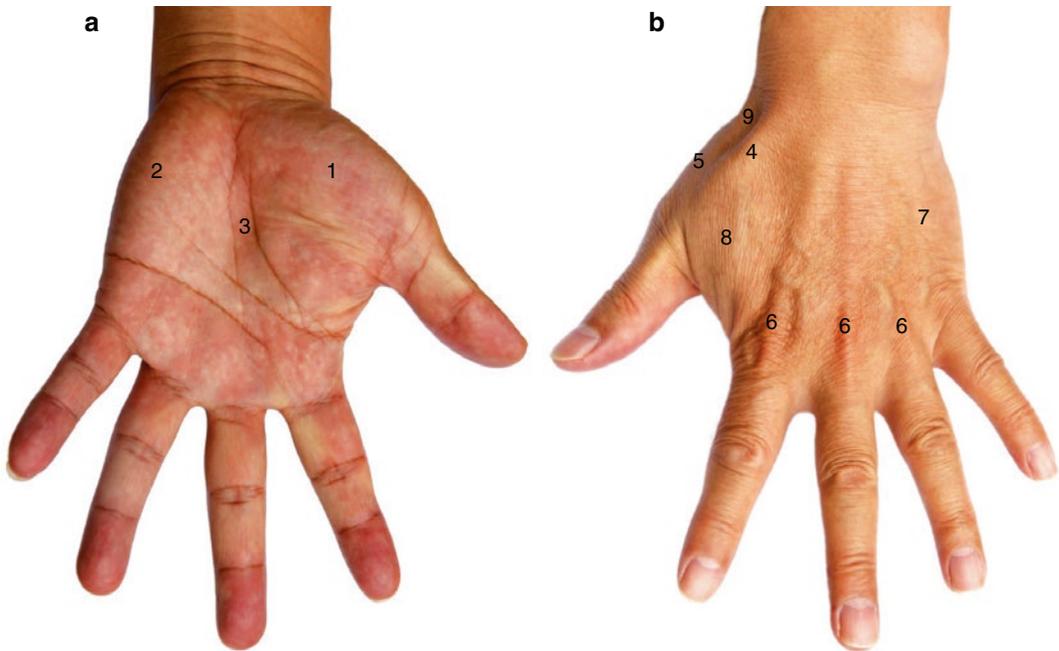
**Thenar:** This is the fish-abdomen-shaped eminence, mainly formed of the thenar muscles at the radial side of hand's palmar surface. Injuries of the median nerve can cause paralysis and atrophy of the thenar muscles, causing the thenar to be flat.

**Hypothenar:** This is the fish-abdomen-shaped eminence mainly formed of the hypothenar muscles at the ulnar side of the hand's palmar surface. Injuries of the ulnar nerve can cause paralysis and atrophy of the hypothenar muscles and interosseous muscles, causing the hypothenar to be flat, and the intermetacarpal spaces to become deepened.

**Center of the palm:** The triangular pit at the center of palm, on the deep surface of which lie the large vessels, nerves, finger flexor tendon, lumbrical muscle, interosseous muscles, etc.

**Tendon eminence:** In the case of the extension of the thumb, the thumb extensor tendon is palpable from the dorsal aspect of the thumb and the base of the distal phalanx. In the case of the extension of the remaining fingers, it is clearly visible that the finger extensors run toward all the fingers. When the thumb and the index finger are close to each other, an eminence formed by the first dorsal interosseous muscle is visible at the first intermetacarpal space.

**Anatomist's snuff-box:** This is a pit visible at the dorsal aspect below the radial bone in the case of thumb abduction and dorsal extension. At the lateral border lie the short extensor tendon of the thumb and the extensor tendon of the thumb, at the medial border lies the long extensor tendon of the thumb, and at the fossa base lie the navicular bone of the hand, the larger multangular bone,



**Fig. 2.3** Muscle (tendon) landmarks of hand. (a) Palm of the hand. (b) Dorsal aspect of the hand. 1 Thenar. 2 Hypothenar. 3 Center of the palm. 4 Extensor pollicis longus tendon. 5 Extensor pollicis brevis tendon. 6 Extensor digitorum. 7 Extensor digiti minimi. 8 First dorsal interosseous muscle. 9 Anatomical snuffbox

and the first base of the metacarpal bone. The radial styloid process is located in the fossa, and the radial artery runs through this fossa until the first intermetacarpal space. The cephalic vein is one of the important contents of the superficial layer structure in the nasopharyngeal fossa, and its course runs from inner to outer, obliquely across the long extensor tendon of the wrist on the radial side, and then upward.

## 2.1.2 Hand Posture

### 2.1.2.1 Resting Position of the Hand

The resting position of the hand consists of a kind of natural and half-fisted position during sleep or general anesthesia (Fig. 2.4). The wrist joint is in the position of dorsiflexion ( $10\text{--}15^\circ$ ) with mild ulnar inclination; the thumb has a mild abduction, and the radial margins of the distal interphalangeal joint of the index finger is palpable at the finger pulp. The fingers from the index finger to the little finger, the metacarpophalangeal joint



**Fig. 2.4** Resting position of the hand

and the interphalangeal joint are in the semi-flexed position; a trend toward the ulnar side means a larger flexion, the index finger becomes mildly inclined toward the ulnar side, and the little finger becomes mildly inclined toward the radial side. In this position, the muscular tensions of the flexor and extensor are relatively balanced. If the hand is damaged, this balanced status is destroyed.

### 2.1.2.2 Functional Position of the Hand

The functional position of the hand is like the position of holding a cup, which is also the position for performing most functions of the hand (Fig. 2.5). The wrist joint is in the position of dorsiflexion (about  $30^\circ$ ) with mild ulnar inclination (about  $10^\circ$ ), the thumb is fully abducted, and the thumb metacarpophalangeal joint and interphalangeal joint have a slight flexion. All fingers are separated by flexion of varying degrees; i.e., the metacarpophalangeal joint becomes flexed by  $30\text{--}45^\circ$ , the proximal interphalangeal joint by  $60\text{--}80^\circ$ , and the distal interphalangeal joint by  $10\text{--}15^\circ$ . In the functional position, the hand can perform maximal functions. Thus, for hand fractures following injury, it is generally necessary to fix the hand in the functional position.

### 2.1.2.3 Pinching Position of the Hand

The pulps of the thumb and index finger (sometimes including the middle finger) have close contact to pinch a thin and small object (such as writing and pinching a needle), which is the pinching position. At this time, the wrist becomes obviously dorsiflexed, the first metacarpal bone is rotated and abducted, the thumb metacarpophalangeal joint and interphalangeal joint have mild flexion, the index finger metacarpophalangeal joint and interphalangeal joint also have flexion, the thumb tip can touch the index finger tip, the thumb and the index finger resemble the two arms of a forceps, and the thumb adductor and the first and second dorsal interosseous muscles provide strong muscular strength. During

needle threading, the thumb's interphalangeal joint and the index finger's distal interphalangeal joint turn to the extension position to exert maximal muscle strength (Fig. 2.6).

### 2.1.2.4 Grasping Position of the Hand

Grasping is an important function of the hand, in the following two forms: strong grasping (such as grasping a hammer handle) and fine grasping (such as unscrewing a cap). In the case of strong grasping, the wrist becomes dorsiflexed, the metacarpophalangeal joint and the interphalangeal joint become flexed by  $90^\circ$  and adducted so that the long flexor of the finger can solidly compress the object onto the palm; the thumb becomes opposed and adducted, the thumb's carpometacarpal joint, metacarpophalangeal joint, and interphalangeal joint become flexed, and the thumb is compressed onto the clenched fingers or directly clenched onto the object. In the case of fine grasping, the wrist becomes dorsiflexed or palmar flexed, the finger becomes semi-flexed, and the thumb is opposed to the semi-flexed fingers. In this position, the hand interosseous muscles can drive the fingers to engage in various kinds of movements, rapidly changing from one position to another. The above two forms also appear at the same time. For example, the middle, ring, and little fingers are used to grasp a rope, and the index finger and the thumb are used to buckle the two ends (Fig. 2.7).



**Fig. 2.5** Functional position of the hand



**Fig. 2.6** Pinching position of the hand



**Fig. 2.7** Grasping position of the hand

### 2.1.3 Body Surface Projection

#### 2.1.3.1 Bone and Joint Projection

(Fig. 2.8)

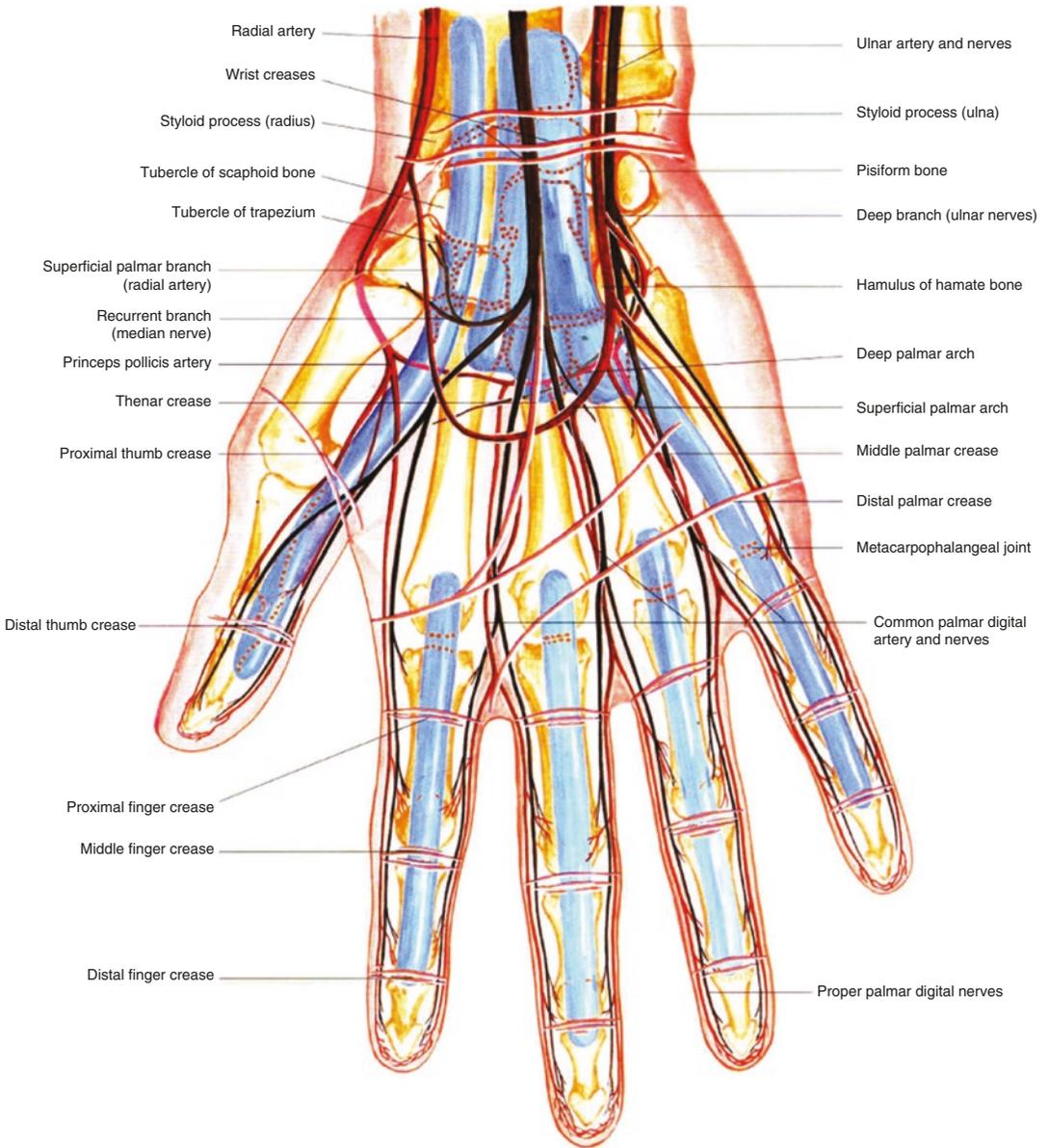
1. Pisiform bone: The distal crease of the wrist happens to pass through the proximal end of the pisiform bone; after the wrist becomes extended backward, the pisiform bone is easily palpable. In the case of wrist anteflexion, there is mild activity.
2. Hamulus of hamate bone: This is located at the site about 1 cm away from the distal radial side of the pisiform bone.
3. Larger multi-angular bone: This is located at the deep surface of the distal side of the wrist. The medial side is covered by the wrist flexor at the radial side, the distal side is covered by the trapezium bone, which is difficult to palpate, and this is relatively obvious in the case of the posterior extension of the wrist.
4. Tubercle of the trapezium bone: This is adjacent to the distal end of tubercle of trapezium bone, and its proximal part is hidden on the tubercle of trapezium bone.
5. Radiocarpal joint: This is located at the deep surface of the proximal transverse crease of the wrist. The radial and tibial eminence covers nearly one third of the navicular bone, and it is about 1.2 cm longer than the styloid process of the ulna.

6. Metacarpophalangeal joint: The slight distal side of the transverse part of the thenar pattern is parallel and level to the metacarpophalangeal joint of the index finger, the slight distal side of the distal palmar crease is parallel and level with the metacarpophalangeal joint of the middle, ring, and little fingers, and the slightly distal side of the proximal crease of the thumb is parallel and level with the metacarpophalangeal joint of the thumb.
7. Interphalangeal joint: The middle crease of the finger opposes the proximal interphalangeal joint, the slightly distal side of the finger distal crease is parallel and level with the distal interphalangeal joint, and the distal crease of the thumb is parallel and level with the thumb's interphalangeal joint.

#### 2.1.3.2 Vascular Nerve Projection

(Fig. 2.8)

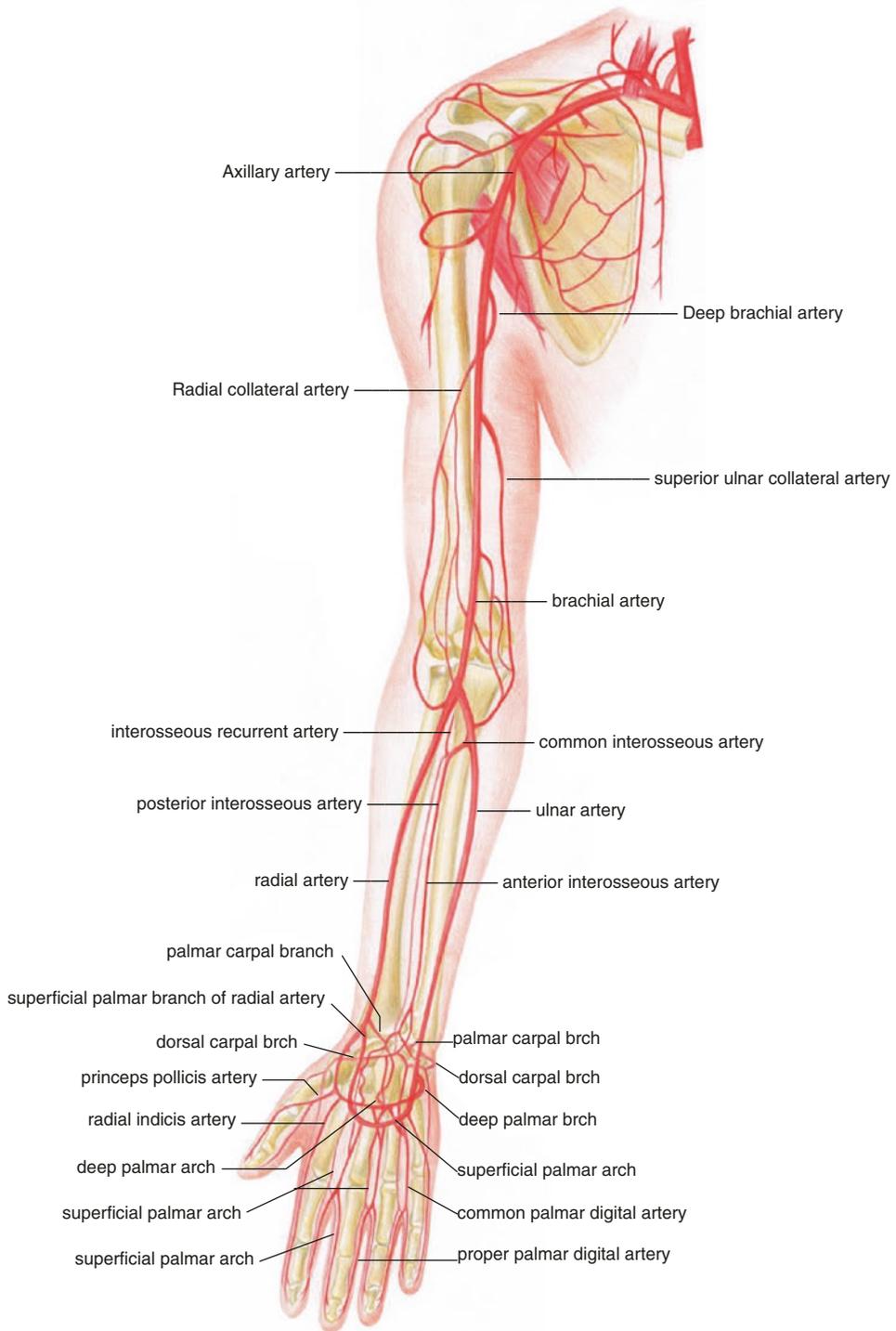
1. Ulnar nerve and ulnar artery: The ulnar nerve passes through the radial side of the lenticular bone, and the ulnar nerve lies on the radial side of the nerves.
2. Superficial palmar arch: An arch line is drawn from the radial side of the lenticular bone, and then connected with the median point of the palmar median line (which is the connecting line between the distal crease of the wrist and the proximal crease of the middle finger) to roughly represent the ulnar part of the superficial palmar arch.
3. Deep palmar arch: This is located at the site about 1 cm away from the proximal side of the superficial palmar arch.
4. Recurrent branch of the median nerve: The radial region at the proximal third of the thenar or ulnar region at the proximal part of the thenar is where the recurrent branch is distributed. Injury or incision in this region may involve the recurrent branch.
5. Deep branch of the ulnar nerve: This runs between the distal margin of the lenticular bone and the proximal margin of the hook of hamate bone, and then surrounds the inner anterior margin of the hook of hamate bone, accompanying the deep palmar arch Figs. 2.9, 2.10, 2.11, 2.12, and 2.13.



**Fig. 2.8** Projection of the deep structures to the palmar surface of the hand

6. Digital arteries and nerves: The common palmar digital artery accompanies the common palmar digital nerves, and the nerves are located at the deep surface. The bifurcation at the arterial side 1.25 cm away from the finger web margin is the proper palmar

digital artery, and the nerve bifurcations are located on the proximal side of the arterial bifurcations. At the plane of the metacarpophalangeal joint, the proper palmar digital artery runs along the margins of all palmar surfaces of the fingers; at the slightly ante-



**Fig. 2.9** Upper limb artery (schematic diagram)

**Fig. 2.10** Upper limb superficial vein (schematic diagram). (a) Dorsal aspect of the hand. (b) Upper limb anterior aspect

