The Thumb

A Guide to Surgical Management

Sang Hyun Woo
Editor

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Preface

With so many advances in our understanding of and success in thumb surgery, the need to provide a comprehensive up-to-date text has been long overdue. Thanks to the hard work of all contributors, we have been able to provide detailed explanations, photographs, and surgical results to this comprehensive book on *The Thumb* with the intent of improving physician practice and enhancing surgical outcomes. The inclusion of visual descriptions of each and every available techniques relating to thumb surgeries aims to equip students, residents, fellows, and experienced physicians alike with the knowledge and confidence they need to make expedient decisions in the process of achieving the most favorable results possible for their patients. From the basic anatomy; deformities and other anomalies in the thumb; problems in the bone, joint, tendon, and nerves; tumors; and, of course, replantation and reconstruction, this is a very special book with many special interests.

The surgeons who have collaborated on this book are at the cutting edge of their field and are world class in their practice, research, and surgical acumen. It is to them that we owe a great debt of gratitude. Even, our staffs of hand surgeons at W Hospital include Young Woo Kim, Hee Chan Ahn, Ho Jun Cheon, Dong Ho Kang, Hyun Jae Nam, Myung Jae Yoo, Young Seok Lee, and Tae Kyung Lee. Their hard work in carrying out elective and all night or weekend emergency operations in over 10,000 cases a year truly make them the dream team.

Many thanks go to Professors Jae Sung Seo and Sung Jung Kim for their mental support and also to my respected mentors, Professor Jung Hyun Seul, See Ho Choi, and Joo-Chul Ihn. Much appreciation goes to all contributors including the teachers of hand surgery, Professor Tsu Min Tsai and Luis R. Scheker in Louisville, Professor Ulrich Lanz in Munich, Professor Fu-Chan Wei in Linkou, Professor Suk Joon Oh and Professor Kwan Chul Tark in Korea.

My gratitude goes out to my publisher and helpers, Vinoth Kuppan and Dinesh Vinayagam, in being patient with this exhaustive process and to Andrew Miller in his proofreading and revisions to help you, the reader, understand all that is in front of you.

Finally, I am indebted to all my family who had to endure the many nights I spent toiling away in the creation of this book and also in my absence as I carried out surgeries on too many nights and weekends to even consider counting.

I have dedicated my working life to helping those with developmental anomalies and those involved in trauma regain as close to 100% physical functionality as possible, the thumb playing perhaps the most important role of all in the futures of my patients. It is with this that I trust you will follow suit and use the contents of this text to the best of your abilities.

Daegu, South Korea
July 30, 2018

Sang Hyun Woo, MD, PhD

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Part I

Introduction

History of "Making a Thumb"

1

Suk Joon Oh

The thumb plays an important role in hand function. Daily tasks involving pinch, grip, grasp, and precision handling are more easily accomplished with an opposable thumb. The causes of thumb deficiency are traumatic loss and congenital anomalies.

Attempts to restore thumb function were recorded as early as 1874, when Huguier [1] reported on the phalangization of the thumb metacarpal, which was carried out by deepening the first web space [2]. In 1900, Nicoladoni [3] described a reconstruction procedure following traumatic amputation of the thumb in which a staged, pedicled transfer of the great toe was performed [2]. Development of microsurgical techniques allowed successful transfer of a toe to a thumb in monkeys in 1965 [4] and in a human in 1966 [5].

The loss of a thumb results in a notable functional impairment. Multiple reconstructive procedures have been described to address these deficits. Compared with no reconstruction, any procedure is of benefit. However, each of the described methods offers subtle benefits and downsides and may be more applicable in certain situations. A reconstructed thumb ideally will (1) have adequate length; (2) have a sensate, nontender tip; (3) have stability; and (4) be positioned to meet the other digits, with an adequate first web space [6]. *Littler* [7] analyzed these attributes and believed that although all of them are important, strategic positioning of the thumb is the key factor to achieving optimal function. Emphasizing this, he stated, "It is not the full length of the thumb, nor its great strength and movement, but rather its strategic position relative to the fingers and the integrity of the specialized terminal pulp tissue which determines prehensile status."

Traumatic Thumb Defect

Lister [8] divided thumb defects into four groups: (1) acceptable length with poor soft tissue coverage; (2) subtotal amputation with questionable remaining length; (3) total amputation with preservation of the basal joint; and (4) total amputation with loss of the basal joint.

1. Amputation at or distal to the interphalangeal (IP) joint rarely results in a functional deficit. These cases require a sensate and supple tip, which can be provided by glabrous and nonglabrous skin flaps. Glabrous flaps include Moberg, V-Y advancement [9], Littler's neurovascular island [10], free toe pulp transfer [11], and partial hallux transfer [12]. Nonglabrous skin flaps include the first dorsal metacarpal artery (Foucher) [13], cross-finger [14, 15],

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dorso-ulnar or dorso-radial, and distant or free flaps such as the distally based posterior island interosseous flap [16], reverse radial forearm flap [17], free groin flaps [18], and free neurovascular medial plantar flaps [19].

2. Proximal amputation of the proximal phalanx inevitably results in reduced hand span, difficulty grasping large objects, and fine pinch limitations. Distal proximal phalanx amputations often suffice with web-deepening procedures.

   Procedures that provide relative lengthening without true lengthening have been termed "phalangization" and use local, regional, distant pedicled, or free flaps to deepen the web space. Flap options include Z-plasty (single [20], four-flap [21]), dorsal rotation [22], and regional or free flaps including posterior interosseous artery flap, reverse radial forearm flap, groin flap [23], first web space free flap of the foot [24], and free medial plantar flap [19] (Fig. 1.1a–c). In an on-top plasty [25], adjacent digits are used to extend thumb length and, in doing so, deepen the first web (Fig. 1.2a, b). Distraction osteogenesis described by Matev IB [26] has been used in the past, but currently alternative options are preferable.

3. Total thumb amputations with preservation of the basal joint result in substantial impairment. Toe transfer is a good option for amputations distal to the carpometacarpal (CMC) joint and optimally where intrinsic thumb muscles are intact, providing the most reliable cosmetic and functional outcome. The procedure requires microsurgical expertise. A toe free transfer is usually performed as a delayed procedure to allow the patient time to appreciate the severity of the situation, although acute transfer has been described with equivalent

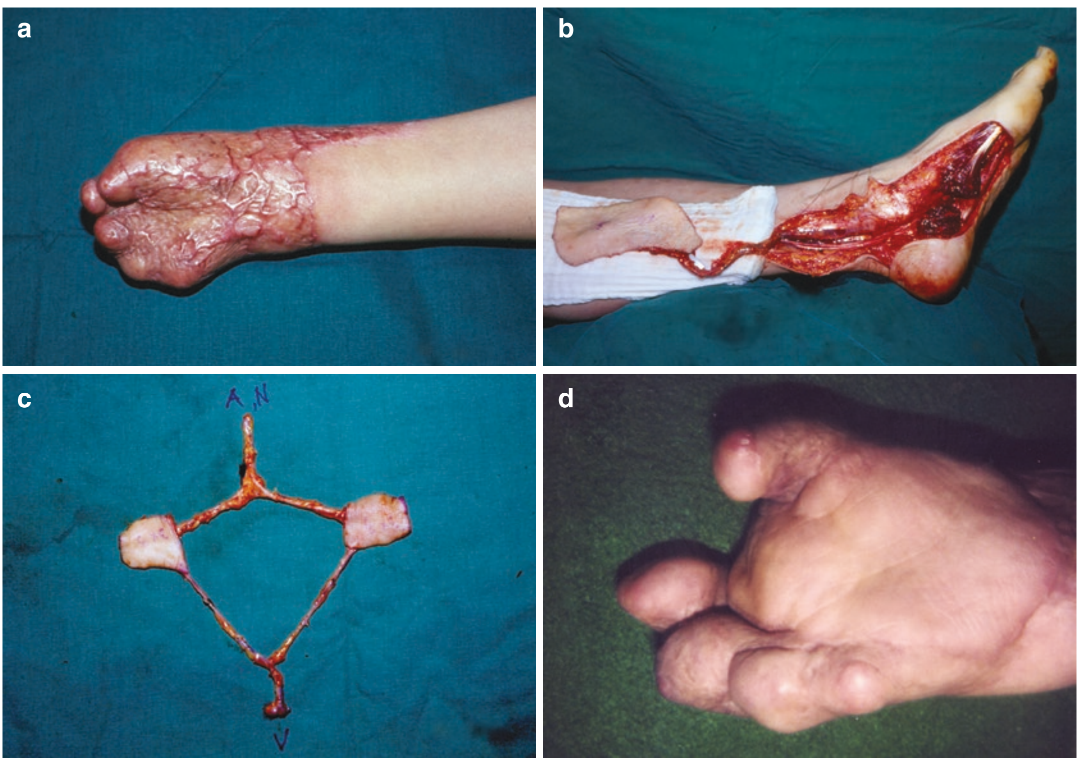

Fig. 1.1 Phalangization of the thumb. (**a**) Mutilated hand after degloved injury. (**b**) Harvested medial plantar neurovascular flap. (**c**) Harvested twin digital neurovascular flaps from the ulnar side of the middle finger and radial side of the ring finger of opposite hand. (**d**) The first web and palm covered with medial plantar neurovascular free flap and insensate tips of the thumb and index finger covered with flow-through twin digital neurovascular free flaps

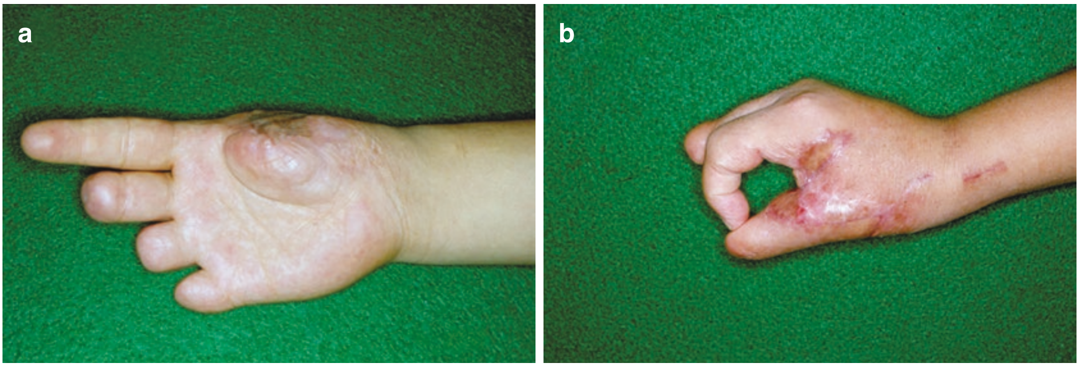

Fig. 1.2 On-top plasty. (**a**) Thumb amputation with multiple fingers. (**b**) Postoperative result of neurovascular pedicle transfer of the distal segment of an amputated ring finger with ray amputation to lengthen the thumb

outcomes [27]. When a future toe transfer is likely, a local or regional flap is not advisable during the initial procedure because this may damage the critical vascular structures. A pedicled groin flap is an excellent option.

Trimmed toe transfer was described by Wei et al. [28] and involves a longitudinal osteotomy to thin the toe. This has the advantage of replicating the native thumb size and maintains some IP joint movement. Morrison et al. [29] described the wrap-around flap, which uses the great toe pulp and nail and a segment of the distal phalanx, which is transferred with an iliac crest bone graft. This procedure results in improved cosmesis of the donor and recipient sites. However, there is no IP joint movement, and the graft is subject to resorption. The second toe [30] is not critical during the gait cycle and allows the entire metatarsophalangeal joint to be harvested. This may be the only toe transfer possible for more proximal thumb amputations. Drawbacks include a poorer cosmetic appearance, the tendency to claw, and a short nail. Occasionally, because of anatomic or cultural reasons, free toe transfer is not a possibility. Alternatively, osteoplastic reconstruction, pollicization (Fig. 1.3a–c), or lengthening may be considered. Although possible, metacarpal lengthening via distraction as described by Matev [26] yields only osteogenesis approximately 3 cm. Although this is still beneficial, better alternatives usually exist. Other limitations include the prolonged length of treatment, poor cosmesis, and lack of movement. Two thirds of the metacarpal is required, along with good skin and a compliant patient.

Osteoplastic reconstruction involves a tricortical iliac crest bone graft (approximately 8 × 50 × 15 mm) that is inserted into the metacarpal medullary canal and secured, usually with Kirschner wires. This is then covered with a pedicled flap, most often a groin flap (McGregor [31]). (A) tubed pedicled skin flap and bone graft (osteoplastic) (Nicoladoni and independently by Noesske [32]); (B) Variations on category A are skin tube and bone graft in separate operations (Noesske [32] and Pierce [33]); skin tube and bone graft in the same operation; bone graft implanted subcutaneously awaiting its vascularization (Shepelmann [34]) before its transfer with skin investment to the thumb amputation stumps (Albee [35]). The author used free neurovascular medial plantar flap for skin investment [36] (Fig. 1.4a–c).

Eric Moberg [37] introduced the digital neurovascular pedicle skin island method for sensibility redistribution in the hand during a discussion of tactile-sense restoration. This perceptive innovation provided special coverage to critical areas of sensory deprivation. Not only were intact sensibility and peripheral circulation restored by this method but also coniferous skin for protective and more effective use of the hand. Tactile sense of traumatic thumb can be restored with free neurovascular digital flap [38]. Gosset [39] was perhaps the first to use the neurovascular pedicle finger transfer method.

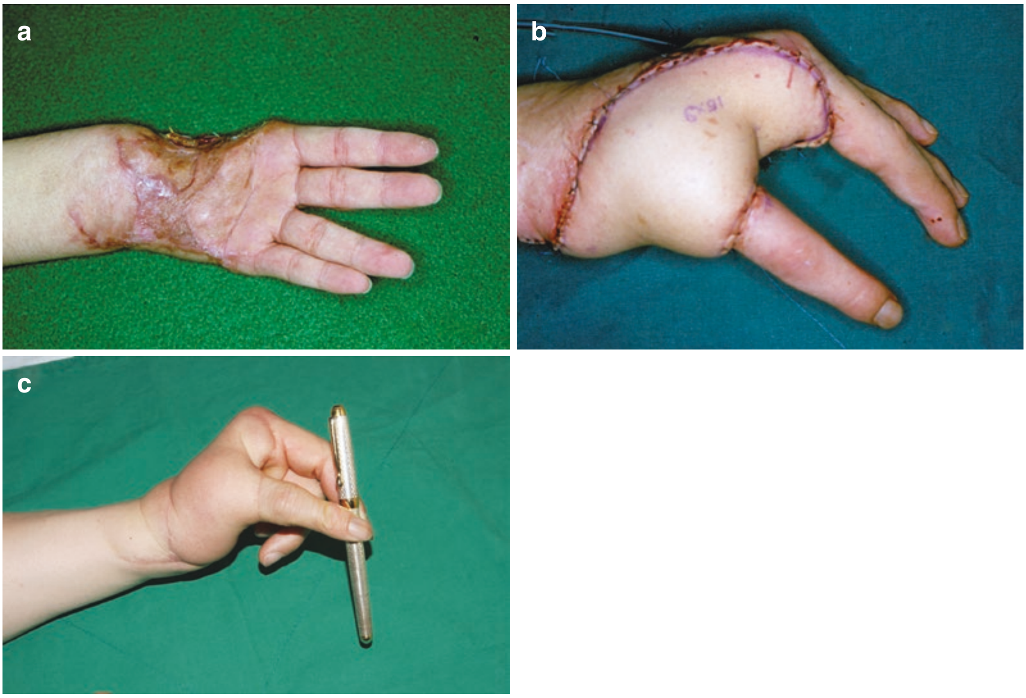

Fig. 1.3 Index pollicization. (**a**) Total thumb amputation with exposed second metacarpal bone. (**b**) Index pollicization included with free radial forearm flap for the coverage soft tissue defect. (**c**) At 21-year follow-up, this patient used the well-pollicized thumb

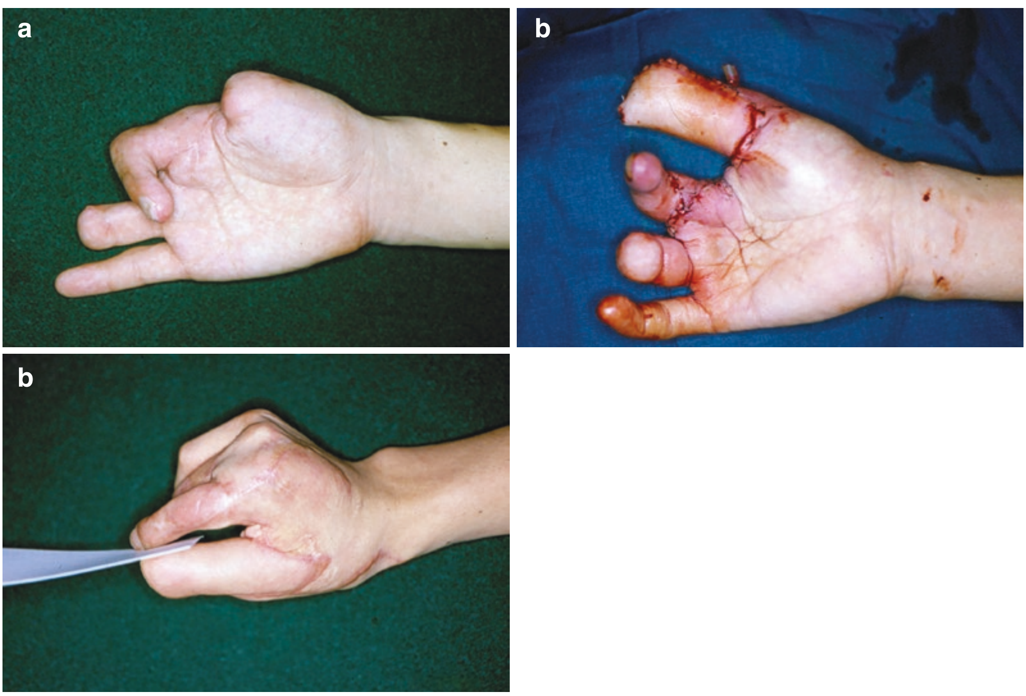

Fig. 1.4 Osteoplastic sensate thumb. (**a**) Mutilated hand with malrotation deformity of the index. (**b**) Osteoplastic thumb reconstructed with a free neurovascular medial plantar flap and the second metacarpal bone graft. Deformed distal index finger transferred to the amputated stump on the third metacarpal head of the middle finger. (**c**) Patient achieved good pinch and grasp

His selection of the index finger was in keeping with Iselin's [40] concept of the ideal procedure for finger-to-thumb substitution. Hilgenfeldt's [41] middle finger-thumb formation method fulfills the essential requirements for thumb substitution. The finger was isolated on its neurovascular bundles with a narrow (unnecessary), longitudinal, pretendinous, palmar skin bridge. A phalangeal length sufficient to complement the thumb loss was determined precisely. The proximal retracted, scar-tethered end of the independent long extensor (EPL) was isolated and sutured to the combined extensor digitorum communis (EDC) and extensor indicis proprius (EIP) primarily; the FPL was transferred to the deep flexor of the transferred finger at a subsequent operation.

Congenital Thumb Anomaly

Congenital thumb anomalies are common and have a major impact given the crucial functional role of the thumb. When surgery is needed to profoundly change the prehension apparatus, the main procedure must be performed early, at about 12 months of age, to coincide with the development of the cerebral pathways that control grasp. Congenital thumb anomalies may occur in isolation (e.g., duplication, hypoplasia, and aplasia) or in combination with other defects. The primary objective of surgery is to improve or restore function [42].

Thumb Duplication

Recognizing and analyzing the duplication is the first step in management strategy. The classification developed by Wassel [43] distinguishes several types based on the level of the duplication. Although this classification is still in use, it is not sufficient to determine the principles of surgical management. Additional information required to that end is whether the duplication is symmetrical (with two digits of identical length and volume) or asymmetrical (with predominance of one digit, usually the ulnar-based digit) and whether there is malalignment in the coronal plane (clinodactyly) [44]. Simple excision of a small accessory digit is only very rarely performed. The main thumb is structurally normal, and its radial edge is attached by soft tissues to a floating thumb, which can easily be removed [45, 46]. Choosing between midline fusion of the two digits (Bilhaut [47]-Cloquet procedure) [48] and reconstruction based on one of the two digits is the next step in the management strategy. The choice is only theoretical, however, as midline fusion is now reserved for strictly symmetrical type I, II, or III duplication, which is rare. Reconstruction of a functioning thumb from one of the two digits is therefore the most widely used procedure and is performed in all cases of type IV duplication, which is by far the most common variant. In this complex technique, great care is given to a set of elementary procedures performed in combination with simple excision of the accessory digit.

Thumb Hypoplasia

The therapeutic management of thumb hypoplasia follows a single guiding principle: major "irreparable" hypoplasia, in which removal of the thumb with pollicization of the index finger is the only valid strategy, must be distinguished from minor hypoplasia, in which the thumb may be improved or reconstructed. There are five types of thumb hypoplasia, originally described by Müller [49] in 1937. Blauth [50] refined Müller's concept, defining five grades of thumb hypoplasia in 1967. The Blauth classification identifies the variants of thumb hypoplasia and is extremely useful for planning treatment, yet it is only a general guideline. According to the severity of thumb hypoplasia, its reconstruction requires the release of the first web space [51], opponensplasty [52–55], and pollicization [56, 57].

Thumb Agenesis

The work of Matthews [56] and Zancolli [57] made possible a high degree of surgical excellence in the transfer of the radial-most finger (preaxial, index) for thumb agenesis. Buck-Gramcko [58] reported a series of 100 consecutive pollicization operations for agenesis. Certain technical considerations of finger transfer in thumb agenesis, not encountered with traumatic thumb loss in the normal hand, demand special attention.

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