Pollicization

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Congenital absence or traumatic amputation of the thumb is a major disability profoundly disturbing the function of the hand, as the thumb represents an estimated 50% of total hand function. The methods for thumb reconstruction utilizing the index finger were developed some twenty years ago, and progress has been made in the last several years with emphasis on intrinsic muscle reconstruction as emphasized by Buck-Gramcko. The method, technique and anatomy of index pollicization is discussed, and representative cases presented for congenital absence of the thumb and for traumatic amputation of the thumb.

INTRODUCTION

Pollicization refers to the reconstruction of a missing thumb utilizing a remaining digit. As thumb function accounts for perhaps 50% of total hand function, construction of a "pollex" or thumb is fundamentally important to the hand, and justifies the use of a remaining digit. Thumb reconstruction for a child, if it can provide improved function and improved appearance, will have a positive influence on that child's future and profession. The economic and social implications should not be underestimated of a child having better hand function through restored prehension, pulp-to-pulp pinch, and better appearance. No child should be deprived of this if there is a simple, effective procedure for restoration of prehension and the critical ability for pulp-to-pulp pinch.

The basic methods and general principles of index pollicization for reconstruction of the thumb were developed some 20 years ago, and our understanding advanced by the work of Littler, Chase, Harrison and others [1–9]. Significant progress has been accomplished in the last 5 years with the signal contribution of Buck-Gramcko who emphasized the reconstruction of the intrinsic muscles of the thumb, and other technical details [10]. This provided a thumb with muscle balance, mobility, stability, a better aesthetic appearance, and diminished the problems and complications that attended the earlier methods. Excellent functional results can be reliably and consistently achieved.

Accordingly, thumb reconstruction by pollicization is generally and broadly indicated in any child missing a thumb. Contraindications are severe mental retardation, the presence of associated disease that unacceptably increases the anesthesia risks, such as severe congenital heart disease, or the situation of a complex hand deformity where many other functional considerations enter into the surgical analysis. A further contraindication, in general, involves people beyond childhood—teenage years or older—who have developed an adaptive system of hand function where restructuring the anatomy would not be to advantage. In radial club hand, pollicization is only one potential component in the overall management and reconstruction of the problem. The procedure may or may not be indicated depending on the overall circumstances of the extremity, particularly the adequacy of elbow motion.
Patients with missing thumbs can be organized into two groups, as there are essentially two different types of pollicization. First, there is congenital aplasia, or significant hypoplasia, of the thumb. These are children on whom pollicization can be carried out at about one year of age. This provides a functional thumb during the early periods when refined dexterity, coordination, concepts of body image, and cerebral cortical representation of hand and thumb develop. It is believed that ultimate hand and thumb function will be better when a reconstructed thumb is present during these early developmental phases.

It is impressive within 2–3 weeks out of plaster how a child immediately, automatically, and spontaneously uses the new pollicized digit as an actual thumb, when operated upon early at one year of age. No education, training, or therapy is necessary. When performed on older children—age 3 or 4 years—several months are sometimes required to properly learn to use the new anatomic arrangement. In older children, the maladaptive patterns of function acquired in the absence of a thumb must be unlearned, and new functional patterns relearned in the presence of a functioning thumb. Accordingly, early surgery is advocated at one year of age, and surgery beyond the age of 12 may not be indicated, depending on individual circumstances.

The second group consists of those patients, usually adults, with traumatic amputations of the thumb, at or proximal to the metacarpophalangeal joint. More distal amputations are reconstructed by different measures than pollicization. In general, the intrinsic muscles of the thumb are present and need not be reconstructed. The method of surgery is different as to the selection of the bony length, the handling of the intrinsic muscles, and the technique of the bone junction.

The principles and the operative technique of pollicization for congenital thumb aplasia will be discussed first, referring only to pollicization of the index finger. We will emphasize the specific objectives and goals of this surgery. These are the measures of the results of surgery; they are the factors by which a postoperative outcome is assessed. We will discuss the functional anatomy and the surgical reconstruction that produce these objectives.

**CONGENITAL APLASIA OF THE THUMB**

The objectives of surgery are to provide a new thumb or "pollex" ray with:

1. correct position and rotation
2. proper length
3. sensibility
4. stability
5. mobility
6. strength
7. extrinsic and intrinsic muscle balance

In pollicization, five surgical concepts are important to achieve these objectives [1,5,10]. They are:

1. reduction of skeletal length
2. rotation
3. angulation
4. muscular stabilization and dynamic balance
5. the neurovascular bundles

1 On closer analysis, it follows that stability is a prior condition for functional mobility and that stability, mobility, and strength all result from the reconstruction of dynamic muscle balance.
FIG. 1a. Congenital thumb aplasia.

FIG. 1b. Postoperative result of index pollicization. Note the position, length and rotation. The intrinsic muscles of the thumb were reconstructed.

FIG. 1c. Thumb span and thumb adduction strength are good.

FIG. 1d. The pinch and prehension are precise. Sensation is normal.
FIG. 2a. Traumatic dominant thumb amputation combined with an index finger partial amputation in a 20-year-old male required index pollicization for reconstruction of thumb function.

FIG. 2b. Postoperative result. The patient is back to work and performs all activities of daily living, and the manual skills necessary to his job.

FIG. 2c. The pinch.
Reduction of Skeletal Length

The shaft and base of the second metacarpal are resected to allow recession of the pollicized digit to the proper length. The skeletal elements are re-ordered accordingly (Fig. 3). The second metacarpal head becomes the new trapezium. The resection is through the epiphysis in order to limit growth of the metacarpal head in its new position as the trapezium. The index metacarpophalangeal joint becomes the new thumb interphalangeal joint.

The metacarpal head is rotated such that the palmar or volar surface of the joint becomes proximal, thus putting the index metacarpophalangeal joint in extension [10]. This prevents an hyperextension deformity from occurring, as this joint is secured in its proper position, in a state of extension. Bone healing is not essential at the new carpometacarpal joint since a stout fibrous union is sufficient.

Rotation

This provides for proper axial alignment and places the pollicized ray in position for prehension. A final position of 120° axial rotation from the plane of the digits is sought once the skin and tendons are sutured.

Angulation

The pollicized digit is placed in 45° palmar abduction. From this position, placement for precision handling and power handling can be initiated. Prehensile function commences from this position.

Muscular Stabilization and Dynamic Balance

The key to stability is muscular balance of both the extrinsic and intrinsic muscles applied to the new thumb [4,10]. Stability is a precondition to mobility, and mobility is a direct function of dynamic muscular balance. The fundamental motions of the thumb are flexion, extension, abduction, and opposition with axial rotation. Properly reconstructed musculotendinous units provide for these fundamental motions [1-6,10].

The long flexors do not need to be shortened, as adaptive shortening occurs in several months to the recessed ray. Reconstruction of abductor pollicis longus function is essential. This provides radial and extension stability of the new thumb, which is necessary for stable motion. Extensor digitorum communis is severed at the metacarpophalangeal level and re-attached to the base of the index proximal phalanx which is now the new first metacarpal. Accordingly, it is a new abductor pollicis longus in function. Extensor indicis proprius is shortened and re-sutured to the central portion of the extensor mechanism to provide for new extensor pollicis longus function.

Reconstruction of the thumb intrinsic muscles is important for stability and the ultimate refined mobility of the thumb. This concept was developed and emphasized by Buck-Gramcko [10], and represents the major, recent advance in the surgical capabilities for congenital absence of the thumb. The first dorsal and first volar interossei muscles are used for this purpose. The first dorsal interosseus muscle becomes the new abductor pollicis brevis, and the first volar interosseus muscle becomes the new adductor pollicis. They are detached from the index digital extensor mechanism and subsequently stripped sub-periostially from the second metacarpal shaft, preserving their nerve and blood supply. The index ulnar and radial lateral bands of the digital extensor mechanism are dissected the length of the index
FIG. 3. Schematic diagram of the anatomic reorganization involved in index pollicization for congenital absence of the thumb. The index metacarpal head becomes the new trapezium. The index proximal phalanx becomes the new thumb metacarpal. The index proximal interphalangeal joint becomes the new thumb metacarpophalangeal joint. The index middle phalanx becomes the new thumb proximal phalanx. The first dorsal interosseous muscle becomes the new abductor pollicis brevis. The first volar interosseus muscle becomes the new adductor pollicis. Extensor digitorum communis becomes the new abductor pollicis longus. Extensor indicis proprius becomes the new extensor pollicis longus.

proximal phalanx to the level of the proximal interphalangeal joint, which is the new metacarpophalangeal joint (Fig. 3). The radial lateral band is then looped through the tendinous portion of the first dorsal interosseus back upon itself where it is securely sutured. The ulnar lateral band is similarly looped through the tendinous portion of the first volar interosseus back upon itself and sutured. The former then anatomically constitutes the new abductor pollicis brevis, and similarly the latter, the adductor pollicis. In effect, this accounts for the skeletal shortening and transfers the interossei insertion from the index metacarpophalangeal level to the index proximal interphalangeal, which is the new metacarpophalangeal level (Fig. 3). This is done after the metacarpal head is placed between the interossei muscles proximally where they secure and hold the bone.

These new positions of both the extrinsic and intrinsic musculotendinous units establish a muscular stabilization and provide for the refined mobility required in precision and power handling [10].

The Neurovascular Bundles

During the dissection, the pollicized ray becomes a virtual island suspended on its two neurovascular bundles. Meticulous care of the nerve and vascular supply is mandatory to preserve viability and feasibility. To permit adequate mobilization, the proper digital artery to the radial side of the middle finger is divided, and the common digital nerve is longitudinally split. Postoperative sensation is normal.

Postoperatively, the hand is immobilized in plaster for three weeks. A protective splint is provided for a further two weeks. Thumb function rapidly develops, and in the one-year-old is almost immediate and spontaneous. Active flexion takes several months to develop, accounting for the adaptive shortening of the flexor tendons.
TRAUMATIC AMPUTATION OF THE THUMB

This constitutes the other group of patients with amputated thumbs, at or proximal to the metacarpophalangeal joint. The objectives are the same as with congenital aplasia. The concepts are the same. The differences are in (1) the selection of skeletal length, (2) the method of bone junction to the first metacarpal remnant, and (3) the management of muscle balance—both extrinsic and intrinsic.

Note that the normal thumb length approximates the index finger proximal interphalangeal joint level. The selected index length should approach this estimation, with due care that it is better to be shorter than to err, and be longer. This often involves the transfer of the index proximal phalanx, with completion of the index ray amputation. For complete thumb amputation at the carpometacarpal joint level, the surgical techniques become the same as for congenital aplasia, including the handling of the intrinsic muscles. For the bone junction, the proximal phalangeal shaft is fixed to the first metacarpal shaft by one of several techniques, and secured with judicious use of k-wires. These include a mortis and tenon [2], end-to-end with intramedullary bone graft [5], differential step cut [1], or an angled wedge into the side of the first metacarpal shaft [3,4].

In the general case, the thumb intrinsics are present. Repair consists of advancing the tendinous portion of abductor pollicis brevis to the extensor mechanism of the new metacarpophalangeal joint on the radial side, and the tendinous portion of the adductor pollicis to the extensor mechanism on the ulnar side of the new metacarpophalangeal joint. Long flexors do not require adjustment, as adaptive shortening occurs in several months. For minimal length recession, the two extrinsic extensors do not require shortening. For moderate to considerable recession of the index ray, they do require shortening and re-suturing.

Postoperatively, the hand is immobilized in plaster for three weeks. A protective night splint is provided for a further three weeks. A progressive educational and rehabilitation program is essential to optimize postoperative function in the adult. Younger people do better than older people; highly motivated patients recover greater function than less motivated individuals.

As thumb function is crucial to the hand, thumb reconstruction by pollicization is justified and indicated for most patients suffering from thumb amputation. The postoperative total function of the hand can be significantly improved. Hand function is highly important to any individual, in his work, his activities of daily living, and his economic, social and family welfare.

CONCLUSION

For patients with congenital aplasia of the thumb, or with traumatic thumb amputation, useful thumb function can be reconstructed with index pollicization. The functional objectives of stability, mobility and sensibility with proper length and rotation in thumb reconstruction can be achieved by the methods discussed.

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