Pollicization of the Index Finger

METHOD AND RESULTS IN APLASIA AND HYPOPLASIA OF THE THUMB

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Children with congenital absence or marked hypoplasia of the thumb usually are very skillful in the use of their hands. Despite this natural dexterity, the important pulp-to-pulp pinch is missing (Fig. 1), so that the choice of a profession in the later years is restricted. Therefore, reconstruction of a thumb, if it provides not only better function but also an improvement in the appearance of the hand, will have a positive influence on the child’s future, and all the obvious implications, economic and social, on the child and his family should not be underestimated.

The high incidence of congenital malformations of the thumb in the years from 1959 to 1962—mostly resulting from the thalidomide tragedy—has led to a widespread interest in their surgical treatment. The progress in the field of surgery of the hand led to technical modifications of previously used procedures for pollicization, and better results followed. A good result, however, requires that one use a refined technique. Unfortunately, this has not been practiced in all cases of pollicization and disappointing results may be obtained, particularly by inexperienced surgeons (Fig. 2). These bad results may be responsible for some low estimates of the value of this procedure, published in the last few years, for example, that, “at best, pollicization gives a hand that is cosmetically distasteful and functionally disappointing”.

White stated that “a transposed index finger can never be made into a thumb especially in the congenital cases,” and “that no transplant can emulate the thenar muscles and that flexion and extension may be the only worthwhile movements.”

![Fig. 1](image-url)

Impossibility of performing pinch and its compensation in two patients with high-grade hypoplasia of the thumb.

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Figs. 2-A and 2-B: Disappointing result of a trial to pollicise the index finger, performed elsewhere. An osteotomy of the metacarpal and resection of the proximal interphalangeal joints was done, but the essential features of shortening, muscle stabilization, and adequate rotation were lacking.

results presented in this paper show that these statements are not correct if small but important details of technique are observed.

The technique of pollicization in congenital cases is based on the procedure evolved for the reconstruction of the thumb in traumatic amputations. From the fascinating literature concerning this problem, I would emphasize the contributions in operative technique by Gosset, Hilgenfeldt, and Littler \(^ {10,11}\), who developed the fundamental principles for pollicization in cases of aplasia and hypoplasia of the thumb. Other authors such as Harrison \(^ {7,8}\) and Riordan \(^ {12}\), also have made important contributions.

From 1959 to the present I have performed 114 pollicization operations, and of this number 100 were in congenital cases. The experience with this large number of pollicizations has led to modifications in the operative technique with improvement of the results \(^ {2,3,4}\). Twenty-one of the seventy-three patients had unilateral problems, with normal contralateral upper extremities. In sixteen there were other malformations of the head, the other side or a femur. An osteotomy of the metacarpal head and resection of the proximal phalangeal joints was done, but the essential features of shortening, muscle stabilization, and adequate rotation were lacking.
malformations of the other hand which did not require pollicizations with the exception of nine in whom the procedure will soon be done. This leaves twenty-seven patients who had the procedure done bilaterally.

Twelve of the patients who had pollicization also had a radial club hand on the side operated on, and six of them had the condition bilaterally; but I did not pollicize the index finger in any patient with bilateral involvement. However, I did perform a centralization procedure on the contralateral hand in two of the six patients with bilateral involvement. In this procedure the hand was centralized over the end of the ulna.

**Theoretical Concepts**

In creating a new thumb from the index finger with stability and optimum position, the reduction of the length of the bones is important. For attaining the same number of bones and joints as in a normal thumb a shortening of the over-all length of the ray is necessary: the second metacarpal is removed with the exception of its head which acts as the new trapezium. However, the metacarpal should not be allowed to continue to grow much; for this reason the epiphysis must be resected. The metacarpophalangeal joint will then become the new carpometacarpal joint. The proximal phalanx of the index will become the first metacarpal and the proximal interphalangeal joint the metacarpophalangeal joint of the new thumb, and so forth (Fig. 3).

A rotation of the index finger on its longitudinal axis is also performed to provide proper axial alignment. Rotation of only 90 degrees, as is often done, will not give good opposition. The result will be a type of key grip against the long finger. The index finger has to be initially rotated about 160 degrees during the operation so that it is opposite the pulp of the ring finger. This position changes somewhat during the suturing of the muscles and the skin, so that at the end of the operation there is rotation of about 120 degrees.

In addition to the shortening and rotation, an angulation of about 40 degrees of palmar abduction should be obtained. In this way, the new thumb is then well placed to later move in opposition as well as in adduction and abduction.
Operative Technique

For the pollicization operation there are four basic principles of equal importance, relating to the following: (a) the neurovascular pedicle; (b) the skeletal readjustment with preservation of the metacarpophalangeal joint; (c) the muscular stabilization; (d) the skin incision.

The first, the technique of fashioning the neurovascular pedicle, is now well known. The freeing-up of the neurovascular bundle between the index and the long finger is obtained by ligating the artery to the radial side of the long finger. The common digital nerve is then carefully separated into its component parts for the two adjacent fingers. This ensures that no tension will be present after the index finger is rotated. Sometimes an anomalous neural ring is found around the artery. This ring is split very carefully so that angulation of the artery after transposition of the finger will not occur. The radial digital artery to the index finger is occasionally absent. In such cases it is possible to perform the pollicization on a vascular pedicle of only one artery. On the dorsal side at least one of the great veins must be preserved.

For skeletal fixation after bone readjustment, the length of the index finger is of considerable importance. If the phalanges are relatively short, the base of the metacarpal must be retained in order to obtain the right length of the new thumb. The metacarpal head is fixed to its base by means of one or two Kirschner wires. If the phalanges are of normal length, the whole metacarpal is resected with the exception of its head. A short thumb is desirable, as it is functionally and esthetically better than a long one, which bears too close a resemblance to a finger bones, which is not essential. This good function.

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THE JOURNAL OF BONE AND JOINT SURGERY
The physiologically wide range of movement of the metacarpophalangeal joint, especially in the child, was the reason that hyperextension deformity developed in my earlier cases (Fig. 5). It was more disturbing esthetically than functionally. This deformity is now prevented by turning the metacarpal head about 70 to 80 degrees so that its palmar side becomes proximal (Fig. 6). In other words, the proximal phalanx is brought into a position of hyperextension in relation to the metacarpal head. The normal joint looseness is markedly reduced and hardly any further extension is possible. This procedure, combined with the new muscle attachments has increased the stability of the thumb. No further tendency to hyperextension has been observed.

For muscle stabilization, the adjustment of the extensor tendons and the intrinsic mechanism is one of the most important steps of the operation (Fig. 7). The intrinsic muscles and the long extensor and flexor tendons are responsible not only for the mobility, but also for the stability of the digit. Stability is more important than mobility for good function of the thumb. Experience has shown that it is not necessary to shorten the flexor tendons. They adapt themselves in the course of a few months to the shortening of the ray and will then flex the new thumb to the required extent. One of the two extensor tendons, that of the extensor digitorum communis, is severed at the metacarpophalangeal level; its proximal end is sutured, after the metacarpal resection, to the base of the former proximal phalanx (now acting as a first metacarpal), to become the new abductor pollicis longus. The extensor indicis proprius tendon is shortened and then resutured by end-to-end anastomosis.

The interosseus muscles of the index finger are also important for stabilization of the thumb. They should first be detached from the proximal phalanx and the lateral bands of the dorsal aponeurosis. Their origins from the metacarpal bone are partially stripped subperiosteally. Careful preservation of nerves and vessels is a necessity.
Diagram of the muscle stabilization by the two interossei resutured to the separated lateral bands of the dorsal aponeurosis. The extensor communis tendon is fixed to the base of the new metacarpal as an abductor pollicis longus; the extensor indicis proprius tendon is shortened.

After osteotomy and resection of the second metacarpal, the head of the second metacarpal must be set in the aforementioned position between the muscles in such a way that they hold the bone well. The stabilization of the ray will be ensured by resuturing the tendinous insertions of the two interossei to the lateral bands of the dorsal aponeurosis. These lateral slips will have been separated from the middle band the entire length of the proximal phalanx. The slips are woven through the distal parts of the muscles and turned back to form a loop. In this way, the first palmar interosseus will become an adductor pollicis, and the first dorsal interosseus an abductor brevis.

The new way of attaching the muscles is accompanied by a further change in the skin incision. Previously, an S-shaped incision was made on the radial side of the hand with an oval incision at the base of the index finger. Now, since the interossei are reattached in the neighborhood of the proximal interphalangeal joint, an additional dorsal longitudinal incision over the proximal phalanx is needed. Since the volume of the space comprising the proximal phalanx has been increased by muscle and tendon transfers, direct closure is not possible. A dorsal skin flap is used to close this defect.

In order to obtain this flap, the incision is made more palmarly than radially. It also continues as far as the middle of the phalanx (Fig. 8). The distal end of this flap is excised.

**Follow-up**

Each patient was seen routinely during the first year after operation, and thereafter at two years, four years, and six to eight years. Depending on the year in which the operation was done, follow-up was as follows: twelve years, one patient; six to eight years, seven patients; four to six years, twenty patients; two to four years, twenty-five patients; one to two years, seven patients, and less than one year, thirteen patients. Many of the patients had bilateral involvement; this accounts for the discrepancy between the letters.
The main change in the range of motion and in the dexterity of the hand operated on took place during the first two years after the operation. At the end of the three weeks of immobilization after operation, the joints of the pollicized index finger could move just a few degrees, usually; but in the next three to six weeks, all children gained the ability to perform pinch between the new thumb and the long finger, and some could even touch the thumb to the ring finger. Most children could do this by the sixth to eighth week, and could touch the little finger four to five months after the operation.

There was no significant difference in the rate of improvement with different
ages, except for infants under the age of fifteen months, who could not cooperate to demonstrate pinch, but even these infants were able to use the hand operated on in a natural way and were gripping objects between the new thumb and fingers or between the new thumb and the long finger. Active flexion of the pollicized finger sometimes began in the fourth week, but in the majority not before the third month. The motion increased slowly but steadily during the first year because of slow adaptive shortening of the flexor tendons, not shortened surgically.

The motion and strength of radial abduction was the greatest variable in the group of patients. They depended not only on the strength of the extensor muscle, and on the position of fixation of the metacarpal head relative to the remains of its base on the carpal bones, but also on the active use, and on the presence of other anomalies in the extremity. For instance, in the radial club hand, there usually was little active motion in the interphalangeal joints of the index and long fingers, and, therefore, after pollicization, little motion existed in the former metacarpophalangeal joint and none in the interphalangeal joints. In this case, therefore, the digit had to be fixed in less radial abduction and act more as a post for the function of pinch.

All of the children used their new thumbs naturally except those with radial club hand, who frequently used the side-to-side grip of ring and long fingers for smaller objects. One other exception was a child with a "five fingered" hand, who used this method for pinch preoperatively and continued to do so because of insufficient power in the intrinsic muscles. None of the new thumbs showed sensory or vascular deficiency with one exception—a hand in which there was anomalous absence of the palmar arteries and postoperative thrombosis of the metacarpal artery with necrosis and subsequent loss of the thumb.

It was necessary to add skin grafts in six operations, in three of which scars from previous operations were the reason. In the other three a small full thickness graft was used from the excess skin on the dorsum of the finger. In these the reason was retention of much of the second metacarpal because of the shortness of the phalanges.

The reattached intrinsic muscles were important for the appearance as well as for the function of the thumb. They gave to the transposed index finger the appearance of a thumb. They also produced a real thenar eminence, and, after a period of training, led to relatively normal mobility of the thumb (Fig. 9).

![Fig. 9](image-url)

Normal opposition and radial abduction of a pollicised index finger with a real thenar eminence by the described muscle transfer.
could not cooperate to hand operated on in a incomplete hand, and fingers or because of slow adaptive function of pinch. The presence of other anomalies, and, therefore, the digit had to provide intrinsic power for the rotated index finger. These muscles gave the new thumb normal balance and stabilization, which are the prior conditions for good mobility, as well as the ability to perform pinch and normal prehension (Fig. 11).

In cases of radial club hand, usually there were several additional anomalies and bad mobility of the radial fingers; the postoperative results in these cases were not as good as those previously described, but the operation did provide an increase in function and usefulness of the hand. The correction of the club hand by centralization of the hand with removal of the lunate and capitate bones and tendon transfers was performed at the first operation, the pollicization at the second (Fig. 12).

In the case of the so-called five-fingers-hand the decision whether or not the radial finger was to be removed or used for pollicization sometimes was difficult. If the radial finger was of about the equal size of a normal finger, pollicization of this finger gave a very satisfactory result (Fig. 13). If the finger was too small and hypoplastic, it was better to remove it and pollicise the index finger.

Finally, the optimum age for performance of the operation was the first year of...
Result three years after pollicization; normal position in writing and crochet-work.

life. At the beginning, I considered that the age of two and a half years was most appropriate. However, in the last few years I have operated upon several infants, the youngest being eleven weeks old, and now I think that the first year of life is the best age for pollicization and, incidentally, for some other operations in congenital malformations of the hand. There are two decisive factors here: The first is that it is from the age of about six months onward that the so-called thumb feeling is sup-

Fig. 11
Result three years after pollicization: normal position in writing and crochet-work.

Fig. 12
Result in radial club hand with centralization of the hand and pollicization of the index finger.
posed to develop, and, therefore, the new thumb will be felt as being a normal one. The second is the fact that the transposed index finger will have the longest period possible for growth under the influence of its function as a thumb. Several years after pollicization we have been able to demonstrate a slow transformation of the structures of the pollicized index finger in the direction of a normal thumb. Not only do the muscles become stronger, but also the bones. Especially the new first metacarpal becomes larger than the first phalanx of the long finger, to which it was equal in size preoperatively (Fig. 14).

The operation was not done in the mildest cases of hypoplasia of the thumb, in which there was only absence of thenar muscles and a slight adduction contracture. In all other cases of hypoplasia, in which there were not enough good intrinsic muscles and long flexor and extensor tendons for good function, the dysplastic thumb was removed, and the index finger was pollicized. The operation also was not done in radial club hands where centralization of the hand over the ulna was not possible because of restriction of elbow motion.

Roentgenograms of a hand with pollicized index finger four years after operation. Note the broadening of the base of the new first metacarpal in contrast to the base of the long finger.

VOL. 33-A, NO. 8, DECEMBER 1971
The experiences with 100 operations of pollicization of the index finger in congenital deformities of the thumb in seventy-three patients are reported on. The operation is indicated in aplasia and in hypoplasia if there is no stable metacarpophalangeal joint and there are adduction contracture and poor mobility due to abnormalities of muscles and tendons. The operative technique was improved by the experiences in twelve years of use. Most important are the bone fixation and the muscle stabilization. In transformation of an index finger into a thumb it is necessary to shorten the ray, to rotate it sufficiently, and to give it the right angle of abduction. The shortening takes place in the metacarpal bone with preservation of its head: the metacarpophalangeal joint becomes now the carpometacarpal joint and the metacarpal head the new trapezium. For preventing a hyperextension deformity it is necessary to rotate the metacarpal head. For good muscle stabilization and good mobility the two interossei of the index finger have to be detached and to be fixed in the shortened position on both sides of the new thumb to the mobilized lateral slips of the dorsal aponeurosis. This new manner of muscle fixation gives a very good thenar eminence not only in respect to appearance but also in function with full or nearly full opposition and abduction. It requires a new skin incision with a dorsal-radial skin flap for covering the gap between the wound edges of the former proximal phalanx broadened by the muscle masses. The excellent results show a surprising adaptation of bones and soft tissues due to function and growth—a reason for an early performance of the operation.

References


DISCUSSION

Dr. J. W. Littler, New York, N. Y.: Through a tragic pharmacological mishap Dr. Buck-Gramcko has gathered this unprecedented series (100 cases) of thumb aplasia. His paper is a splendid one and therefore a pleasure to discuss: its clarity is refreshing, the surgical approach is exact, and the functional reward for these little patients is superior. His outstanding contribution gives great authority to this particular procedure.

Several points, however, deserve emphasis. First: the surgical timing. For many years I have resisted transposing the radial digit into thumb position during infancy, believing that the...
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...surgically unmolested child, possibly with another anomaly, would better tolerate the operation later. Never, however, have I hesitated to encourage the removal, relatively early, of any rudimentary, functionally and hopelessly blighted first pre-axial digit.

It is acknowledged that the thumbless child will endeavor to force his independent index finger as an opponent of the other digits. What we attempt with our surgery is to complete that endeavor. Both Dr. Buck-Gramcko and Dr. Riordan now firmly believe that the digital transposition should be done during infancy. This may or may not be true for the best result. It is my opinion that a non-existing thumb has no special cortical representation; any oppositional function resides in the next most independent digit, regardless of the time of any transposition. Heretofore, I have awaited the age of from two to four, but perhaps my approach is too cautious, despite parental pressure.

Certain technical aspects are most important and of these the incision is of primary concern, for finally the closure must have allowed the digit to be shifted into proper position, providing an adequate cleft and a sufficient proximal phalangeal skin envelope to house the bulk of the intrinsic muscles advanced to encompass the recessed proximal phalanx (now acting as the metacarpal).

Though it is not carefully documented in this paper, the head of the epiphyseal-arrested metacarpal fails to develop, but as shown in some of the illustrations, the hypertrophic proximal phalanx has taken on the characteristics of a thumb metacarpal. It also shows good projection (despite an incomplete carpal arch) and has a firm fibrous base to meet the oppositional demands. In the words of Sir Charles Bell:

"On the length, strength, free lateral motion and perfect mobility of the thumb, depends the power of the human hand. The thumb is called Pollex because of its strength; and that strength is necessary to the power of the hand, being equal to that of all the fingers."

It must be admitted that to bring the thumb-deprived primitive hand into a more advanced state, the pre-axial finger can be substituted through careful surgery and that with time and use, though imperfect, its appearance and function will approach quite nearly that prime digit which failed to develop.

Edited by C. B. Wynn
