RECONSTRUCTION OF THE THUMB

D. A. Campbell Reid, Derby, England

From the Hand Surgery Service, Derbyshire Royal Infirmary and Harlow Wood Orthopaedic Hospital

The object of this paper is to discuss the ways in which total or partial loss of the thumb, including congenital absence, may be treated. Total loss of a thumb, in an otherwise undamaged hand, constitutes about 40 per cent disability in that hand. Reconstructive surgery is certainly indicated for total loss and should also be considered for partial loss.

Absence of a thumb due to congenital abnormality differs in several respects from loss by injury. A child born without a thumb is able, to a varying extent, to compensate for the deficiency, the index finger tending to assume the position of the missing thumb. Even so, the disability in congenital cases may be considerable, and reconstruction is usually justified—especially if done at an early age, when re-education occurs readily and the functional results are excellent. The technique is essentially the same whether the deficiency is congenital or traumatic.

During the evolution of reconstruction of the thumb several different methods have had their vogue. In the late nineteenth century Guermonprez (1887) stressed the importance of reconstructing the mutilated hand on functional lines by utilising remnants of the badly mangled hand to fashion a functional pinching and grasping organ.

The next phase was influenced by Nicoladoni (1900), who undertook many reconstructions by transferring toes or by using skin flaps and bone grafts. These methods prevailed until the second world war when there was a return to the principles stressed by Guermonprez. In recent years they have become accepted as the rational approach to the problem in general. No precise rules can, however, be laid down. Each case presents its own problem and careful planning is required to determine the most suitable procedure.

EMERGENCY TREATMENT OF INJURIES OF THE THUMB

The essential principle of primary treatment is that the thumb must not be shortened solely to facilitate closure. If the skin cannot be sutured without tension an adequate covering of skin must be provided by other means. This may be accomplished by a free skin graft or by a flap raised from the back of one of the fingers. When skin, pulp and part of the terminal phalanx are lost, the covering provided by a cross-finger flap is superior to that achieved by a free skin graft. When the stump is short that technique cannot be employed and a cross-forearm, cross-arm or pectoral flap is used instead. The last is the most generally useful method in these cases because fixation is easy and the position is comfortable. The forearm and arm provide skin of better texture but the technical difficulties are greater.

A degloving injury should be treated by an immediate tubed flap taken either from the chest wall or the opposite forearm. The circumference of the thumb is about three inches; the flap must therefore be at least three inches wide and of a length corresponding to the degloved area to be covered. The flap is raised and made into a tube. It is then draped over the degloved thumb and its periphery sutured to the corresponding skin of the thumb. The base of the flap is divided three weeks later.

CLASSIFICATION OF INJURIES OF THE THUMB

Classification is based on the level of loss, since this is the main factor influencing the choice of treatment. 1) Amputation distal to the metacarpo-phalangeal joint, leaving an adequate stump of proximal phalanx or of proximal and distal phalanges. 2) Amputation
distal to or through the metacarpo-phalangeal joint leaving a stump of inadequate length. 3) Amputation through the metacarpal leaving some intrinsic musculature. 4) Amputation at the carpo-metacarpal joint.

In group 1 there is enough length for useful function, and, provided the thumb is covered with stable skin and the end is not tender, no reconstruction is necessary.

In group 2 the stump is not long enough to provide a useful thumb and will benefit from lengthening. Some patients are unwilling to undergo this but will accept a more limited alternative, namely phalangisation. This involves a simple deepening of the first intermetacarpal cleft which will enable the hand to grasp more easily.

Groups 3 and 4 may conveniently be grouped together from a functional point of view to cover all cases of total thumb loss. Most cases of congenital absence of the thumb fall into group 4.

AIMS AND METHODS OF RECONSTRUCTION

The requirements of a reconstructed thumb have been listed by Tanzer and Littler (1948) as follows: 1) It should have sufficient forceful flexion and extension to permit grasping; 2) it must be possible to oppose the tip of the reconstructed thumb to one and preferably two fingers; 3) the tip of the thumb should have some tactile sensation, otherwise much of its usefulness is lost; 4) a less important but desirable requirement is a reasonable appearance.

It is not possible to satisfy all these requirements in every case. After severe mutilations one may have to be content with a stable thumb post against which some finger element can oppose.

Excluding phalangisation, which has already been mentioned as a procedure of limited value, the following four main methods of reconstruction are available: 1) Lengthening of the thumb stump by local flap and bone graft—the Gillies thumbstall lengthening procedure; 2) phalangisation of one of the fingers; 3) lengthening of, or building-up, a thumb by means of bone graft and tubed flap. The important principle of thumb autografting is included in this group; 4) transfer of a toe.

RECONSTRUCTION BY LENGTHENING WITH LOCAL FLAP AND BONE GRAFT

At the first meeting of the British Association of Plastic Surgeons in 1946 Gillies discussed a hypothetical method of lengthening a short thumb by a local skin flap combined with a bone insert. He applied the term "cocked hat" flap to describe the method but now prefers to call it the "thumbstall" lengthening procedure. It was suggested at the time that, although the nerve supply to the skin of the local flap would be interrupted, reasonable sensation might return because the skin possessed normal end organs into which the fibres would grow. The method was put to the test and reported by Hughes and Moore (1951). They described their experience of two cases and viewed the method with enthusiasm. It is eminently suitable for group 2 cases, but when amputation of the thumb at the metacarpo-phalangeal joint is associated with a partly amputated finger phalangisation of that finger is indicated. The Gillies method provides a means of achieving limited lengthening by one operation. For group 2 cases this gain in length is sufficient to increase considerably the value of the thumb. 

Technique—A horseshoe-shaped incision concave distally is made around the base of the thumb metacarpal and the distally based flap is completely reflected from the thumb. The advancement of this flap allows lengthening of the thumb by insertion of a bone graft. The skin defect left by the flap advancement is covered by a split skin graft (Figs. 1 and 2).

A most important observation by Hughes and Moore (1951) was that the new thumbs appeared to possess almost at once some tactile and thermal sensibility. Whillis (quoted by Hughes and Moore) believed that the impression of tactile sensation must be entirely proprioceptive. He believed that light touch involved slight movement of the carpo-metacarpal
The slight joint movement in the abnormal thumb is associated by the patient with the sensation that normally accompanies it. In other words, normal tactile appreciation probably involves in the digits infinitesimal movements of the joints without which the representation in the sensorium is incomplete. The impressions from skin receptors are normally predominant, but after an interval during which the patient gets used to the absence of skin sensation a modified sensorial impression of touch is produced when the joint movement alone is produced.

**FIG. 1**

Case 1—Avulsion of the thumb through the base of the proximal phalanx.
The advantages of the method are a single operation only, and a strong stable thumb with
good sensation and fair appearance. The disadvantages are the limited lengthening, occasional
absorption of the graft, and distal displacement of the web between thumb and index finger.
which can, however, be corrected readily by a subsequent Z-plasty.

POLlicisation

The term pollicisation implies the utilisation of one of the fingers to replace a missing
thumb. Iselin (1955) gave a detailed historical review of the development of this technique.
recalling that as long ago as 1887 Guermonprez described his experience in using injured
fingers to replace avulsed thumbs. The method did not receive wide acceptance, and only
isolated cases were reported (Noesske 1920, Perthes 1921, Bonnet 1930). Bunnell (1931)
described his experience of an operation for the physiological restoration of a thumb by using the remains of a mutilated index finger. The finger was swung as a pedicle into the position of the thumb and restored useful function to the hand. The next phase came during the second world war, when the large number of severe hand injuries brought a new stimulus. Gillies and Cuthbert (1943) described a case of severe burns with loss of the thumb at the metacarpal head and loss of the index finger at the proximal interphalangeal joint. Pollicisation was undertaken in three stages. At the first stage the index metacarpal was divided at the junction of proximal and middle thirds and the distal fragment wired to the thumb metacarpal.
Stage two established the interdigital cleft between index and middle fingers, the medial side of which was lined with palmar and dorsal skin flaps. The other side was covered with a free graft. At the final stage a rotation osteotomy was undertaken and tendon adjustment performed. The final result was a rather short but very powerful thumb with good abduction and adduction and fair opposition. Figures 3 to 10 illustrate use of this method for a hand mutilated by severe burns. A satisfactory functional result was achieved. At stage two it was necessary to line the newly established cleft with a tubed pedicle for want of suitable local skin.

More cases were reported (Cuthbert 1948, Moore 1948, Tanzer and Littler 1948) in which the damaged index finger was pollicised. At that time most surgeons believed that pollicisation of an index finger should be limited to patients with subtotal loss of that finger, arguing that
an intact finger should never be jeopardised. Cuthbert was the first to report a completed case using a normal index finger. This was done for total loss of the thumb leaving a stump without any active small muscle remnants. Both Cuthbert and Moore used a large dorsal flap based on the radial side of the hand. This was used to cover the defect on the pollicised digit after the cleft had been established. The other side of the cleft was resurfaced with a free graft. Tanzer and Littler used an abdominal flap to line both sides of the cleft. Dunlop (1923) described a case in which a tubed pedicle flap was used to close this secondary defect. Most of these procedures were undertaken in three stages. One of the main disadvantages of this method when a normal finger is used is the unsightly appearance of the pollicised finger, which is much too long for a thumb and has three interphalangeal joints instead of two. To overcome the undue length, Cuthbert shortened the proximal and middle phalanges without interfering with joint and tendon function.

The next step was the transference of a digit of the same hand as an island flap, the transferred finger depending for its nourishment entirely on its digital vessels. Hilgenfeldt (1950) used the middle and Gosset (1949) the index finger. These methods still left a thumb which was too long, and Gosset advised shortening it by removing part of the distal segment.

Littler (1953) described important modifications of the method. The index finger is moved on its neurovascular bundles, the two digital arteries providing the only blood supply. This gives an excellent arterial circulation and the venae comitantes provide an adequate venous drainage. Isolation of the digit gives it a wide range of freedom and enables it to be placed readily in its new site. Littler recommended shortening of the digit by removing all or part of the metacarpal. This recession of the digit to its required length facilitates closure of the defect, which is achieved without the addition of skin from elsewhere. This method may be used for patients in groups 3 and 4 and is the method of choice. It is also indicated in group 2.
Case 3—Condition two months after one-stage pollicisation of the stump of the index finger. The local flap established the new web but was inadequate to complete the closure of the sides of the cleft between the thumb and middle finger, for which split skin grafts were used. Note the fixation of the transposed metacarpal by a Kirschner wire. The patient has a thumb of adequate length, opposable and with its end covered with skin of normal sensibility.
Technique of pollicisation of index finger. Figure 16—
The skin flaps marked. Figure 17—The web flap
reflected.

Exposure of digital vessels between the index and
middle fingers. Note the transverse intermetacarpal
ligament.
Fig. 19
Technique of pollicisation of index finger (continued). Figure 19—Division of the second metacarpal close to its base. Figure 20—After removal of the distal segment of its metacarpal the index finger is attached only by its neurovascular bundles and by its tendons.

Fig. 21
Closure of skin at the base of the transposed index finger.
Case 4—Pollicisation for congenital absence of thumb. Initial photograph showing the condition before operation, with the skin flaps marked.

FIG. 22

Case 4—Radiograph after pollicisation, showing fixation by two Kirschner wires. One fixes the transposed proximal phalanx to the base of its metacarpal; the other holds the new thumb in the required position.

FIG. 23

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FIG. 24
Case 4—The early result, showing good position of the new thumb.

FIG. 25
Case 4—The final result.
Case 5—Pollicisation for congenital absence of thumb in a boy of ten. Condition before operation.

Case 5—Result after one-stage pollicisation of index finger.
cases in which partial loss of the thumb is accompanied by partial loss of the index finger. By combining two functionally deficient elements a useful thumb of good appearance is produced (Figs. 11 to 15).

**Technique**—(Group 4 cases) (Figs. 16 to 21)—The flaps are outlined (Fig. 16) and reflected (Fig. 17). The one structure that will prevent full mobilisation of the index finger, namely the digital artery to the radial side of the middle finger (Fig. 18), must be divided and ligated. The digital nerves to the adjacent sides of the cleft between index and middle finger are separated from one another proximally into the palm. The second and third metacarpals may now be separated, the transverse ligaments and the interossei being divided. The second metacarpal is divided close to its base (Fig. 19) and the ray is shortened by removing the distal segment of the metacarpal. The extensor and flexor tendons are left undisturbed. Finally, the base of the proximal phalanx is removed, or—if a growing epiphysis is present—simply denuded of its articular cartilage. The isolated digit (Fig. 20) is transposed and fixed to the base of the second metacarpal or to some element of the carpus by one or preferably two Kirschner wires, with care that the new thumb is in the best position of abduction and opposition. The skin is closed by transposing the web flap into the defect caused by the shifting of the index finger (Figs. 21 and 22).

Techniques in cases of congenital absence of the thumb are shown in Figures 22 to 27. In the first case (Figs. 22 to 25) exploration was undertaken five months after pollicisation because of defective function of the new thumb. The flexor tendon was found to have taken up the slack but to be adherent. Simple tenolysis gave satisfactory flexor action. The extensor tendon was shortened at the wrist. The patient now has good function, lacking only a small degree of active extension (Fig. 25).

In the second case (Figs. 26 and 27) active interphalangeal flexion was present at the first dressing two weeks after operation. At six weeks this was practically full and active extension was developing. Three months after operation the patient had virtually full flexion and extension. Bony union at the base of the thumb failed, but the consequent false carpometacarpal joint proved an advantage. The Kirschner wire was removed at six months. A year after operation the boy had developed a good range of movement at the new carpometacarpal joint. Both long flexor and long extensor actions were almost normal. He was able to flex the pulp of the thumb powerfully against all the fingers in turn (Fig. 27).

In pollicisation for group 3 cases the first dorsal interosseous muscle may be detached from its distal insertion or left intact, the pollicised digit being passed dorsal to it. This tends to make the thenar region bulky and skin closure difficult. The transposed finger is united to the first metacarpal by an intramedullary bone graft. The tendons of the transposed digit may later be sutured to existing tendons of the thumb at the wrist.

**RECONSTRUCTION BY BONE GRAFT AND TUBED FLAP**

Elongation of a thumb by means of a bone graft in a skin envelope has long been one of the standard methods of reconstruction. The tubed pedicle is usually fashioned from the abdominal wall, or preferably from the acromio-pectoral region because its skin has a better texture and less subcutaneous tissue. The circumference of a normal thumb is in the region of three inches and the flap should therefore be about three and a half inches wide. This method usually necessitates four procedures—one for raising the tube, a second for attaching it to the thumb, a third freeing the tube from the chest, and a final one, after a suitable interval, for the insertion of the bone graft. Many variations have been introduced from time to time. For example, the bone has been transplanted as a preliminary step under the abdominal wall so as to be carried to the thumb with the pedicle. Albee (1919) carried a piece of clavicle with the pedicle. These methods offer no advantage; they merely complicate the procedure unduly, increase the difficulties of attaching the bone to the recipient site, and
encourage loss or absorption of the bone graft from inadequate blood supply, lack of bony contact and sepsis.

**Technique**—In the case shown in Figures 28 to 31 this method was used to reconstruct a thumb at the time of injury. A flap $3\frac{1}{2}$ inches by $3\frac{1}{2}$ inches was raised on the chest wall, tubed and attached to the thumb stump within a few hours of the accident (Fig. 29). Three weeks later the tube was detached from the chest wall and the blind end closed. Three months later the seam of the pedicle was reopened, and a graft of cortical and cancellous bone from the ulna was inserted, being wired to the remains of the proximal phalanx (Fig. 30). Sound union occurred, and three months later the patient went back to his employment as a carpenter. At one year sensation was present throughout the thumb though it was of defective quality. There were no trophic changes, and both appearance and function were satisfactory (Fig. 31).
Fig. 31
Case 6—The final result.
Thumbs reconstructed by means of tubed pedicle skin are initially anaesthetic. They do, however, regain a certain amount of sensation to light touch and pinprick within six months to a year. but the important property of stereognosis is never regained. The circulation is poor and the skin is liable to trophic disturbance leading to ulceration or repeated breakdown. This instability of the skin is a considerable disadvantage.

These thumbs can be useful, however, because, even if acting only as a fixed opposition post, they add appreciably to the function of the hand as a whole. This method of thumb reconstruction does have considerable limitations, notably the defect of sensation and liability to trophic changes. With the advances of technique in pollicisation, the indications for reconstructing a thumb by means of bone graft and tubed pedicle are few. It still, however, has a place in the reconstruction of the severely mutilated hand when lack of local elements excludes other types of repair.

This is an appropriate place to mention the procedure of thumb autograft after traumatic amputation. Gillies (1940) suggested an operation for regrafting an amputated digit. Obviously a severed digit will not survive if sutured back in place. The principle of Gillies's operation is to remove the skin from the severed digit, reattach the digit by suturing flexor and extensor tendons, and bury the whole in a skin tube. A new blood supply is thus established. Successful cases of thumb autografting have been reported by Gordon (1944) and Wilflingseder (1953). The writer has also recorded two successful cases of autografting the ends of index fingers (Gillies and Reid 1955, Reid 1956) and has recently employed the principle in a case of thumb avulsion. A boy of sixteen sustained in a pit accident complete avulsion of the end of his right thumb (Fig. 32) at the interphalangeal joint, the end remaining attached only by the flexor pollicis longus tendon. The plane of avulsion was oblique from dorsal to palmar aspect, sparing the greater part of the pulp. There was total loss of the dorsal soft tissues. The distal phalanx was removed from the avulsed part and reattached, as a free graft, to the proximal phalanx by a Kirschner wire (Fig. 33). The entire defect was then covered by a direct skin flap from the chest wall (Fig. 34). This flap was divided three weeks later. The patient has regained excellent function and has returned to normal work in the mine. The tactile part of his thumb is covered by normal skin, and sensation is not affected. Sound fusion between the terminal and proximal phalanges has given complete stability (Fig. 35).

In a total thumb autograft, a skin tube from the opposite forearm provides skin of more satisfactory texture than that of the abdomen or chest wall. An effort should be made to suture the digital nerves at the time to ensure some return of tactile sensation.

TOE TRANSPLANTS

The transference of a toe to replace a thumb has been practised from time to time for the past fifty years. Nicoladoni described a successful case in 1900, and several more have been reported since. Clarkson (1955) has described his experience of transferring
Case 7. Figure 33—The terminal phalanx used as a free graft and fixed to the proximal phalanx by a Kirschner wire. Figure 34—The entire defect covered by a chest flap.

Case 7—The final result.
fifteen digits in six patients, losing only half a digit in one three-digit transfer. He considers that dorsal flap transfer of a toe is safe and that the new digit can develop useful function. It is the only one of the four methods of reconstruction which can add to the hand a digit capable of movement and having a growing nail. The transfer necessitates a considerable programme of staged procedures and is certainly not to be embarked upon lightly. It does

Case 8. Figure 36—Right hand showing gross congenital abnormality. Figure 37—Radiograph of right hand.

Case 8. Figure 38—Right foot showing "lobster claw" deformity. The skin flap is marked. Figure 39—Radiograph of right foot.
not provide normal sensory innervation; crude sensation will return but stereognosis is absent. Toe transfer is probably justified only in the exceptional case without an adequate alternative. The case described here seemed ideally suitable for using an unwanted toe to provide a badly needed thumb. A child had gross congenital abnormalities of both hands and both feet. The hands had the little fingers only and nothing against which these fingers could oppose (Figs. 36 and 37). The feet showed the lobster claw type of deformity, severe enough to cause considerable disability (Figs. 38 and 39), and to prevent the fitting of shoes. It was felt that although abnormal joints and lack of tendons made a movable new thumb unlikely, a stable

Case 8. Figure 40—First stage of the transfer. The dorsal flap on the foot is being delayed. Figure 41—Second stage of the repair. The hand and foot are now joined by means of the dorsal foot flap.

Case 8—Condition after transfer of toe. The hand is posed to show the effective pinch aimed at in the final reconstruction.
post against which the little finger could oppose would greatly enhance the function of the hand. 

Technique—The method of dorsal flap transfer perfected by Clarkson was used. The dorsal flap, being distally based, must first be delayed. The flap was outlined (Fig. 38) and completely undermined leaving a proximal bridge of intact skin (Fig. 40). It was then resutured. Fourteen days later the flap was raised completely and attached to the hand in a prepared defect. A split skin graft was applied to the consequent raw surface of the foot (Fig. 41). The hand and foot were maintained in apposition by surrounding adhesive elastic strapping from shoulder to heel, beneath the foot and back to the shoulder again. The circulation from the foot was progressively reduced by dividing each digital vessel at an interval of two weeks. The final division of toe from foot was performed through the metatarso-phalangeal joint six weeks after the initial attachment. Figures 42 and 43 show the toe after transplantation and the pincer action that may be achieved by placing the new thumb in the most suitable position. The transplanted toe has now been fused to the radial side of the hand by a bone graft to provide the required stability. The final reconstruction has not yet been completed.

SUMMARY

1. Absence of a thumb, whether congenital or due to injury, is a severe disability. Reconstructive surgery has much to offer.
2. Pollicisation is the most satisfactory method, being the only means of providing a thumb with normal tactile sensibility. The importance of this has often been overlooked and has been emphasised by Moberg (1958). Pollicisation offers also the best functional and aesthetic results. When applicable, the neurovascular pedicle technique of Littler is the one of choice. It is indicated in group 2 cases associated with a partly amputated finger, when this is swung on to the thumb stump, and for patients in groups 3 and 4 when the normal index finger is used. If this method is not feasible a staged pollicisation may be used instead.
3. The Gillies method of thumb lengthening has a more limited application, but it is valuable in selected cases.
4. Reconstruction by tubed pedicle and bone graft is seldom indicated and is best reserved for reconstruction in the mutilated hand when local elements are deficient.
5. Replacing a thumb by a toe should be reserved for exceptional cases.
6. Autografting the amputated thumb is feasible, and should be considered when the amputated digit has been preserved.

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