A re-look at pollicization

Bhaskaranand Kumar, Ashwath Acharya, Anil K. Bhat
Department of Orthopaedics, Kasturba Medical College, Manipal, Karnataka, India

Address for correspondence: Dr. Anil K. Bhat, Department of Orthopaedics, Kasturba Medical College, Manipal – 576 104, Udupi District, Karnataka, India. E-mail: anilkbhat@yahoo.com

ABSTRACT

One of the most difficult and intricate surgeries in the field of hand surgery is that of Pollicization. It involves transfer of one of the fingers to create a new functioning thumb when it is absent. This elegant surgical technique has evolved over the 100 years from a simple, though unaesthetic transposition of digits to a complex procedure which demands an intelligent use of skin flaps, osteotomy and muscle balancing to create an almost normal looking aesthetic thumb. We present a review of this procedure briefly touching on its historical development, indications, and refinements in the critical steps of the technique, long term results and complications. Pollicization continues to be one of the most useful surgeries in improving the function of the hand and has stood the test of time.

KEY WORDS

Amputation; digital transposition; hypoplastic thumb; index finger; pollicization; toe transfer

INTRODUCTION

On the length, strength, free lateral motion and perfect mobility of the thumb, depends the power of the 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.

Sir Charles Bell

The Hand – Its Mechanisms and Vital Endowments as Evincing Design, Fourth Bridgewater treatise, 1833[1]

This statement, which was made 178 years ago, demonstrates the importance of the thumb which has been a defining trait separating man from the animals. Without the opposable thumb, which is an evolutionary marvel, it would have been impossible to achieve the highly civilised, sophisticated and technological lifestyles that we enjoy today.

The vast amount of literature that is available describing the reconstruction of the thumb in the last 100 years clearly shows the difficulty in achieving the functions of the normal thumb in dexterity, strength and adaptability. Perhaps one of the most rewarding surgeries in the reconstruction of hand in the last century has been that of pollicization. The monumental works of Buck-Gramcko, Littler, Bunnell and others in the development and subsequent refinements of this procedure has enormously helped in achieving currently an excellent result in the length, motion and stability of transferred digit.

HISTORICAL ASPECTS

A number of articles have been published describing the
history of thumb reconstruction by pollicization, of which the one by Littler remains a classic.\(^2\) The earliest case of pedicled transfer of digits to create the thumb was described by Guermonprez in 1885 when he transferred the middle finger to reconstruct the thumb.\(^2\) Hilgenfeldt described his method of middle finger pollicization in 1943 which was a digital transposition based on palmar skin-neurovascular pedicle.\(^3\) Subsequently, after the Second World War, Gosset (1949) in France described for the first time his method of transferring index finger islanded on a neurovascular pedicle.\(^2,3\) Later, further modifications were introduced to transfer any one of the intact digits and also mutilated digits.\(^2\) Buck-Gramcko, based on his vast experience of operations in over 400 cases, published his landmark work in 1971 and subsequently in the next two decades, popularising the index finger for pollicization.\(^2-4\) Very little has changed in the technique of this procedure since then, and his recommendations and results continue to be followed worldwide today.

**INDICATIONS**

**Where to use?**
This procedure has been done across all age groups for loss of thumb function due to congenital hand differences and post-traumatic amputations [Table 1].

**Which digit to use?**
Index finger pollicization continues to be the most commonly used digit and remains the choice for thumb reconstruction in congenital differences of thumb when indicated.\(^3,4\) As late as 1989, Michon argued for transferring the intact ring finger instead of the index finger in post-traumatic thumb amputations.\(^9\) According to him and Gosset, the rotation arch maintains the correct tension on the flexor tendons and the pollicised digit achieves a greater strength, better cosmesis as the palm width is maintained, a lesser requirement of opposition movement with middle finger and the presence of a cleft which can be aesthetically improved in a secondary procedure.\(^9,10\) The use of middle and little finger has been also described but has not become popular in view of obvious disadvantages. The disadvantage of transferring any one of these three digits lies in loss of independent action of the digit which acts along with the profundus tendon of other digits. Tendon transfer will be needed to achieve autonomy.\(^1,9,10\) Besides, the dorsal veins have to be severed for transfer, necessitating a need for microanastomosis at the recipient site in case of venous congestion.\(^9\) Currently, the only area where an intact index finger is avoided for pollicization is in mutilating hand injuries where the amputation stump of the partially mutilated digit is used as a spare part.\(^11,12\) This improves not only the function, but also aesthetic appearance of the hand [Figure 1a–g].

**When to use?**
Buck-Gramcko believed that the first year of life is the best age for pollicization in congenital differences of the hand, based on two reasons. The first reason is that from the age of about 6 months onwards, the so-called thumb feeling is supposed to develop, and therefore the new thumb will be felt as being a normal one. The second reason 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.\(^8\) Manske et al., in their study of 28 cases of pollicization, have shown this concept to be flawed. In their view, the index finger is represented in the cerebral cortex as the radial post in the absence of the thumb and this develops by 9–12 months of age. Since pollicization is simply the repositioning of the radial post, the age at which this procedure is performed should not be critical from the functional point of view. They did not find any relationship between the usage of the pollicised digit and age at the time of operation. They still do advise to perform this procedure early in life for social reasons.\(^13\) In the post-traumatic

[Table 1: Indications for pollicization](#)
amputations, with the development of many other microsurgical techniques, the indications for pollicization of the intact digit have considerably decreased, even though pollicization of damaged digit remains a viable and useful option.\(^1\) The timing of this complex surgery either as an emergency or as an elective procedure has its advantages and disadvantages. In certain situations, Raja Sabapathy et al. have pointed out the indications of an emergency procedure. The first situation is where in addition to the thumb amputation, the neighbouring index finger is injured beyond reconstruction and the remaining stump is of inadequate size to be of any functional benefit.\(^2\) As Michon points out, in such situations, the aim is to maximise the function of the whole hand rather than the thumb alone.\(^9\) The second situation is where the amputation of the thumb occurs through the carpometacarpal joint with an intact index finger: Pollicization is the only reasonable surgical treatment in this instance.\(^4\)

Another situation would be that of a devascularised finger. Here, the risk of vascular repair after transposing the digit is worthwhile in view of the difficulties in doing a secondary transfer.\(^1\) The main advantages are: 1) it reduces the total rehabilitatory period, swiftly restoring the function of thumb, 2) dissection is made easier, especially those of vessels in the absence of scar tissue, and 3) is more cost-effective.\(^4\) Elective procedure
becomes necessary in the presence of palmar wounds, severe crush injuries, and massive contamination in view of risks of infection.\cite{12,14}

**TECHNICAL ASPECTS**

Buck-Gramcko’s recommendation for pollicization in congenital thumb defects, with a few modifications, continues to be the most commonly followed technique today.\cite{6,13} This technique is based on the refinements brought by Riordan, Zancolli, Littler, Malek, and others.\cite{2}

In post-traumatic cases, certain prerequisites are needed to ensure the success when transferring damaged digits. The carpometacarpal joint and the thenar muscles must be preserved and the first web space must be either intact or capable of being reconstructed by means of a flap. The segment that is being considered for pollicization must be long enough to allow opposition with the remaining fingers after the transfer. The digit that is to be transposed must have good distal sensibility. At least one artery must be intact and the neighbouring fingers must retain at least one feeding artery after the transfer.\cite{11,12}

**PRINCIPLES**

There are four basic principles to be followed while performing pollicization. Each one is of equal importance. They are:

a. Skin incision;
b. Neurovascular pedicle;
c. Skeletal readjustment with preservation of the metacarpophalangeal (MP) joint; and
d. Muscular stabilisation.\cite{8}

**Skin incision**

This is an important technical consideration since subsequent skin closure will give the pollicised digit the appearance of a thumb, rather than a finger in the position of the thumb.\cite{15} Buck-Gramcko introduced his method of incision, considering the increase in the volume around the proximal phalanx by muscle and tendon transfers in the vicinity of proximal interphalangeal joint of the transferred digit\cite{8} [Figure 2a, b]. Other modifications improving the appearance of the thumb have also been seen in the recent literature.\cite{6,16} In cases of floating thumb, the affected digit has been found to be a useful source of a cutaneous flap and also as a vascularised adipofascial flap for augmentation of the thenar eminence.\cite{16,17} In post-traumatic situations, the whole palmar approach of Foucher renders the procedure less demanding and helps to avoid a conspicuous dorsal scar. It also allows an easier access for oblique osteotomy of the metacarpal, which, according to Foucher, prevents the risk of a dorsal bump.\cite{11,12}

**Neurovascular pedicle**

At least one artery must be present for the transfer which usually is based on palmar common digital artery.\cite{8,18} But successful transfer has been done based on the first and even the second dorsal metacarpal arteries.\cite{10,11,19} The neurovascular bundle between the index and the long fingers is dissected and the artery to the radial side of the long finger ligated [Figure 2c]. The common digital nerve is then carefully separated into its component parts for the two adjacent fingers. Sometimes, an anomalous neural ring is found around the artery, which can be split carefully to prevent its angulation after transposition of the finger.\cite{8}

On the dorsal side, at least one of the great veins must be preserved to prevent the risk of oedema and venous congestion.\cite{8} When a digit other than the index finger is used, the technique is identical. However, it is not possible to preserve the continuity of a dorsal vein. The palmar bundle, dissected en bloc with the surrounding fat, contains some veins; but in the event of earlier trauma to the palmar tissues, it is better to prepare two dorsal veins for microanastomosis.\cite{11,12}

**Skeletal readjustment**

In pollicization of the index finger, the second metacarpal is removed with the exception of its head and base which acts as the new trapezium. Its epiphysis at the neck must be resected to prevent growth and lengthening [Figure 2f]. The index finger has to be initially rotated by about 160° during the operation, facing the pulp of the ring finger. This position changes to about 120° during the suturing of the muscles and the skin [Figure 2i]. In addition, an angulation of about 40° of palmar abduction is also obtained. To avoid hyperextension deformity at the new carpometacarpal joint, the metacarpal head is turned palmarwards by about 70°–80° so that proximal phalanx is brought into a position of hyperextension in relation to the metacarpal head\cite{8} [Figure 2g].

**Muscular stabilisation**

The two extensor tendons of index finger, the extensor
digitorum communis (EDC) and extensor indicis (EI) are divided at the MP joint level [Figure 2f]. On the distal side, dorsal digital expansion is split into three slips based on the central extensor and the two lateral bands, till the level of proximal interphalangeal joint [Figure 2d]. The two interosseus muscles of the index finger are divided at the base of proximal phalanx and lateral bands and their origins from the metacarpal bone stripped\[8\] [Figure 2e].

The proximal end of EDC is sutured, after the metacarpal resection, to the base of the new first metacarpal, to become the new abductor pollicis longus. The EI tendon is shortened and then resutured with the split central slip of dorsal digital expansion. This becomes the new extensor pollicis longus (EPL). If only one of the long extensors is present, priority is given for reconstruction of EPL.\[8\]

The ends of the interossei are respectively sutured close to the new MP joint using the two split slips of the dorsal digital expansion as a loop [Figure 2h]. The 1st dorsal interossei becomes the abductor pollicis brevis and the 1st palmar interossei becomes the adductor pollicis.\[8\]

The flexor tendons need not be shortened. They adapt subsequently to achieve optimum flexion. The A1 pulley must be divided\[8\] [Figure 2e].

\[Figure 2: Pollicization skin incision: (a) volar, (b) dorsal. (c) Palmar neurovascular dissection: Radial digital artery (yellow arrow) of the middle finger for ligation; (d) the dorsal digital expansion split into three slips distally; (e) the two interossei have been prepared (yellow arrows), A1 pulleys divided (green arrow); (f) metacarpal neck resected at epiphysis (green arrow), extensor has been divided at metacarpophalangeal (MP) joint and shortened; (g) Metacarpal neck (yellow arrow) fixed to its base in hyperextension after shaft resection; (h) first dorsal interossei sutured after passing the prepared radial slip of the dorsal expansion as a loop (yellow arrow); (i) position after skin closure\]
When other digits are used, intrinsic stabilisation is possible if the thenar muscles are at least partially intact. The superficialis tendon, E1 and abductor digiti minimi have all been used to augment opposition of the thumb. The profundus tendon has to be divided proximally to preserve the independent action of the thumb.

RESULTS OF POLLICIZATION

When compared to hypoplastic/absent thumb

In general, the results of pollicization have been universally good, as reported in the literature. There has been no evidence of altered sensibility of the pollicised digit, and all patients used the pollicised digit for activities. The quality of the results depended on the preoperative state of the hand. Most of the children use their new thumb, except those with radial club hand, who use the side-to-side grip of ring and long fingers for smaller objects. Best results were seen in isolated hypoplastic thumb (Figures 3a–e).

Sykes reported that before operation, all their 22 patients had difficulty picking up and handling small objects. Thirteen patients had developed a side-to-side “cigarette” pinch between the index and middle fingers or the ring and little fingers. After pollicization, they were able to handle smaller objects more accurately than with their previous “cigarette” grip. They could also grasp large objects between the thumb and the remaining fingers more effectively. Manske and MacCarroll observed that all their patients had difficulty in grasping large objects and had altered pattern of precision prehension. Postoperatively, they were able to grasp the objects which they could not before surgery. Preoperative status of precision prehension however persisted after surgery,
and change occurred only if the pollicised digit functioned more effectively than the previously established pattern.

According to Manske et al., the pollicised thumb was used as normal thumb or in a modified manner in 84% of 14 activities, in 92% of the 7 activities relating to handling large objects, and only in 77% of those involving smaller objects. They showed that there is a tendency to use the pollicised digit more extensively when the opposite thumb has limited function. Parental and patient satisfaction with cosmesis was found to be acceptable in all the studies.

When compared to normal thumb

The total active movement of a normal thumb is 185°, and after pollicization, 50% of this was achieved on an average. Movement is always better in the absence of associated conditions like radial club hand. Kozin observed manual dexterity to be 70% compared with standards of efficiency of age and sex. 55% of them used side-to-side pinch when stressed under time.

In the study of Manske et al., the average grip strength was 21% and the pinch strength ranged from 22 to 26% of the standard for age and sex. Times to complete tasks were found to be 22% longer with these digits.

Aliu et al., in a small study group, found that children who have undergone index finger pollicization have changes in function comparable to normal development. They found a steady improvement in strength and functional dexterity and in activities of daily living as determined by the Jebsen Hand Function Tests in seven hands. The percentage improvements in strength and dexterity were neither greater nor lesser than the anticipated rate of improvement, which could be explained by progressive expected age-appropriate development.

Clark in their study of pollicization into adult life with 27-year follow-up has shown that in all the patients reviewed, except one, there were few functional limitations in general use of the hand. In patients with isolated congenital absence of the thumb, the procedure gives a good functional and cosmetic result, the benefits of which are maintained in adult life. In those with radial club hand, the results are less reliable.

Goldfarb et al. studied the objective features and subjective aesthetic outcome of pollicised digits compared with normal thumbs. Subjectively, none of the 31 thumbs in their study were considered to have the appearance of a normal thumb based on Visual Analogue Score assessments of the surgeon, therapist, and patient caregivers. Pollicised digits were longer and had reduced girth and nail width compared with age-matched normal thumbs. The most significant abnormal features were decreased girth, excess length and angulation.

In post-traumatic cases, Foucher published a large series compromising transfers of a severely damaged digit to reconstruct an amputated thumb. Activities of daily living were classified as good in 37%, fair in 41% and poor in 22%. Motion was found good only in 41% based on Kapandji scores. Cortical orientation was complete in only 37% of cases. Grip and pinch strength were 78 and 75% each (when compared to opposite digit) in the absence of a single digit, which decreased when more digits were involved. Absence of the nail is frequent and this leads to a poor cosmetic result. There is also a bulky appearance of the thumb, especially with incorporation of the MP joint.

Figure 4: (a) Acrosyndactyly of the radial four digits with loss of thumb at MP joint and ring finger at PIP joint. Both index and middle fingers have middle phalanges; (b) after pollicization of ring finger, (c) the child can now hold a small and (d) grasp a large object
When compared to toe transfers
Generally, the indications for pollicization and toe transfers are applicable for different sets of patients, but there is a select group where both of them may be a viable option [Figure 4a–d]. This is seen when some element of thenar muscles and 1st Carpo metacarpal (CMC) joint is preserved. The benefits of pollicization are seen in cases of a single damaged digit along with the presence of thumb amputation at metacarpal level.[14] This may be observed also in symbrachydactyly and acrosyndactyly. This benefit may not stand in the presence of multiple digit amputation where toe transfers are a better option, especially in young patients.[9,11,12]

Luchetti et al. evaluated the results in 73 cases of thumb reconstruction for isolated amputation distal to the distal third of metacarpal in manual labourers.[27] But for the reasons of cosmesis and growth potential, there were no fixed criteria for selection for any one technique, which was either pollicization or vascularised toe transfers or conventional procedure. According to them, pollicization scores over toe transfers in achieving a far superior sensibility due to the presence of an intact pulp. The outcome of microsurgical techniques is generally better, both globally and for individual scores. This includes length, motor function, grip strength, manual dexterity tests, cosmesis and growth potential. Considering the small number in their series, strong statistical correlations were not demonstrated and were only “indicative of general trends.”[27]

COMPLICATIONS
Immediate/early
Arterial inflow compromise has been found to be low in the literature.[8,19,28,29] Buck-Gramcko’s report in 1971 noted that only one thumb was lost as a consequence of compromised inflow.[8] He described vascular compromise of 12 cases in 460 pollicizations for congenital thumb hypoplasia. He attributed it to careless dissection and anomalous vascular anatomy.[4] Chafik et al. reported a vascular anomaly, where they found a short metacarpal artery arising from the deep palmar arch, with absence of an index-long web common digital artery arising from the superficial palmar arch. Postoperatively, the viability of the pollicised index finger was compromised, requiring postoperative warming, releasing skin incisions, leech therapy, and anticoagulation.[28] In their series of 73 cases, Goldfarb et al. noted that the most common

Figure 5: Stiffness of pollicised digit is a common problem in radial dysplasia

Figure 6: (a) Excessive length of the pollicised digit due to (b) persistent growth of the index metacarpal
perioperative complication was venous congestion, which occurred in 3 cases. They recommended careful assessment of the colour of the digit at the conclusion of the case before dressing placement and, subsequently, over 48–72 hours. If concerns are noted, the patient should be promptly returned to the operating room for exploration. To prevent this problem, Buck-Gramcko advised preservation of at least one of the great veins on the dorsal side.

Marginal necrosis is another common problem in this procedure. The dorsal proximal skin is in an area of extensive surgical dissection that likely contributes to the necrosis. In that area, the proximal dorsal skin flap is often sutured under tension to facilitate the proper degree of digital rotation. It can usually be treated by regular dressing, and/or by skin grafting.

Late
First web space contracture, stiffness, lack of opposition and extension, excessive length, and malrotation have been reported to be some of the late complications. Sykes observed that 36% of their patients underwent another surgery to achieve satisfactory results which included scar revision, opponensplasty and excision of bony spikes. Manske reported the need for tenolysis, arthrodesis, and rotational osteotomies.

Scar contracture usually can be managed with z-pasties. Stiffness has been usually attributed to poor pre-operative function in cases of radial dysplasia [Figure 5]. In these cases, they act as posts for holding larger objects. Scarring due to past infections and haematoma may respond to tenoadhesiolysis.

Failure to ablate the index metacarpal epiphysis is a common cause of excessive thumb length. Persistent growth of the metacarpal will elongates the thumb over time [Figures 6a, b]. Epiphysiodesis of the metacarpal growth plate and shortening of bone are used to correct excessive thumb length. Rotational errors can be corrected by metacarpal osteotomies.

Lack of opposition is a problem to be expected in radial dysplasia for which secondary opponensplasties will be needed. Foucher has advocated transferring the EI, if present, through the 1st dorsal compartment to maximise abduction. Extensor deficit at the MP joint is a frequent problem and can be prevented if primary shortening of the extensors is done in pollicization. Subsequent MP joint flexor stiffness has been successfully addressed with extensor tendon imbrication and Metacarpo phalangeal (MCP) joint arthrodesis.

CONCLUSIONS
The current technique of pollicization represents an amalgamation of ideas based on the contributions from surgeons over the last 100 years. It is a complex and difficult procedure needing experienced hands and strict attention to detail. Optimal end results that last a lifetime can be achieved in almost all types of injuries and anomalies.

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