Traitement conservateur des hypoplasies sévères du pouce

Toe Phalanx Transfer for Blauth Types III B-C and IV Thumb Hypoplasia

Alain Gilbert [1,3], Bran Sivakumar MD [2,3]

1- Centro Medico Teknon - Trauma Unit - Carrer de Vilana 12 08022 Barcelona, Espagna.
2- Great Ormond Street Hospital for Children - Consultant Pediatric Hand Plastic and Reconstructive Surgeon - Great Ormond Street Hospital London WC1A 3JH United Kingdom.
3- Institut de la Main - Clinique Bizet – 21, rue Georges Bizet 75016 Paris, France.

Résumé

Les hypoplasies sévères du pouce (stades III et IV de Blauth) sont habituellement traitées par une pollicisation. Cependant de nombreuses familles n'acceptent pas la main à quatre doigts qui en résulte. Pour ces cas des techniques de reconstruction variées ont été proposées. Les auteurs rapportent les résultats de l'utilisation de transferts de phalanges d'orteils chez 32 patients. Les résultats sont inférieurs à ceux des pollicisations mais les familles sont dans l'ensemble satisfaites.

Mots clés

♦ Malformations pouce
♦ Hypoplasia pouce
♦ Transfert phalange

Abstract

Thumb hypoplasias have been classified by Blauth and Buck-Gramcko. The most severe grades III and IV are best treated with pollicization. However, some families refuse the resulting four-fingers hand. For these cases, have been developed some alternative techniques. The authors have used, in 32 cases, non-vascularized toe phalanges. The results show that the results are acceptable but usually inferior to pollicization. However, the families are mostly satisfied by the results.

Keywords

♦ Thumb anomalies
♦ Thumb hypoplasia
♦ Plalanx transfer

Correspondance

Professeur Alain Gilbert
Institut de la Main - Clinique Bizet – 21, rue Georges Bizet 75016 Paris, France.
E-mail : agilbert@wanadoo.fr – Tel : 06 62 85 42 00

Introduction

Thumb hypoplasia can be categorized into five overall grades which can help guide management (1-3). Type I thumbs are small with mild anatomical hypoplasia and typically require no treatment. Type II thumbs comprise a tight first web space, instability of the metacarpophalangeal joint and hypoplasia of the thenar musculature. Type III thumbs show all the characteristics of those seen in type II with additional skeletal hypoplasia and some deficiency of intrinsic and extrinsic musculature. These thumbs are further subclassified into types III-A, which possess a stable carpometacarpal (CMC) joint, and III-B, where the CMC joint is unstable (4). A more detailed and still clinically relevant classification was described by Buck-Gramcko (1981) which divides type III into three stages of worsening metacarpal hypoplasia – IIIA up to proximal one third of metacarpal missing, IIIB up to proximal two thirds absent and IIIC less than one third of distal metacarpal present.

The 'pouce flottant' or type IV thumb is small with rudimentary skeletal elements and type V represents complete aplasia of the thumb and radial carpus. It is generally well accepted that grades II to IIIA respond predictably to surgical reconstruction and grades IIIB-C, and IV are best ablated and substituted through pollicization of the index finger (5-7). Despite the advantages of a pollicization in grade IIIB-C and IV thumbs, some cultural or parental beliefs may preclude ablation of the deficient thumb and demand alternative forms of reconstruction to preserve total digit number. This has become more and more common in Asia and the Arab world, although there is no strict religious necessity.

Ideally, reconstruction must ensure a stable osteo-articular column with some mobility at least two of the three joints (carpo-metacarpal (CMC), metacarpo-phalangeal (MCP) and interphalangeal (IP)), a well lined sufficiently deep and wide first web space, adequate motors for strong IP or MCP joint flexion, extension and capacity for thumb opposition (7). Staged reconstructive approaches utilized in the context of type IIIB and IV thumbs have included the use of both vascularized and non-vascularized tissue transfers.

Vascularized metatarsophalangeal or interphalangeal joint transfers enable soft tissue augmentation of the first web space and stabilization of a hypoplastic metacarpal through reconstruction of a CMC joint (8,9). Despite the potential for growth and functionality of these transfers, results from short series have shown limitation in motion and long-term problems of

donor site morbidity (10,11). In addition, the demands, complexity and risks of microsurgical free tissue transfer in the pediatric setting should not be underestimated.

Non-vascularized free phalangeal transfers have been used extensively in the setting of digital reconstruction (12-14). In the context of thumb hypoplasia, when pollicisation is not an option because of parent's refusal, we believe phalangeal transfer offers a simple and effective method of salvaging a severely deficient thumb by increasing functional length and stability. We present a technique of reconstruction of type IIIB-C and IV hypoplastic thumbs using free non-vascularized phalangeal transfers and an abductor digiti minimi opponens plasty.

Technique

If the overall length of the thumb is insufficient soft tissue distraction, using an Orthofix Minifixator, may be rarely (1/32 cases) considered before a non-vascularized phalangeal transfer can be planned (Fig 1, 2)

Stage 1: Free Phalangeal Transfer

Recipient site preparation

After exsanguination and under tourniquet control exploration of the thumb is carried out. An incision along the dorsal aspect of the thumb allows exposure of the base of the existing hypoplastic metacarpal. The quality of existing extrinsic and intrinsic muscle/tendon elements is assessed. Care is taken to visualize and protect the neurovascular bundle to the thumb. The stump of the metatarsal is freshened by shaving the bone. The cartilaginous structures of the radial carpus are then exposed. The number and length of toe phalangeal transfers required to stabilize the thumb osteo-articular column can then be calculated.

Free non-vascularized phalangeal harvest

Generally, either one or two phalanges are sufficient for a single thumb reconstruction. The non-dominant leg is used and incisions are planned over the third and fourth toes depending on the size of the recipient thumb base skeletal defect at the base of the thumb. Following tourniquet inflation, a midline longitudinal incision is made on the dorsum of the toe from the proximal interphalangeal (PIP) joint to the neck of the metatarsal. The extensor tendon is retracted laterally and the entire proximal phalanx and metatarso-phalangeal joint is exposed taking care not to damage periosteum. The toe PIP joint is then disarticulated and the flexor sheath is dissected to allow elevation of the proximal phalanx. The donor site flexor and extensor tendons are sutured together using a mattress suture to stabilize the remaining phalanx and after hemostasis, the skin is closed using a 4/0 resorbable suture. A padded dressing is then applied. No post-operative splintage is required.

In shorter defects, it is possible to manage with only harvest of a second toe phalanx which has the benefit of mitigating the degree of long-term shortening of the toe.

Phalangeal stabilization of the thumb

The articular cartilage at the distal end of the transferred phalanx if removed through careful sharp dissection. The harvested toe phalanx is then engaged on a central longitudinal 0.8mm Kirschner wire. The phalanx is orientated distally within the recipient soft tissue pocket of the thumb. The wire is then driven from proximal to distal through to the tip of the thumb. The proximal end of the phalanx is then carefully positioned onto the side of second metacarpal base or radial aspect of the exposed carpus to ensure optimal orientation of the thumb in palmar abduction and extension. The K-wire is then driven proximally to maintain this position and then trimmed externally to facilitate removal in the outpatient setting (Fig 8,9). After hemostasis, skin closure is carried out using a 4/0 resorbable suture. A bulky bandage is applied including a splint to immobilize the thumb from the MCP joint to the wrist. K wire removal is carried out at 5 weeks. When the two phalanges are utilized, the articular cartilage between them is removed to create bony union.

In reconstruction of a Pouce Flottant, the skin pedicle is very narrow and needs to be augmented, using a local rotation flap.

Stage 2: First web reconstruction

The web is enlarged, using local flaps, as long as they do not jeopardize the vascularity of the reconstructed thumb (Fig 6).

Stage 3: Opposition Transfer

In order to address the deficiency of thumb palmar abduction, an opposition transfer is carried out. This can be done either in the same session or once a bony union is achieved to allow for a more accurate assessment of innate palmar abduction/opposition. An abductor digiti minimi transfer serves to improve both palmar abduction and the contour of the deficient thenar eminence (Huber, 1921). In addition, a skin paddle can be included as part of the transfer to further augment the soft tissue and skin deficit seen in type IIIB and IV hypoplastic thumbs (Littler and Cooley, 1963, Manske and McCarroll, 1978, Ogino et al., 1986), Oberlin and Gilbert (1984). A degree of associated first web space contracture can be corrected simultaneously through the use of a four-flap z-plasty technique (Fig 5)

Results

Between 2010 and 2019, 32 patients were treated for Grade IIIB-C or IV thumb hypoplasia with toe phalanx transfer. During the same period 17 families had chosen pollicization.

8 Grade IIIB had transfer of one proximal toe phalanx.

16 Grades IIIC and 8 Grade IV had a double toe phalanx. No vascular compromise or complication occurred in the 8 treated cases of 'pouce flottant'.

Abductor Digiti Minimi was transferred in all cases, 28 during the bone procedure and 4 in a second stage.

Bone healing was achieved at an average of 5 weeks in most patients, however in cases of double phalangeal transfer, the healing was complete at 7 weeks. Radiological signs of complete healing took up to five months to be seen (Fig 2,10). Two cases developed secondary fractures which healed spontaneously with conservative management.

All cases recovered pinch with the index finger, seventeen incorporating the 4th finger and three the 5th finger (Fig 6,7).

All parents reported satisfaction with the final cosmetic result and in bilateral cases opted for a parallel procedure to be carried out on the affected contralateral side.

Discussion

Most surgeons agree that the most predictable and functional approach to types IIIB and IV thumbs is ablation and pollicization of the index finger. However, some parents and families will not accept the aesthetic and cultural implications of losing a digit particularly in the presence of a good-sized type IIIB thumb. In these cases, staged reconstruction is possible and can yield reasonable functional and aesthetic results.

Osseous stability of these thumbs can be reconstructed using both vascularized and non-vascularized skeletal transfers. Matsuzaki et al reported one of the earliest vascularized toe joint transfers for thumb hypoplasia. He described the reconstruction of a CMC joint of a type IIIB thumb with a vascularized MTP joint from a second toe (10). The transferred joint maintained long-term functionality and durability. Reported problems around the donor site remained significant as the whole 2nd ray was not removed due to the indication for reconstruction and not ablation of the thumb with index finger pollicization in the first place. Similar problems have been described by other proponents of the MTP joint transfer, despite attempts to stabilize the donor sites using interpositional bone grafts and the creation of cutaneous syndactylies (8,9). Transfer of the smaller proximal interphalangeal joints has also been suggested in an effort to reduce donor site morbidity (20). However, the condylar MTP joint is generally preferred as it is better able to replicate the saddle morphology of the thumb CMC joint than a hinge toe proximal phalangeal (9). Overall, despite their individual merits all vascularized joint transfers are relatively complex and technically demanding, particularly in the pediatric setting. Many surgeons defer this type of surgery until the child is older when the anatomy is larger and the patient more cooperative (7,9,10).

In the past non-vascularized options for the reconstruction of severe thumb hypoplasia have included the use of bridging cortico-cancellous iliac bone grafts and partial or total meta-tarsal transfers for length and stability (21,22). Tsujino et al described the transplantation of the distal two thirds of the fourth metatarsal in the staged reconstruction of two cases of type IV floating thumbs (21). Successful stabilization of the thumbs was seen with functional integration into pinching and grasping tasks. Epiphyseal patency was also noted up to 9 years post-operatively. Shortening of the 4th toe donor site was minimized through the use of an iliac bone graft including the apophysis. Vascularized and non-vascularized hemi-metatarsal transfers have been used by Chow et al (23,24) who concluded that non vascularized hemi metatarsal produced comparable satisfactory results reconstruction on the long term. Osteoplastic techniques using iliac grafts have yielded poor results because of unwanted fusion proximally with the carpus or second metacarpal due to cortical exposure (21) and bone resorption over time.

Tu (25) has published a technique inserting the remnant of Metacarpal into the second metacarpal. He obtains stability and healing but severe lack of mobility.

In contrast, the use of bone transfers with intact periosteum allows the creation of a neo CMC joint. This technique has the added advantage of reduced long-term bone resorption in the long-term and a degree of commensurate growth with the child. A non-vascularized phalangeal transfer offers a simple method of increasing the functional length and stability of hypoplastic thumbs with fewer donor site issues. Their use in the context of congenital digital hypoplasia was first described by Carroll and Green (13). Problems of mal-union and graft resorption have been significantly improved through the transfer of bone with intact periosteum (12). Goldberg and Watson showed continued physeal survival and commensurate growth of transferred phalanges harvested extra-periosteally (14). Subsequently a number of other authors have confirmed ongoing growth and increased strength and stability of digits reconstructed using this technique (12,26,27). The majority of these series focus on the use of phalangeal grafts as 'on-top plasties' to provide increased length in cases of symbrachydactyly and constriction ring syndrome. Reports of interposition bone grafts to stabilize cases of thumb hypoplasia are few in number. Case reports exist using metatarsal transfers whereas the use of phalangeal grafts for thumb hypoplasia has not been extensively documented. We believe phalangeal transfers are more versatile than metatarsal grafts and have less of a donor site impact.

Timing of surgery may also be an influential factor for longitudinal growth. Studies have demonstrated optimal results when the surgery is carried out under the age of four years and in particular between 18 and 48 months (12,27). Although growth may occur even in later transfers, it has been suggested that it is optimized through early transfer Our preference has been to carry out transfers between 14 and 16 months of age if possible. However, through examination of our series, thus far, no difference has been noted in terms of longitudinal growth but further long-term analysis and a larger series is required to fully elucidate transferred phalangeal growth potential.

The potential to harvest more than a proximal phalanx from a foot allows for a wide range of metacarpal deficit to be addressed. For example, in one of our cases it was possible to interpose a fused pair of toe phalanges into a floating thumb and through the preservation of periosteum and soft tissue proximally, create a pseudoarthrosis which functioned well as a CMC joint. By using phalanges from separate toes in this way the donor defect can be spread across separate rays in contrast to a single metatarsal transfer.

In some cases, soft tissue distraction was required prior to reconstruction to ensure the soft tissue envelope was sufficient to accommodate transferred phalangeal transfers. This was particularly necessary in type IV thumbs.

The need for donor site reconstruction following phalangeal transfer remains controversial. We adopted the method originally described by Buck-Gramcko of suturing toe flexor and extensor tendons together to minimize collapse of the donor osteoarticular column (12). In line with the findings of a large series reported by Gohla et al (27) we noted few donor site issues using this approach in the short-term (26,27). However, six of 32 of our patients did however go onto to develop a degree of ray shortening and toe instability over time. However no long-term functional issues relating to gait or footwear were reported. As expected, in terms of cosmesis harvest of single middle phalanges appeared to have very little impact aesthetic issues related to shortening despite tendon plication (28,29). With this in mind Bourke and Kay have shown better

maintenance of length and stability of donor toes using cylindrical iliac bone grafts capped with epiphyseal cartilage (29). When the middle phalanx is harvested there is no or little cosmetic consequence.

Stable thumb function including opposition is not possible in the absence of a well-lined pliable web space. This was achieved in all of our cases using Z-plasties. Hypoplasia of the thenar intrinsic leads to a weakness of thumb opposition, another defining feature of type III and IV hypoplasia that must be addressed. In each of our cases good palmar abduction was achieved through the use of an abductor digit minimi opposition transfer. In addition, the thenar contour was improved.

The staged salvage reconstruction of types IIIB and IV thumb hypoplasia using non-vascularized toe phalanges and an abductor digit minimi transfer offers a simple and safe method to achieve stabilization and good thumb function in cases when pollicization is precluded.

References

1. Blauth W. [The hypoplastic thumb]. Arch Orthop Unfallchir. 1967, 62: 225-46.
2. Buck-Gramcko D. Hypoplasia and aplasia of the thumb. In: Buck-Gramcko D, Nigst, H., Millesi, H. (Ed.) Hand Surgery. Sturrgart, Thieme, 1981.
3. Lister G. Reconstruction of the hypoplastic thumb. Clin Orthop Relat Res. 1985: 52-65.
4. Manske PR, McCarroll HR, Jr., James M. Type III-A hypoplastic thumb. J Hand Surg Am. 1995, 20: 246-53.
5. Manske PR, McCarroll HR, Jr. Reconstruction of the congenitally deficient thumb. Hand clinics. 1992, 8: 177-96.
6. Tay SC, Moran SL, Shin AY, Cooney WP, 3rd. The hypoplastic thumb. The Journal of the American Academy of Orthopaedic Surgeons. 2006, 14: 354-66.
7. Upton J. Hypoplastic or Absent Thumb. In: Mathes S. J. HVR (Ed.) Plastic Surgery. Philadelphia, Saunders Elsevier, 2006, Vol. VIII The Hand and Upper Limb: 323-67.
8. Foucher G, Medina J, Navarro R. Microsurgical reconstruction of the hypoplastic thumb, type IIIB. Journal of reconstructive microsurgery. 2001, 17: 9-15.
9. Shibata M, Yoshizu T, Seki T, Goto M, Saito H, Tajima T. Reconstruction of a congenital hypoplastic thumb with use of a free vascularized metatarsophalangeal joint. The Journal of bone and joint surgery. American volume. 1998, 80: 1469-76.
10. Matsuzaki H, Toishi S, Yoshizu T. A Blauth IIIB hypoplastic thumb reconstructed with a vascularised metatarso-phalangeal joint transfer: a case report with 28 years of follow up. Hand surgery: an international journal devoted to hand and upper limb surgery and related research : journal of the Asia-Pacific Federation of Societies for Surgery of the Hand. 2009, 14: 63-8.
11. Tajima T. Reconstruction of the floating thumb In: D B-G (Ed.) Congenital Malformations of the Hand and Forearm. London, Churchill Livingstone, 1998: 369-73.
12. Buck-Gramcko D. The role of nonvascularized toe phalanx transplantation. Hand clinics. 1990, 6: 643-59.
13. Carroll RE, Green DP. Reconstruction of the hypoplastic digits using toe phalanges. J of Bone and Joint Surg 1975;57A:727.
14. Goldberg NH, Watson HK. Composite toe (phalanx and epiphysis) transfers in the reconstruction of the aphalangic hand. The Journal of hand surgery. 1982;7: 454-9.
15. Huber E. Hilfsoperation Bei Medianuslahmanung. Deutsche Zeitschrift F. Chirurgie. 1921, 162: 271-75.
16. Littler JW, Cooley SG. Opposition of the Thumb and Its Restoration by Abductor Digiti Quinti Transfer. J Bone Joint Surg Am. 1963, 45: 1389-96.
17. Manske PR, McCarroll HR, Jr. Abductor digiti minimi opponensplasty in congenital radial dysplasia. J Hand Surg Am. 1978, 3: 552-9.
18. Ogino T, Minami A, Fukuda K. Abductor digiti minimi opponensplasty in hypoplastic thumb. Journal of hand surgery. 1986, 11: 372-7.
19. Oberlin C., Gilbert A. Transfer of the Abductor Digiti Minimi in Radial deformities of the hand in children. Ann. Chir. Main 1984, 3-3 215-20
20. Nishijima N, Matsumoto T, Yamamuro T. Two-stage reconstruction for the hypoplastic thumb. The Journal of hand surgery. 1995, 20: 415-9.
21. Tsujino A, Itoh Y, Hayashi K. Reconstruction of floating thumb by transplanting the fourth metatarsal. The Journal of bone and joint surgery. British volume. 1994, 76: 551-4.
22. Yamauchi Y, Fujimaki A, Yanagihara Y, Yoshizaki K.
23. Reconstruction of floating thumb: especially on the use of vascularised metatarsophalangeal joint grafting Seikei geka. 1979, 30: 1645-8.
24. Chow CS1, Ho PC, Tse WL, Hung LK. Reconstruction of hypoplastic thumb using hemi-longitudinal metatarsal transfer. J Reconstr Microsurg. 2004;20:215-25.
25. C S Chow 1, P C Ho, W L Tse, L K Hung Reconstruction of hypoplastic thumb using hemi-longitudinal metatarsal transfer. J Hand Surg Eur. 2012;37:738-44.
26. Tu YK1, Yeh WL, Sananpanich K, Ueng SW, Chou YC, Ma CH, Lee ZL. Microsurgical second toe-metatarsal bone transfer for reconstructing congenital radial deficiency with hypoplastic thumb. J Reconstr Microsurg. 2004;20:215-25
27. Cavallo AV, Smith PJ, Morley S, Morsi AW. Non-vascularized free toe phalanx transfers in congenital hand deformities--the Great Ormond Street experience. Journal of hand surgery. 2003, 28: 520-7.
28. Gohla T, Metz C, Lanz U. Non-vascularized free toe phalanx transplantation in the treatment of symbrachydactyly and constriction ring syndrome. Journal of hand surgery. 2005, 30: 446-51.
29. Tonkin M, Deva, A.K. Free toe phalangeal transfers for aphalangia : Congenital differences of the upper limb. In: Ogino T (Ed.) 5th International Symposium on Congenital differences of the upper limb. Kyoto, 2000: 190-5.
30. Bourke G, Kay SP. Free phalangeal transfer: donor-site outcome. British journal of plastic surgery. 2002, 55: 307-11.

Figure 1: Stage IIIB. Preoperative lengthening.

Figure 2: After one phalanx transfer. Union is not yet complete.

Figure 3: Grade IIIB Hypoplasia.

Figure 4: After single toe phalanx transfer and Abductor transfer.
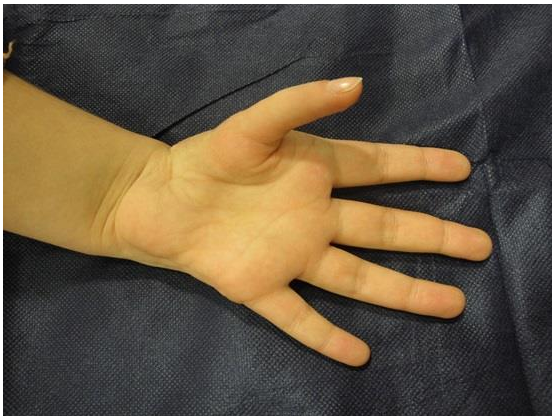

Figure 5: Widening of the first web.
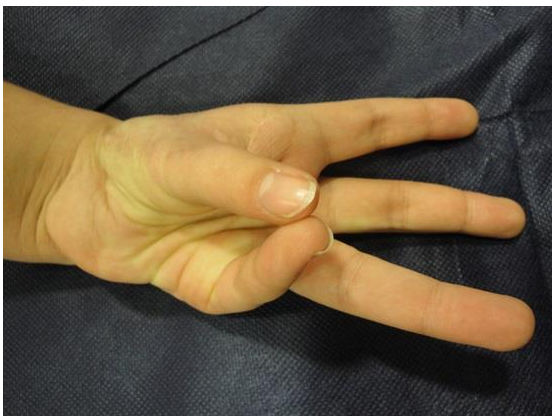

Figure 6: Result after 5 years.

Figure 7: Opposition of the thumb. No interphalangeal movements.

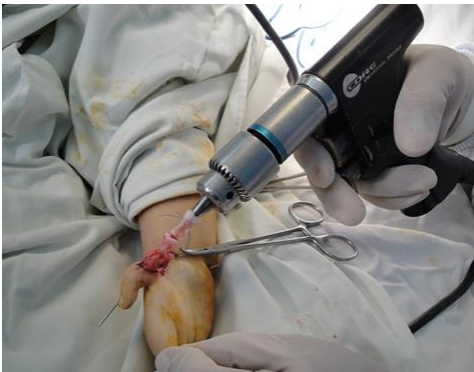Figure 8: Radial club hand. Severe thumb hypoplasia.

Figure 9: The pin is drilled through the two phalanges.

Figure 10: Healing after 5 months.