

Stabilization of the hypoplastic thumb type Blauth IIIB using a non-vascularized proximal interphalangeal joint from the toe as an alternative reconstruction when pollicization is not accepted: Description of the surgical technique

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Conflict of interest

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Abstract

Background. A Blauth IIIB hypoplastic thumb is a significant functional and cosmetic problem for the developing hand in children. The gold standard in treatment is amputation and index pollicization. Despite the good functional results, some parents do not consent to the operation, mainly for cosmetic reasons.

Objectives. The aim is to present a detailed description and features of the technique used in our department for stabilization of a hypoplastic thumb type Blauth IIIB with a non-vascularized proximal interphalangeal joint from the toe. This is the first description of this surgery for this kind of congenital defect, together with the largest group of patients analyzed compared to alternative techniques described in the literature.

Materials and methods. Sixteen patients were included in the analysis. The mean age was 3 years (standard deviation (SD) ± 2). In most cases, it was a unilateral and isolated defect. We described the surgical technique and postoperative management in detail and assessed intraoperative factors such as donor selection, operative time, technical problems, stabilization time, complication rate, and reoperations. Appropriate statistics were performed.

Results. Most often, the graft was taken from the 3rd toe. The average operation time was 59 ± 17.5 min. No technical problems were found during the surgery. The Kirschner wire was removed after an average of 6.5 weeks. The complication rate was 25%, which included the destabilization of Kirschner wires or graft non-union, but it decreased to 6% after reoperation. Five patients underwent tendon transfers.

Conclusions. The presented technique is based on principles such as vascularized metatarsophalangeal joint transplants. It may be an option for stabilizing a hypoplastic thumb if parents do not consent to pollicization. Having microsurgical skills is unnecessary. The operation and anesthesia times are significantly shorter, resulting in less burden on the child's body. The study will continue assessing long-term postoperative functions and the comparison to pollicization.

Key words: proximal interphalangeal joint, thumb hypoplasia, Blauth IIIB, PIP joint transfer, thumb stabilization

Background

Congenital disabilities occur in approx. 1% of newborns, and 10% are associated with upper limb anomalies. Of all hand defects, only 11% relate to thumb hypoplasia or aplasia, which is part of radial longitudinal hand deficiency. It can occur as an isolated defect or be associated with such syndromes as Apert syndrome, Rubinstein syndrome, Holt–Oram syndrome, Fanconi anemia, VACTERL association, and congenital radial deficiency.^{1–3} The modified Blauth classification, based on the clinical picture and X-ray images, describes the degree of thumb hypoplasia and helps to select an appropriate surgical treatment.^{4,5}

Thumb aplasia or hypoplasia significantly impairs the hand grip function and the proper physical and mental development of the child.⁶ Surgical treatment can help to reduce the degree of disability, improve the child's development and reduce restrictions in everyday life. It is essential to implement appropriate treatment early to prevent the formation of inappropriate grip patterns, which – when preserved in the cerebral cortex – can significantly hinder rehabilitation and subsequent grip development.^{6–8} The choice of a surgical method depends on the degree of thumb hypoplasia and on cosmetic and ethical aspects, which increasingly influence the parents' decisions.^{5,9–11}

Grade IIIB thumb hypoplasia, according to the modified Blauth classification, is characterized by shortening and narrowing, flattening of the thumb's commissure, underdevelopment of the thenar muscles, tendons of the flexor pollicis longus (FPL), extensor pollicis longus (EPL), extensor pollicis brevis (EPB), and abductor pollicis longus (APL), as well as proximal 2/3 of the first metacarpal and instability of the metacarpophalangeal and carpometacarpal joints. The gold standard of treatment is the amputation of the thumb and index finger pollicization. This operation is associated with good functional effects. The range of motion of the transferred finger is equivalent to 50% of an average thumb movement, while the force of the global and 2-point grip is equivalent to 63–67% and 55–60% of a healthy hand force, respectively. Over 70% of patients are satisfied with the surgery results.^{2,12–15}

Despite the treatment's outcomes, some parents do not accept the amputation since it forms a 4-fingered hand.

In the literature, few reconstructive surgeries are presented that are aimed at increasing the stability of the hypoplastic thumb, where hypermobility and instability are the leading causes of dysfunction.^{9–11,16–23}

Objectives

We want to present an alternative technique used for over 20 years in the authors' workplace, partly based on principles described in the literature. It consists of stabilizing the hypoplastic thumb with a non-vascularized proximal interphalangeal joint (PIP) graft from the toe to reconstruct the first carpometacarpal joint (CMC) and stabilize the thumb (Fig. 1). This technique can be supplemented with tendon or muscle transfers to improve active movements of the thumb and add more stability, e.g., transfer of the superficial flexor tendon of the ring finger or a Huber transfer for thumb opponensplasty and an extensor indicis proprius tendon transfer for extension and radial abduction of the thumb.^{18,20}

The article aims to present a detailed description of the technique and evaluates the technical aspects of the surgery. This is the first description of this surgery for this kind of congenital disability, together with the largest group of patients analyzed compared to alternative techniques.

Materials and methods

Study design

This is a retrospective study, assessing clinical data included in the medical records from the hospital and outpatient treatments, preseting also a detailed description of the surgical technique. The data were summarized, and basic statistical operations were performed.

Participants

With this technique, 16 patients were operated on (9 men and 7 women) in the years 2005–2022. The mean age at the operation was 3 years. All patients underwent reconstructive

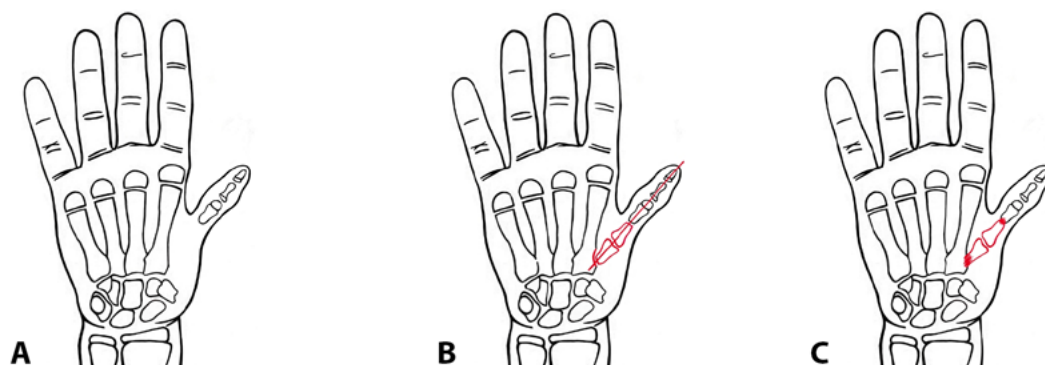


Fig. 1. Schematic drawing showing stabilization of the hypoplastic thumb type Blauth IIIB using a non-vascularized proximal interphalangeal joint from the toe. A. Hypoplastic thumb type Blauth IIIB before the operation; B. Thumb after the procedure; transferred joint and K-wire are marked in red; C. Thumb after obtaining bone union of the graft

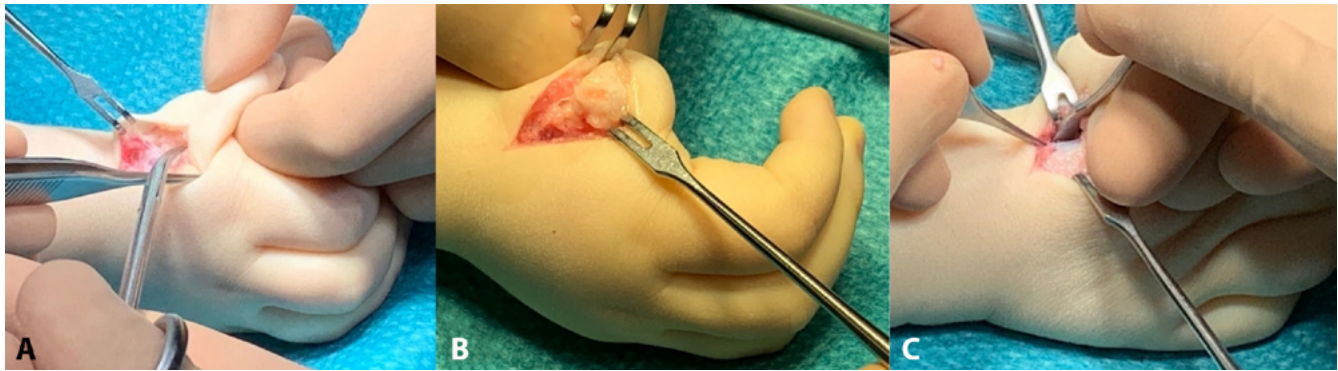


Fig. 2. A. An incision on the dorsal-radial side of the base of the thumb; B. Exposure and release of the proximal part of the first metacarpal bone; C. Preparing a space for a proximal interphalangeal joint (PIP) joint graft

Table 1. Details of the patients

Number of patients	Gender	Mean age at the operation [years]	Blauth classification	Unilateral defect	Complex defect
16	male – 9 female – 7	3 (SD ±2)	III B – 16	yes – 13 no – 3	yes – 3 no – 10

SD – standard deviation.

surgery of a type IIIB hypoplastic thumb, consisting of its stabilization using a non-vascularized PIP joint graft from the foot. In 13 cases, it was unilateral, and in 10 cases, it was an isolated defect of the thumb; in 3 cases, it was a complex upper extremity defect like congenital radial deficiency, and in 4 patients, an additional diagnosis of Poland's syndrome, congenital hearing loss, hydrocephalus, and an extra thumb or thumb aplasia in the contralateral hand was present.

Before the operation, parents were presented with the possibility of performing index finger pollicization, which they disagreed with because of the adverse cosmetic effect of a 4-fingered hand (Table 1).

Nine right hands and 7 left hands were operated on. The donor of the PIP joint was harvested from the right foot 11 times and the left foot 5 times, of which 63% (10/16) of grafts were taken from the same side as the operated hand. Most often, the graft was taken from the 3rd toe in 50% of cases, while in the remaining cases, the 4th and 2nd toes were used as the donor; 5 (31%) and 3 (19%) times, respectively.

Description of the operating technique

Four orthopedists performed all surgeries under the same operating room conditions. The surgery was performed in a bloodless field with a tourniquet through a longitudinal dorsal radial incision at the base of the thumb. Visualization of the first metacarpal bone was achieved. Exposure and release of its proximal part and preparation of the proximal stump to cancellous bone were performed to increase the chance of osseointegration with the graft. A space was prepared for the graft from the base of the first metacarpal bone to the proximal shaft of the second metacarpal bone (Fig. 2).

Our preferred joint donor from the foot is the 3rd or 4th toe because their size resembles the CMC I joint. In our

experience, its absence did not cause significant dysfunctions of the foot, which does not prevent possible microsurgical transfers from the 2nd toe (Fig. 3).

A longitudinal dorsal incision of the toe is made above the PIP joint, next to the extensor tendon with its protection. Using a bone cutter, an osteotomy of the proximal and medial phalanges is performed to collect the joint graft with capsule and collateral ligaments. We harvest a graft length to fill the distance between the second metacarpal proximal metaphysis and the hypoplastic first metacarpal stump after maximum traction of the thumb, so that after the graft is introduced, there is compression between the bones, which increases the chance of osseointegration. We close the space with stitches. The toe is stabilized with a centrally inserted 1.0 or 0.8 mm Kirschner wire (Fig. 4).

Through the PIP joint graft, one 1.0 mm Kirschner wire is inserted longitudinally (Fig. 5). We prepare a bed for the graft from the radial proximal 1/3 side of the second metacarpal bone shaft. The harvested joint is stabilized on the first metacarpal stump by inserting the Kirschner wire antegrade. Then, it is stabilized to the previously prepared bed on the second metacarpal bone retrograde using the same axial wire to set the thumb at about 30° radial and palmar abduction (Fig. 6).

Additionally, 5 patients underwent tendon transfers to improve the active movement of the thumb, like flexor digitorum superficialis tendon 3rd or 4th finger to flexor pollicis longus tendon, abductor digiti minimi tendon or flexor digitorum superficialis tendon 4th finger to thumb opposition, extensor carpi radialis longus and flexor digitorum superficialis tendon 3rd finger on thumb's proximal phalanx for metacarpophalangeal joint extension and flexion, and extensor indicis proprius tendon to extensor pollicis longus. To close the skin wound, an absorbable suture of 4-0 or 5-0 is used,

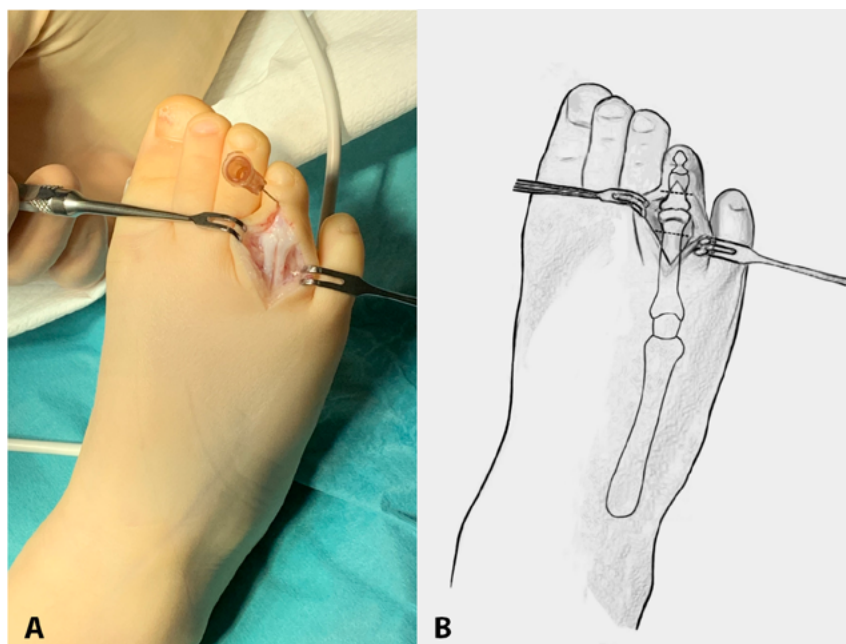


Fig. 3. A. Dorsal skin incision and exposure of the proximal interphalangeal joint (PIP) joint; B. Schematic drawing showing the harvesting of the PIP joint from the foot (osteotomy marked with a dashed line)

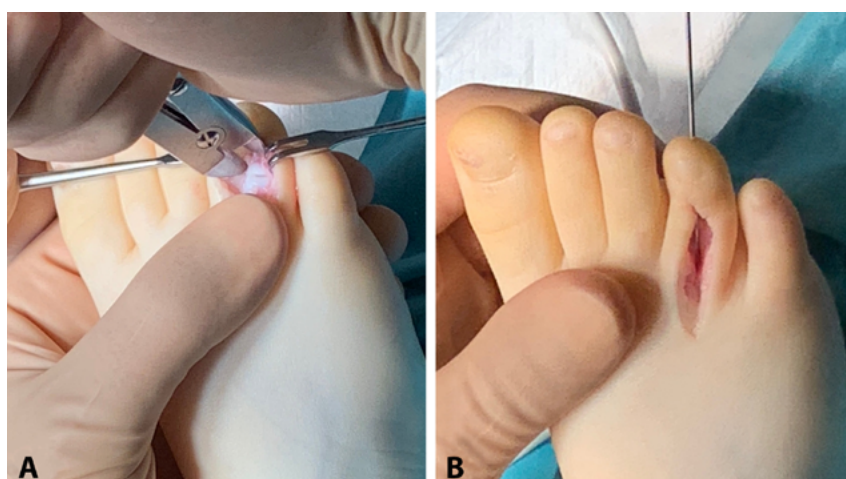


Fig. 4. A. Harvesting of the proximal interphalangeal joint (PIP) joint from the foot using a bone cutter; B. The toe is stabilized with Kirschner wire 1.0 or 0.8 mm inserted longitudinally

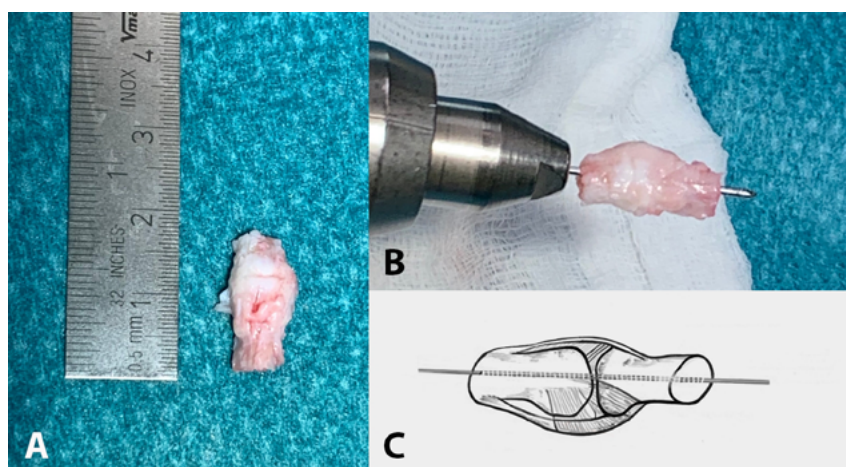


Fig. 5. A. The harvested proximal interphalangeal joint (PIP) joint graft with capsule and collateral ligaments is measured; B. One Kirschner wire (1.0 mm) is inserted centrally; C. Schematic drawing

depending on the size of the thumb. We secure the operated area with a large amount of cotton wool dressing, which protects and keeps the thumb in a fixed position. Additionally, the operated thumb is secured with an above-elbow cast.

The first change of dressing is performed 2 weeks after the surgery. The wire is removed at 6–8 weeks after the evaluation of bone fusion using an X-ray.

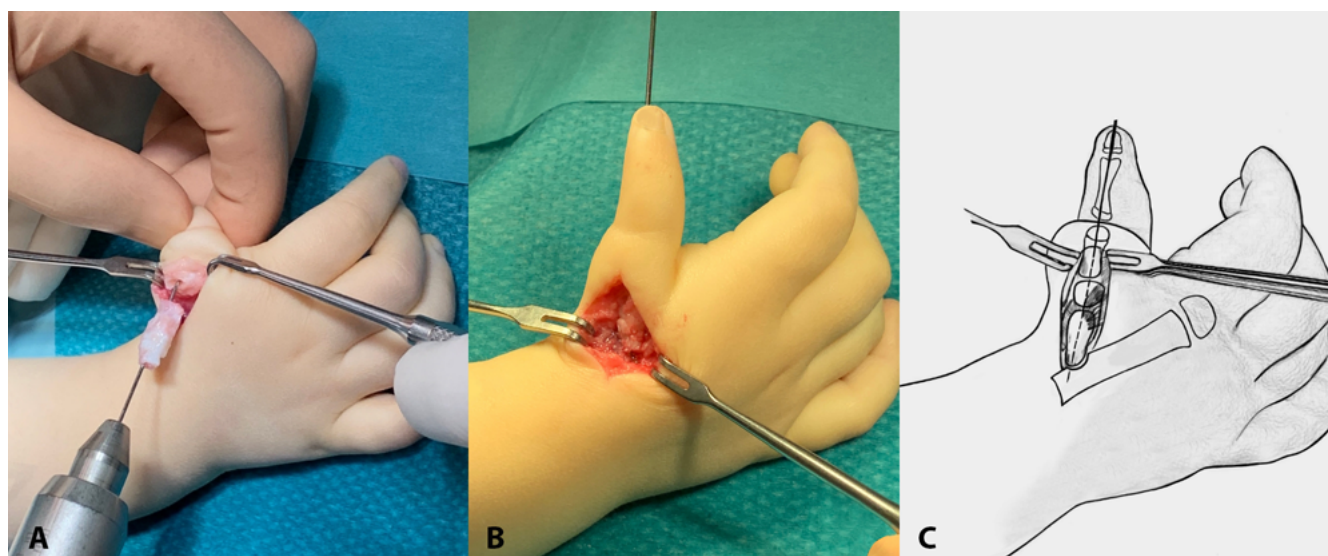


Fig. 6. A harvested joint graft is stabilized on the first metacarpal bone stump by inserting the Kirschner wire (A) and then into the previously prepared bed on the second metacarpal bone using the same axial K-wire (B); C. Schematic drawing

Table 2. Summary of data regarding surgical technique

Number of patients	Hand operated	Foot donor	PIP joint donor – toe	Average time of surgery	Technical problems during operation	Average time of Kirschner wire stabilization	Complication	Reoperations	Tendon transfer
16	right – 9 left – 7	right – 11 left – 5	2 nd – 3 3 rd – 8 4 th – 5	59 min (SD ±17.5)	none	6.5 weeks (SD ±2.5)	4 cases*	3 cases*	5 cases*

* Details included in the text. SD – standard deviation; PIP – proximal interphalangeal joint.

Results

No significant technical problems were found during surgery in any patient. After surgery, the Kirschner wire was removed after an average of 6.5 weeks (Fig. 7,8). The average operation time was almost 1 h. The complication rate was 25% (4 patients), and there were 2 cases of destabilization and earlier removal of Kirschner wires where, in 1 case, graft union was not achieved, and there were 2 cases of non-union of the graft to the 1st or 2nd metacarpal bones. For this reason, reoperation was performed in 3 cases, consisting of only graft restabilization in 1 case, and in 2 cases, resection of the pseudoarthrosis, filling the defect with a bone graft and restabilization was required. After surgery in these 3 patients, union was achieved in 2, while pseudoarthrosis persisted in 1 (Table 2).

Discussion

The generally accepted gold standard of treatment in type IIIB thumb hypoplasia, according to the modified Blauth classification, is amputation of the thumb and index finger pollicization.²

Some parents do not accept this treatment method, as it results in an unfavorable cosmetic appearance

in the form of a 4-fingered hand. Therefore, surgical techniques that preserve a hypoplastic thumb and improve thumb stability and function are being developed.

The main goal of reconstructive techniques described in the literature is to increase the stability of the hypermobile thumb, i.e., vascularized/non-vascularized metatarsophalangeal joint (MTP) transplant, free toe phalanx transplant, transfer of half the width or the entire metatarsal bone, vascularized metatarsal bone transplant with a full-thickness skin graft, and a non-vascularized structural transplant from the iliac crest.^{9–11,14,17–19,23–28}

Allogenic (vascularized/non-vascularized) transfer of all or part of the PIP joint from the foot is widely described in the literature, both in adults and children, as an alternative to arthrodesis or endoprosthesis of the joint. The main indication is a congenital/post-traumatic/post-infectious deformation of the PIP joint.^{29–31}

Kuzu et al.³⁰ presented the results of 7 adult patients after a transfer of a vascularized PIP II joint from the foot to improve the range of motion of the PIP joint of the finger. At 1-year follow-up, there was an increase in the amplitude of passive movement from 5° to 53° and active movement from 2° to 43°.

Dautel²⁹ presented the results after reconstructing 43 PIP joints in children and adults, with a 5-year follow-up. The average amplitude of active movement was

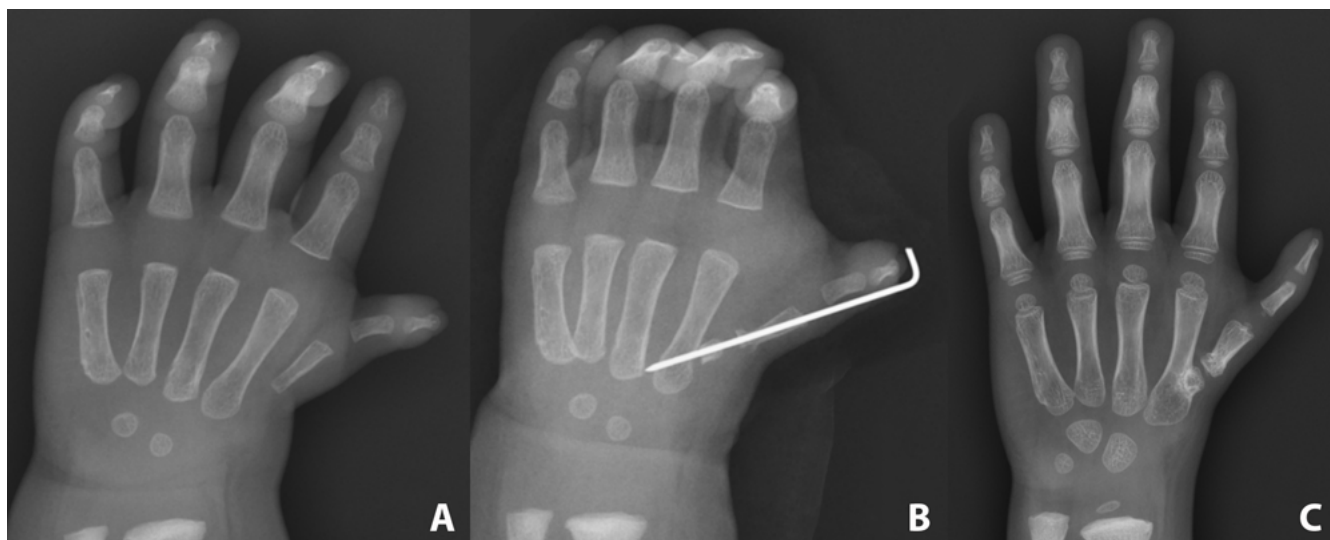


Fig. 7. X-ray of one of the operated patients: hand in anterior-posterior (AP) position before (A), after the operation (B) and after 3 years (C)



Fig. 8. A 4-year-old boy with a type IIIB hypoplastic thumb, 3 years after proximal interphalangeal joint (PIP) joint transfer. There is a visible shortening of the thumb, with atrophy of the thenar muscles, which is in an intermediate position

45°, with an average range of motion (ROM) of 34–79°. In 2 cases, the author observed total ankylosis of the transplanted joint.

Finding papers describing the use of the PIP joint to reconstruct a type IIIB hypoplastic thumb is difficult. Several authors described using a vascularized MTP graft for reconstruction as an alternative to pollicization.^{14,18,25} We used a non-vascularized PIP joint graft, most often from the 3rd toe, where, in our opinion, this joint has adequate size to reconstruct the CMC I joint.

In cited works, the operation was performed on 9 patients with an average age of 9, whereas in our group of 16 patients, the average age was approx. 3 years. The parents did not accept pollicization in younger patients like many of our older patient cases. In older patients,¹⁴ the surgery was performed to improve the stability of the thumb without a prior proposal of pollicization. In all cited cases,

appropriate tendon transfers were performed to recreate the active movements of the thumb during the same operation²⁵ or in the next stage.^{14,18} In this group of patients, just over 30% of cases had tendon transfers performed in the next stage of treatment. The parents of the remaining patients were not willing to undergo further operations, or the patient did not seek further treatment.

All authors achieved better thumb stability after surgery; however, only 1 article¹⁸ described the ROM of the transplanted joint – 45° of radial and 75° of palmar adduction. In some patients, the force of the global grip was 3 times higher, and the key grip was 1.5 times lower compared to the patients after the pollicization.²⁵ Another article described it as 40% of the global grip strength and 14% of the 2-point grip strength compared to the opposite, healthy hand.¹⁴ In 2 studies,^{18,25} all patients could grasp small and large objects using the operated thumb. Foucher

et al.¹⁴ stated that more than half of the patients could grasp small things using the thumb. However, in their daily activities, they used it only occasionally. Most of the patients were able to hold larger objects.

Unfortunately, the description of the technique and post-operative procedures in the cited works is not detailed enough to allow them to be appropriately compared. Additionally, those papers are based on a few clinical cases.

All cited works^{14,18,20,24,25} are based on a vascularized joint transplant compared to our technique, where we use a non-vascularized graft. This means that it is not necessary to have highly specialized microsurgical skills. The risk of blood circulation disorders in the operated finger is significantly reduced, and the operating time is shortened from 6 h²⁴ to less than 1 h on average. As a result, the child's anesthesia time is also significantly shorter. The surgical approach of all authors, both on the foot (dorsal) and on the hand (dorsal-radial), was similar to our technique. We inserted the graft between the first and second metacarpal bone, as Foucher et al.¹⁴ or Nishijima et al.²⁰ described. At the same time, Matsuzaki et al.¹⁸ and Shibata et al.²⁵ placed the graft between the first metacarpal bone and the wrist bones. All authors used Kirschner wires to stabilize the graft as we do, but differently. Three papers^{18,20,25} described 2 crossed wires, and 1 paper¹⁴ an axial wire that only stabilizes the graft. However, our technique involves an axial wire inserted from the distal phalanx to the second metacarpal bone. In our group, the Kirschner wire was removed after an average of 6.5 weeks, similar to the paper by Foucher et al.,¹⁴ which kept the wire in place for 5 weeks.

No complications were presented in any of the cited studies; only Foucher et al.¹⁴ stated that all patients had graft ingrowth. In our work, 3 cases (19% of cases) were a non-union of the graft, and 1 case has been linked to wire destabilization. After reoperation in these 3 patients, union was achieved in 2, while pseudoarthrosis persisted in 1.

Long-term follow-up and evaluation of the donor site in the foot should be considered because as Garagnani et al. described in their work, the harvest of bone from the toes causes consequences that can only be identified after long-term follow-up. This is very important because if a deformity can be identified, the patients and their families should be informed about it before the operation.³²

Limitations

The article presents a detailed description of the technique and an assessment of the technical aspects of the procedure. Despite the small group of patients who underwent surgery, this is the largest group analyzed compared to alternative techniques described in the literature. Slight differences in technique may be present due to the fact that more than 1 orthopedist performed all the surgeries.

However, they took place in the same operating room conditions. It is necessary to continue research with long-term follow-up and functional assessment studies (both short-term and long-term).

Conclusions

The presented technique of reconstruction of the IIIB hypoplastic thumb with a non-vascularized PIP joint from the foot is based on principles like those reported in the literature on vascularized MTP transplants. It may be considered as one of the options for stabilizing a hypoplastic thumb in patients whose parents do not consent to pollicization. The main difference in the technique is that having highly specialized microsurgical skills is unnecessary. Also, the operation time and, consequently, the anesthesia time is significantly shorter, resulting in less burden on the child's body.

In the following research stage, it is necessary to examine the function of the hand after the operation described above. It will be valuable to compare the obtained results with patients after index pollicization as the gold standard for treating grade IIIB thumb hypoplasia.

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