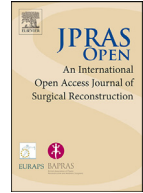




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Original Article

Operative technique and management of central foot polydactyly

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ABSTRACT

Polydactyly is characterized by the manifestation of supernumerary digits in the hands and feet. It can be isolated or associated with a genetic syndrome. Based on the location of duplication, it is categorized as preaxial, postaxial, or central. The latter is a rare abnormality, comprising approximately 6% of cases. There is a paucity in the literature regarding this congenital anomaly and its overall management. Nonoperative treatment is generally unsuccessful in managing symptoms such as excessive width, abnormal digit alignment, and growth. Though surgical management addresses the individual patient's needs, general goals include preservation of digits with the greatest axial alignment, resection of symptomatic digits, alignment correction of the remaining great toe, stabilization of the soft tissues, and adequate soft tissue coverage. This study aims to delineate effective operative techniques for central foot polydactyly. Two patient cases are discussed, providing a framework for pre and postoperative care, complications, and outcomes. The techniques detailed offer a straightforward, efficacious, and safe method to reconstruct central foot polydactyly, returning form and function to the patient.

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Introduction

Polydactyly is characterized by the manifestation of supernumerary digits in the hands and feet. Based on the location of duplication, it is categorized as preaxial, postaxial, or central. The last is a rare abnormality, comprising approximately 6% of cases.¹ Various classifications have been reported based on morphology. Venn-Watson centered his classification system on the anatomic pattern of the first and fifth metatarsals and duplicated bony components. Six variations are described for pre and postaxial polydactyly: normal metatarsal with distal phalanx duplication, block metatarsal, Y-shaped metatarsal, T-shaped metatarsal, widened metatarsal head, and ray duplication.² Watanabe modified the system by describing the type of ray involvement and level of duplication and included central-ray pattern types.¹

Clinically, patients experience difficulty with using shoes, pain during walking, psychosocial issues, and poor cosmesis. Nonoperative treatments include shoe modification and are generally unsuccessful. Owing to the interpolated nature of the duplicated ray in central foot polydactyly, reconstruction is more complex than with pre and postaxial polydactyly. There is a paucity of articles in the literature regarding this particular congenital difference and a lack of consensus on an ideal approach to surgical management. Existing studies describe surgical approaches to isolated distal and proximal phalangeal duplication, case reports with limited outcome assessment, and a wide range of possible options, including dorsal and plantar advancement flaps, z-plasty with capsulotomy, wedge resection, and microsurgical flaps.^{2–5}

The goals of surgery include preservation of digits with the greatest axial alignment, resection of symptomatic digits, alignment correction of the remaining great toe, stabilization of soft tissues, and adequate soft tissue coverage. This study aims to delineate effective operative techniques for central foot polydactyly. Two patient cases are discussed, providing a framework for pre and postoperative care, complications, and outcomes. The techniques detailed offer a straightforward, efficacious, and safe method to reconstruct central foot polydactyly, returning form and function to the patient.

Patients and operative methods

Surgery is often intended to address pain, tender calluses, inability to wear standard shoes, difficulty with ambulation, psychosocial issues, and poor cosmesis. Intervention is commonly delayed until after the onset of walking to allow for gait evaluation. Occasionally, it can also be deferred until skeletal development or ossification to enable accurate anatomical assessment of the affected rays.

Patients

Patient #1

A 15-month-old Caucasian female with a history of left talipes equinovarus was treated with Ponseti serial casting with excellent results and presented for surgical treatment of left central foot complex polydactyly with four additional digits (Figure 1a and b). The four duplicated toes were located between the hallux and four morphologically normal lateral toes. Though minimally hypoplastic, there was no syndactylism of the polydactylous toes. Radiographs demonstrated seven metatarsals and eight proximal phalanges without tarsal bone duplication (Figure 2). One of the duplicated metatarsals was Y-shaped; one of the proximal phalanges was bifid. Corrective surgery proceeded with excision of the four duplicated digits, metatarsal osteotomy of the great toe with transfer to the second metatarsal base, reconstruction of the intermetatarsal ligaments, and medial transposition of the normal lateral toes.

Patient #2

A 17-month-old Caucasian female with a history of right complex central foot polydactyly presented for surgical treatment to address difficulty with ambulation and cosmesis. Physical examination demonstrated eight toes (Figure 3). Radiographs showed an accessory cuneiform, eight metatarsals,



Figure 1. a and b. Preoperative photos of both the dorsal and ventral views of Patient #1.



Figure 2. Preoperative radiograph demonstrating seven metatarsal bones and eight proximal phalanges including one bifid.

and eight proximal phalanges. The duplicated bony parts were hypoplastic (Figure 4). Surgical correction proceeded with excision of the second, third, and fourth toes with transposition of the fifth toe to the second metatarsal base with partial wedge excision of the midfoot (Figure 5). The decision to transpose a digit or metatarsal bone is based on the anatomic similarity of the bones involved.

Our institution utilizes a multi-disciplinary approach with a pediatric orthopedic surgeon and pediatric plastic surgery hand surgeon as there is no pediatric foot and ankle specialist available with experience in such types of cases.

Operative methods

The patient is positioned supine on the operating table, while general anesthesia is administered. Regional anesthesia may be considered as an adjunct to provide additional intraoperative and post-operative pain control. Antibiotic prophylaxis is administered, and a padded tourniquet is placed on



Figure 3. Preoperative photo of Patient #2.



Figure 4. Preoperative radiograph demonstrating an accessory cuneiform, eight metatarsals, and eight proximal phalanges.



Figure 5. Surgical correction with excision of the second, third, and fourth toes with transposition of the fifth toe to the second metatarsal base with partial wedge excision of the midfoot.

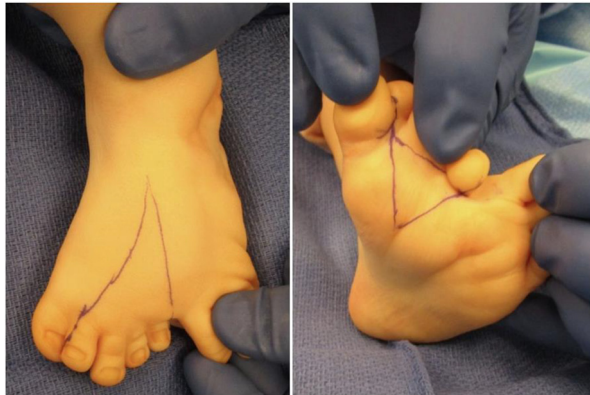


Figure 6. a and b. Surgical markings of the dorsal and ventral foot.

the patient's thigh and set at 200 mmHg. Once the leg is prepped and draped in the usual sterile fashion, the skin incisions are marked to remove the desired digits and provide access to the forefoot and midfoot, as shown in [Figure 6a](#) and [b](#). In general, we prefer to design a wedge-shaped incision around the polydactylous digits to be removed. We also incorporate a Barsky flap to reconstruct the involved webspace, in order to keep the incision line out of the commissure and help prevent future web creep.

The skin incision is made with a #15 blade, and careful dissection is performed with a Jacobson hemostat or a tenotomy scissor through the dorsal subcutaneous fat plane. We take care to identify and preserve the dorsalis pedis and arcuate arteries as well as dorsal veins and extensor tendons. Dissection is performed along the course of the extensor tendons to confirm their insertions, preserving the extensor to the digits that are to remain and transecting the extensors to the digits to be removed.

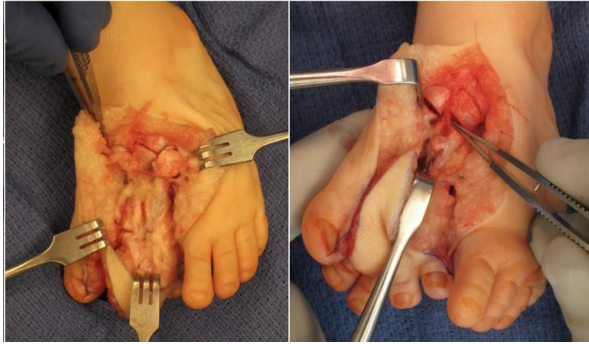


Figure 7. a and b. Identification of the tarsometatarsal joints for the polydactyly metatarsals and hallux with transverse osteotomies at the proximal metaphyseal-diaphyseal junctions.



Figure 8. Wedge resection of the central foot polydactyly, digits 2–5.

We then make longitudinal periosteal incisions along the polydactyly metatarsals to be removed and identify the tarsometatarsal joint these rays (Figure 7a and b). In single-digit excisions, the postexcision gap may be able to be closed without transposition of a digit or digits, but in wider excisions that encompass multiple digits, we plan to perform an osteotomy of the metatarsals and transfer metatarsal rays appropriately in order to narrow the gap. We use a sagittal saw or osteotome to perform a transverse osteotomy of the most medially involved metatarsal distal to the physis, at the proximal metaphyseal/diaphyseal junction (Figure 7a and b). We then carry out a similar osteotomy on the most lateral polydactyly metatarsal and dissect circumferentially in the subperiosteal plane to excise all polydactyly metatarsals which are to be removed.

We extend the skin incision along the plantar surface to remove a wedge of redundant soft tissue. Then, dissection is performed in the subcutaneous plane, preserving the digital nerves and arteries to the great toe and normal second toe. We elevate a laterodigital cutaneous flap Barsky type flap⁶ along the medial surface of the normal second toe for later inset into the great toe in order to preserve the second webspace commissure. We separate all polydactyly digits by gently spreading with a Jacobson hemostat. All removed digits are submitted to pathology (Figure 8).

At this time, we deflate the tourniquet and copiously irrigate the wound, confirming hemostasis. We then advance a 0.045 Kirschner (K)-wire in an antegrade fashion through the metatarsal of the great toe until the proximal tip is within the metatarsal shaft. The great toe metatarsal base is transposed to the more medial polydactyly metatarsal base, and the K-wire is advanced in a retrograde manner across the osteotomy site to fixate the great toe in a more lateral position. We confirm posi-

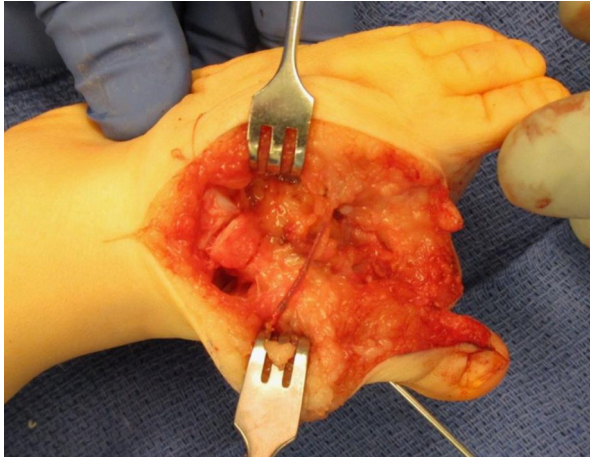


Figure 9. Transposition of the great toe metatarsal base to the more medial polydactylous metatarsal base.

tioning and reduction of the osteotomy using fluoroscopy. There should be a significant improvement in the interdigital gap without the confluence of the second and great toes. The proximal remnant of the great toe metatarsal is subsequently resected (Figure 9).

To reconstruct the intermetatarsal ligament and anterior metatarsal space, we place a 2–0 ethylene terephthalate (Ethibond, Johnson & Johnson, Bridgewater, New Jersey, USA) figure-of-eight suture in the periosteum of the more medial and that of the more lateral polydactyly metatarsals. We leave the suture untied and place a second figure-of-eight with 2–0 suture into the previously divided intermetatarsal ligament along the lateral aspect of the great toe and that of the second toe. Appropriate tensioning is applied by carefully tying the sutures to narrow the intermetatarsal space. We aim to avoid creating a convergence of the great and second toes and confirm with fluoroscopy. In cases of midfoot involvement, a similar suture is placed in the midfoot capsule for support. A second 0.045 K-wire is placed transversely from the first to second metatarsals in order to preserve the plane of the foot and intermetatarsal space (Figure 10).

At this point, we copiously irrigate the wound and confirm hemostasis. The Barsky flap is inset into the great toe lateral aspect, creating a smooth first webspace. The dorsal and plantar incisions are closed with 4–0 chromic gut suture on a horizontal mattress in the interrupted pattern (Figure 11). We cut and bend the K-wires and place protective caps. Then, we place a well-padded, molded long leg cast with the knee in slight flexion. At this time, we verify capillary refill and general perfusion of the foot.

The patient is admitted for observation and pain control overnight. Most patients can be discharged the following day with pain medications. Postoperative antibiotics are not generally prescribed. Patients are seen back in the clinic in four weeks for cast removal and possible pin removal pending visualization of callus on X-ray imaging.

Results

The patients discussed had no complications in the immediate postoperative period, reflecting the low rate of postoperative complications. These potential risks include bleeding, infection, pain, scar, stiffness, problems with ambulation, nonunion, malunion, foot ischemia, growth disturbance, digital loss, and asymmetry. Owing to their young age, patients are generally allowed to resume full activity as tolerated and have not required formal physical therapy in our limited experience after removal of the cast and pins.

The first patient with a history of talipes equinovarus demonstrated a plantigrade foot with excellent motor power and good dorsiflexion of the ankle (Figure 12a and b). Two years postoperatively, her



Figure 10. Transposition of the great toe metatarsal base to the more medial polydactylous metatarsal base. Placement of a 0.045 K-wire through the great toe metatarsal across the osteotomy site, fixing the great toe in a more lateral position. Second 0.045 K-wire placed transversely from the first to second metatarsals in order to preserve the plane of the foot and intermetatarsal space.

foot was noted to be in a relatively varus position, but radiographs showed overall good alignment. Again, Ponseti serial casting was initiated. With limited improvement, the patient underwent anterior tibial tendon transfer, capsulotomy, and talonavicular re-alignment by orthopedic surgery colleagues in a staged fashion to address the talipes equinovarus. Postoperative physical therapy after her talipes equinovarus revision included gait training. At the five-year follow-up, the patient was noted to be doing well with the uninhibited ability to run and play. No functional limitations, instability, skin breakdown, or pain were reported. On evaluation, the patient was able to hold her foot flat on the ground without significant eversion. There was no clinodactyly or web creep noted. Radiographs showed maintenance of acceptable alignment without significant diastasis at the site of correction. The patient has not required any revisional procedures for the central foot polydactyly, and she and her parents report satisfaction with her overall form and function after her initial operation. The second patient is similarly doing well with no postoperative complications. She was seen in the clinic ambulating with no difficulties, wearing shoes of equal sizes, and engaging in “normal” play with her parents.

Discussion

Though sparse, the literature regarding surgical management of central foot polydactyly describes a range of possibilities. Moreover, despite limited firsthand experience with this uncommon congenital



Figure 11. Inset of the Barsky flap into the great toe lateral aspect, creating a smooth first webspace and closure of the dorsal and plantar incisions with 4-0 chromic suture.



Figure 12. a and b. Postoperative photo of the dorsal and ventral foot at three years.

anomaly, plastic surgeons with congenital hand experience may utilize the basic principles of plastic surgery to provide safe and efficient care to this patient population. Wide phenotype diversity mandates creativity and flexibility in the application of these published techniques. Most cases of recurrence or results prompting revision are secondary to axis deviation, incomplete syndactyly separation, residual polydactylous components, and overall foot widening.⁷

Vlahovic et al. describe a wedge resection of the duplicated rays with complete release of the first metatarsophalangeal (MTP) joint and that of the abductor hallucis tendon. The first ray was brought laterally to close the wedge, and a k-wire was used to hold it in place. The authors note that the postoperative foot was wide with the abduction of the first MTP joint. Radiographs further demonstrated a wide space between the first and second rays. A revision procedure excised a supernumerary tarsal bone and repositioned the first metatarsal bone with re-insertion of the abductor hallucis tendon and K-wire placement.⁸ The simple wedge resection without significant soft tissue manipulation or excision of the supernumerary tarsal bone lends itself to a widened foot in the postoperative period.

Piette et al. further emphasize the importance of soft tissue reconstruction, explaining the successful return of function in a heptadactylia case. Authors describe a wedge resection of the extra digits using an interdigital incision on the dorsal foot and second stage reconstruction of the intermetatarsal ligament of the first and fourth metatarsals using suture and K-wire.⁵ Combined bony and ligamentous reconstruction helps to achieve a narrow foot. Belthur et al. discuss a single patient with mirror foot and four supernumerary toes who underwent dorsal and plantar laterally based flaps with ray excision. An accessory anterior tibialis tendon was re-inserted into the medial cuneiform. No additional reconstruction was described, and the outcome was noted to be “good” without further detailed assessment.¹ Papamerkouriou et al. similarly used a dorsal and ventral V-shaped incision in the center of the foot to excise the extra skin and polydactylous central rays. The remaining metatarsals were approximated using a K-wire, and a plantar skin flap from the excised second medial toe was used to cover the lateral surface of the great toe. The postoperative evaluation demonstrated widening of the foot.⁹

Though no general consensus exists in the literature regarding surgical treatment of the central foot polydactyly, the existing data and our center’s recent experience with central foot polydactyly indicate the importance of (1) complete excision of the polydactylous bony components including supernumerary tarsal bones, (2) intermetatarsal ligament reconstruction to prevent long-term widening, (3) adequate resection of excess dorsal and plantar soft tissue, (4) metatarsal transfer in cases of large gaps between the adjacent normal metatarsals, (5) use of local flaps to re-create an appropriate webspace and reduce the risk of web creep, (6) K-wire fixation to establish bony stability, and (7) postoperative casting to protect the ligament reconstruction and prevent the collapse of the foot. This study is intended to provide a one-stage, effective, and safe method to reconstruct central foot polydactyly and provide a functional and cosmetic foot.

Ethics

Ethical approval is not required. Written permission to publish patient photos for educational purposes obtained.

Declaration of Competing Interest

None declared.

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