Brachymetatarsia with the Use of Digital Arthroplastic Bone

A review of autogenous bone graft alternatives for the correction of brachymetatarsia is presented with an introduction of a unique autogenous choice. This involves the harvesting of bone from the second and third digits of the ipsilateral foot and transplanting it to the hypoplastic fourth metatarsal. A case study is discussed with its indications, techniques, and results. Provided in the case study are photographs of preoperative and postoperative x-rays with a follow-up of 14 months.

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Brachymetatarsia is a term that refers to an abnormally short metatarsal bone. This abnormal metatarsal length can result from various etiologies, either congenital or acquired. Kite proposes that the condition results from premature fusion of the epiphyseal plate at the distal aspect of the metatarsal and occurs most frequently at the fourth metatarsal (1). The reason for premature fusion is unknown, but may result from hereditary, traumatic, or environmental factors. Brachymetatarsia has also been associated with systemic pathologies such as pseudohypoparathyroidism, pseudo-pseudohypoparathyroidism, Albright's syndrome, Down's syndrome, myositis ossificans, and multiple epiphyseal dysplasia (2–4).

Brachymetatarsia deformity manifests itself in two forms, those being disfigurement with or without pain. An aberrant metatarsal length pattern results in abnormal weightbearing and a painful hyperkeratotic lesion. The cosmetic psychologic implications often cause embarrassment to the patient, which alone is an appropriate indication for brachymetatarsia surgery, in a properly well informed patient.

Surgical Alternative

Many surgical procedures for brachymetatarsia have been described in the literature, varying from the Callnan-Nicolle finger joint prosthesis (5–7) to actual metatarsal lengthening procedures. For the purpose of this paper, the authors reviewed metatarsal lengthening techniques by the use of autogenous bone grafts. Allographs are not consistent with the unique bone choice selected by these authors.

McGlamry and Cooper became the first authors to describe a cylindrical autogenous bone graft that was taken from the ipsilateral plantar lateral aspect of the calcaneous (8). McGlamry and Fenton, 14 years later, used an autogenous tibial graft (9). In 1988, Pasternack described the use of a hypertrophic navicular bone for metatarsal lengthening (10). Kaplan and Kaplan described a technique employing intermetatarsal transfers (11). This was performed by using a shortening osteotomy of the second metatarsal, removing a 1-cm. block of bone, and transposing it into the short fourth metatarsal. Chairman *et al.* described a similar technique by using bone from the fifth metatarsal (12). Autogenous bone grafts have been harvested from the hip, another metatarsal, tibia, fibula, navicular, or calcaneous as documented by Scheiner and Chamas (13), as well as Page *et al.* (5). A search of the literature has failed to describe the technique of harvesting bone from the second and third digits to correct a short fourth metatarsal.

Case Report

A 44-year-old Hispanic female presented to Medical Arts Center Hospital with the chief complaint of a short, unattractive fourth toe, bilateral. Although there were plantar metatarsal three and five tylomas, these lesions were asymptomatic and the patient's primary concern was cosmetic. The history was negative for trauma. The family history was unremarkable with no

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evidence of any congenital malformations, including osseous deformities.

Physical examination revealed intact, normal vascular, and neurological systems. Orthopedic examination revealed a dorsally displaced and contracted fourth toe bilateral (Fig. 1). Redundant skin was noted on the dorsal aspect of the fourth metatarsophalangeal joint bilaterally. Radiographically, a hypoplastic fourth metatarsal was noted bilaterally. The second and third proximal phalanges were moderately elongated relative to the hallux with approximately the same width as the hypoplastic fourth metatarsal (Fig. 2). The surgical objective was to harvest bone from the proximal phalangeal heads of digits two and three, and interpose the bone graft into the hypoplastic fourth metatarsal with Kirschner (K) wire fixation.

Surgical Technique

After induction of general anesthesia, the patient's right foot was prepared and draped in the usual sterile manner, and a well-padded pneumatic midthigh tourniquet was inflated to a pressure of 350 mm Hg. for hemostasis. Attention was directed dorsally over the second and third digits where two 2.0-cm. longitudinal converging semielliptical skin incisions were made and the resulting skin wedge excised. The dissection was appended in a manner identical to that of a digital arthroplasty. Once the heads of the proximal phalanges were adequately exposed, utilizing a power saw, the cartilage of each head was excised transversely, perpendicular to the long axis of the phalanx (Fig. 3). The bone was exposed to the level of the metaphyseal-diaphyseal junction, where it was excised from dorsal to plantar at that level utilizing a power sagittal saw. The bone excised from the second and third proximal phalanges measured a combined total length of 1.2 cm. and was placed in sterile saline for future transposition (Fig. 4).

A 2.5-cm. Z-plasty skin incision was then placed over the hypoplastic fourth metatarsal. The incision began midshaft proximally and extended distally to the level of the metatarsophalangeal joint. The three arms of the Z-plasty were identical in length at angles approximating 60 degrees. The incision was deepened to the level of superficial fascia and the skin flaps created were then tagged with suture to avoid excessive tissue handling. It is imperative to preserve as much superficial fascia as possible under these flaps in order to avoid tissue necrosis. The extensor digitorum longus and brevis tendons to the fourth toe were incised longitudinally, prepared for a Z-plasty lengthening, and tagged with suture for retraction.

Figure 2. Radiographic anteroposterior view of the right foot. Notice the length of the second and third proximal phalanges relative to the hallux and lesser phalanges. Notice the width comparison between the metaphyseal-diaphyseal regions of the second and third proximal phalanges to that of the hypoplastic fourth metatarsal.

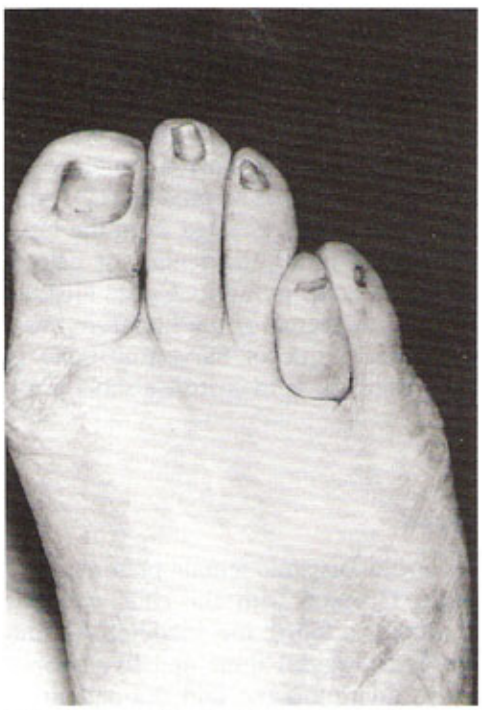

Figure 1. Illustration of the right fourth toe, short and dorsally displaced of this 44-year-old Hispanic female.

Figure 3. Notice the cartilagenous head of the proximal phalanges are excised first prior to the harvesting of the bone graft.

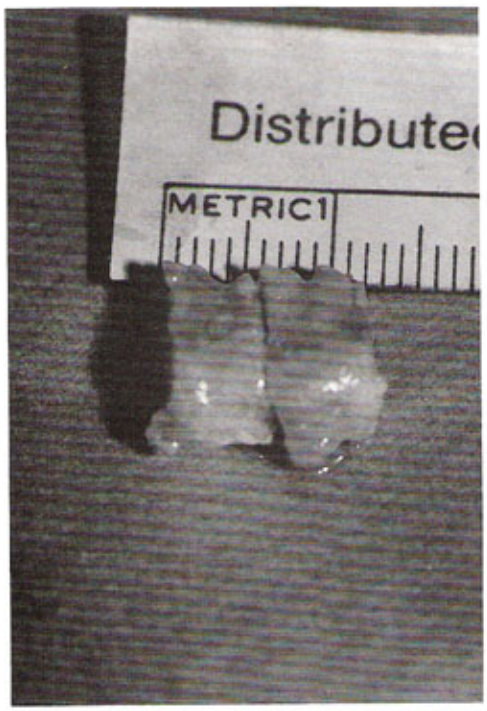

Figure 4. Harvested autogenous bone graft taken from the metaphyseal-diaphyseal junctions of the second and third proximal phalanges. Total combined length was 1.2 cm.

A dorsal-linear incision was made through the periosteum of the fourth metatarsal. The periosteum was meticulously reflected thus exposing the distal one-third of the metatarsal, through which a transverse osteotomy was created at the distal metaphyseal-diaphyseal junction utilizing power instrumentation. A 0.045-inch K-wire was then inserted proximal to distal through the proximal, middle, and distal pulp of the digit, and retrograded back into the previously osteotomized fourth metatarsal capital fragment only. At this time, the K-wired capital fragment and fourth digit were distracted to create a space as well as a counterforce for the bone graft which was then interposed between the two fragments of the metatarsal shaft. With the inlaid bone graft in proper anatomical alignment with the metatarsal shaft, the previously retrograded K-wire was proximally advanced intramedullary through the graft and into the proximal portion of the metatarsal shaft.

After evaluation of stability and alignment, the surgical site was irrigated and the periosteum firmly reapproximated with 3-0 absorbable suture. The extensor tendon apparatus was repaired utilizing 4-0 absorbable suture in a reverse over and over fashion in its new lengthened position under physiological tension. In order to release the dorsal skin tension, the Z-plasty skin flaps were transposed to achieve lengthening. Utilizing 5-0 nylon the skin was reapproximated. The apices were coapted and maintained with an apical suture followed by simple interrupted sutures for the arms. The previously dissected second and third digits were properly maintained in an anatomical position relative to the fourth digit by the use of K-wires, and the extensor apparatus and skin anatomically repaired (Figs. 5, 6).

After the tourniquet was released, the vascular status of all the digits returned to their preoperative state instantaneously. The surgical sites were dressed under adequate compression and a below knee nonweightbearing plaster cast was applied. The sutures were removed after 3 weeks, and a short leg cast reapplied. At 10 weeks postoperative, the short leg cast and K-wire were removed. The patient's foot was placed in a zinc oxide medicated bandage and a postoperative shoe for an additional 2 weeks. Follow-up photographs of postoperative x-rays are provided from 2 to 14 months (Figs. 7–10). The patient progressed uneventfully until follow-up at 14 months, which was the patient's last postoperative contact.

Discussion

The authors believe that this case demonstrates an excellent autogenous choice when confronted with brachymetatarsia. It allows one to harvest an autogenous

Figure 5. Postoperative radiographic appearance showing the shortened second and third digits maintaining stability by 0.045-inch Kirschner wires, as well as the autogenous bone graft transposed into the hypoplastic fourth metatarsal with 0.045 inch intramedullary Kirschner wire.

Figure 6. Postoperative clinical appearance of the adjusted digital hyperbola secondary to the shortened second and third digits and lengthened fourth metatarsal. Notice the central arm of the Z-plasty is now perpendicular to the direction of length that was achieved.

graft through an approach very similar to that of a digital arthroplasty, thus decreasing technical difficulty. The long bone of the phalanx allows rigidity as well as preservation of metatarsal length with less resorption. This procedure should be reserved only for feet with elongated digits two and three in which the width of the proximal phalanx is comparable to that of the hypoplastic metatarsal.

The insertion of an inlaid bone graft into a hypoplastic metatarsal will force the adjacent neurovascular structures to elongate, thus decreasing the arterial lumen with possible vascular embarrassment or neuropraxia. Because of this potential complication, the surgical goal is to approach the ideal metatarsal parabola without causing vascular embarrassment.

The authors' approach to this deformity is an acceptable cosmetic compromise. This unique autogenous choice allows the surgeon to create a more desirable digital hyperbola without compromising the vasculature. In those cases where complete lengthening poses a significant risk, the lack of metatarsal length is compensated by adjacent digital shortening. Each digital shortening would allow for approximately 5.0 mm of metatarsal length. The authors were able to obtain 1.2 cm. of length without vascular compromise, while altering the digits to a more desirable hyperbola.

The choice of Z-plasty skin incision is threefold. First, it allows the surgeon adequate exposure without the tension of excessive retraction. Second, it provides adequate length upon transposition of the skin flaps and third, the surgeon does not have to commit to the Z-plasty. One can start with the central arm only, and add the proximal and distal arms to create the "Z" if length is needed. This is similar to adjusting a V-Y incision at the end of a procedure, which would also be a good skin incision for this procedure.

This unique procedure has been performed three times at Medical Arts Center Hospital without complications. Complications for this procedure may include: vascular compromise, neuropraxia, nonunion, delayed union, malunion, avascular necrosis of the metatarsal head and/or bone graft, or infection. Careful planning must be exercised before any brachymetatarsia procedure is to be attempted. Adequate information concerning risks and benefits must be reviewed with the patient so that proper informed consent could be received, especially when dealing with cosmesis only.

Summary

Brachymetatarsia is a challenging deformity which has perplexed podiatric and orthopedic surgeons for

Figure 7. Two-month postoperative view with intramedullary 0.045-inch smooth Kirschner wire fixation.

Figure 9. Four-month postoperative view.

Figure 8. Three-month postoperative view, 2 weeks after the Kirschner wire fixation was removed.

Figure 10. Fourteen-month postoperative view.

years. There are a variety of surgical techniques available to treat this deformity. The authors have demonstrated a unique choice in autogenous bone grafts to be taken from the distal one third of the proximal phalanx of the second and third digits of the ipsilateral foot. By using bone from the digits, the graft provides good cortical stability and preservation of length while allowing a better overall cosmetic result by shortening the adjacent digits. The use of this procedure is limited to those patients with elongated second and third digits, with the distal one third width similar to that of the hypoplastic metatarsal. Successful brachymetatarsia repair requires meticulous dissection, bone management skills, and a well informed patient.

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