BRACHYMETATARSIA: RECENT ADVANCES IN SURGICAL TECHNIQUE

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Brachymetatarsaia is a well known, though relatively uncommon condition presenting to the podiatric physician. Simply stated, the deformity consists of an abnormally short metatarsal bone. When more than one metatarsal is involved, it is referred to as brachymetapody. The majority of physicians are more familiar with the congenital forms of the deformity, however, traumatic, infectious, and iatrogenic etiologies have also been described.

Congenital forms of this abnormality are thought to be due to a premature, idiopathic closure of the distal epiphyseal growth plate on the involved metatarsal. Kite reported its occurrence in some feet following casting for metadductus or clubfoot deformities.[1] In hereditary forms, the fourth metatarsal is typically involved. Usually, the deformity is unilateral, but bilateral occurrences are not rare. The congenital pattern has also been associated with several pathologic conditions. These include diseases such as neonatal hyperthyroidism, pseudohypoparathyroidism, pseudo-pseudohypoparathyroidism, malignancy, Down's syndrome, Albright's syndrome, multiple epiphyseal dysplasia, myositis ossificans, Turner's syndrome, and sickle cell anemia.[2]

Traumatic, infectious, and iatrogenic causes of brachymetatarsia are not as predictable as the congenital forms in their occurrence. These other types of brachymetatarsia do not show a predilection for a specific metatarsal. In addition, the abnormality may be present as a component of a wide variety of painful forefoot conditions. A major concern to the physician in treating this condition is the status of the joint. If the metatarsal head has been resected and the joint destroyed, then any reconstructive surgical procedure contemplated for the correction of this deformity would require more than just a simple solution.

CLINICAL PRESENTATION

Symptomatology is usually noted in adolescence when the full growth discrepancy is most apparent. In the younger patient, the only complaint may be the unsightly appearance of the shortened toe. As the deformity progresses, symptoms develop in the area of the forefoot.

The most apparent characteristic of the deformity is a short floating toe. (Fig. 1) Though the toe is straight, its

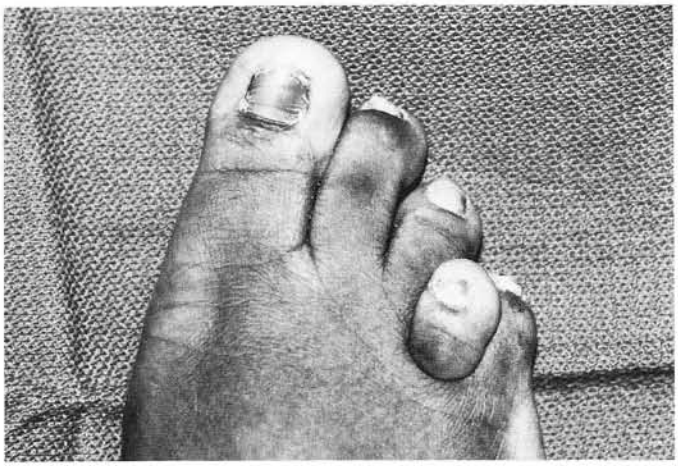

Fig. 1 Typical presentation of a congenital form of brachymetatarsia with floating fourth digit.

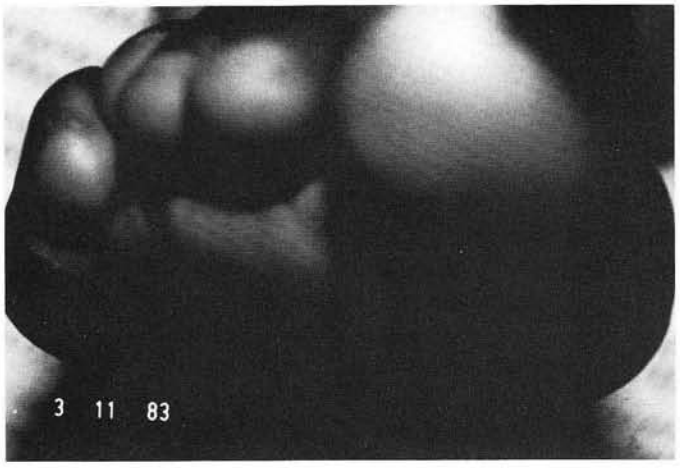

Fig. 2 Clinically, a sulcus can be seen under the involved metatarsal representing the abnormal parabola.

proximal location results in a relatively dorsiflexed attitude compared to the adjacent toes. The adjacent toes typically underlap the involved toe. Plantarly, a sulcus is present beneath the involved metatarsal. (Fig. 2) While the skin beneath the adjacent metatarsal heads often reveals tyloma formation or intractable plantar keratosis, symptoms may also occur over the dorsal aspect of the involved toe as it is irritated by shoe gear.

The decreased weight bearing capacity of the involved segment is readily apparent by performing a push-up test. Flexion of all the digits will occur with the exception of the affected ray. This is due to the inability of the flexor apparatus to load and stabilize the digit on the metatarsal head. Therefore, a floating toe results with adjacent metatarsalgia.

In contrast to congenital forms, the iatrogenic and traumatically induced types of brachymetatarsia are usually more acute and severe in their presentation. Conditions that result in an inordinate amount of shortening or elevation of the metatarsal are included in these categories. The amount of associated disability typically depends on the amount of weight that is transferred to the adjacent metatarsal heads.

OPERATIVE CONSIDERATIONS

Before deciding on a surgical procedure, several preoperative considerations need to be entertained:(1) the amount of length needed to restore the normal metatarsal parabola, (2) whether to lengthen/plantarflex the involved metatarsal or shorten/elevate adjacent metatarsals, (3) soft tissue mobility and neurovascular status of the involved ray including the toe, and (4) use of bone graft and if so, what type - autogenous or allogenic.

There have been numerous types of surgical procedures described for the treatment of brachymetatarsia. The majority of these procedures have centered around lengthening osteotomies with or without bone grafting.[3-11] The reported success rates has been quite satisfactory and encouraging. However, there are certain disadvantages and potential complications associated with each of these procedures. The complications include delayed or non-union of the graft, absorption or collapse of the graft, and development of a painful pseudarthrosis at the graft site. Other complications include the development of postoperative neurovascular compromise or a painful limitation of motion at the metatarsophalangeal joint.

The authors present a new surgical technique under current investigation at Northlake Regional Medical Center. The procedure is designed to be performed in two stages. The initial surgery is intended to increase peri-articular soft tissue mobility by use of an external fixation device. The subsequent procedure, performed approximately 3 weeks later, addressees the osseous aspects of the deformity by use of a diaphyseal sliding osteotomy and application of rigid internal fixation as described by AO/ASIF.

TECHNIQUE

The initial surgery is performed through a dorsal longitudinal incision extending from the proximal interphalangeal joint of the toe to approximately the mid-shaft area of the involved metatarsal. Alternatively, two small dorsal longitudinal incisions can be used. One incision located distally at the level of the metatarsophalangeal joint and one proximally over the metatarsal shaft. (Fig. 3) Dissection is carried through the superficial fascia ensuring identification of all crossing vessels and the development of proper surgical hemostasis as needed. By following the principles of anatomic dissection, minimal tissue disruption results and the surgical layers will be preserved for the subsequent procedure. The extensor brevis tendon to the involved metatarsal is then identified and transected. (Fig. 4) The long extensor tendon is not lengthened at this time due to the detrimental effects the subsequent gradual distraction may have on the initial periods of tendon healing. Maintaining the integrity of the long extensor did not limit the amount of resultant distraction. Lastly, attention is directed to the level of the metatarsophalangeal joint where a dorsal, medial, and lateral capsulotomy is performed. Plantar soft tissues are normally not a source of limitation and do not require lengthening.

The proximal phalanx and metatarsal are then prepared for insertion of the external fixation device (Synthes model). (Fig. 5) The periosteum is carefully dissected off both bones and one self-tapping screw is inserted into each diaphysis. The screws are then clamped to the external fixator. (Fig. 6) The periosteum is carefully sutured, followed by anatomic closure of the superficial fascia and skin. A dry, sterile dressing is then applied, with care being taken to adequately pad the fixation device. (Fig. 7) The patient is kept non-weight bearing throughout both surgeries.

The postoperative lengthening process can be performed by the physician or the patient. Only in those cases where extreme patient compliance is expected should the latter method be used. The device should be lengthened approximately 0.5-1.0 mm on a daily or every other day basis for a total of three weeks.

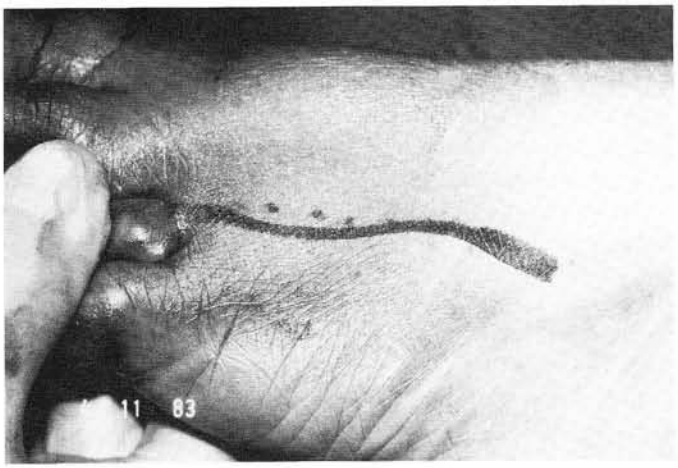

Fig. 3 Typical skin incision extending from the proximal phalanx over the metatarsophalangeal joint and ending at the proximal portion of the metatarsal.

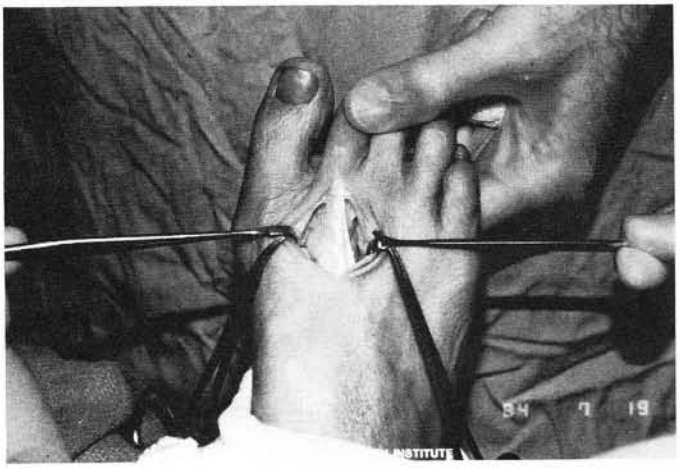

Fig. 4 As part of the initial procedure, the extensor brevis tendon is identified and transected.

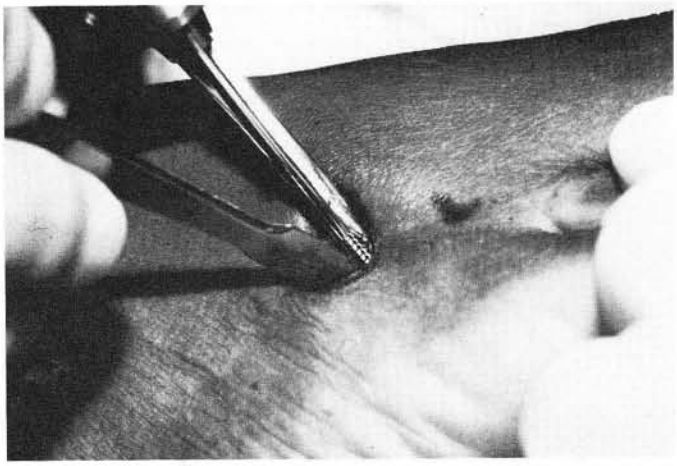

Fig. 5 One 2.7mm self-tapping screw is inserted into the metatarsal and one into the proximal phalanx prior to final connection to the external frame.

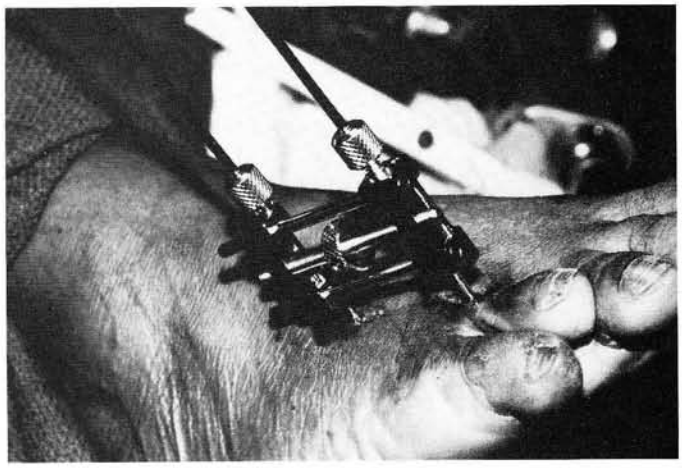

Fig. 6 Final appearance of the external fixation device before dressing application. The circular knob in the center of the device allows for gradual distraction.

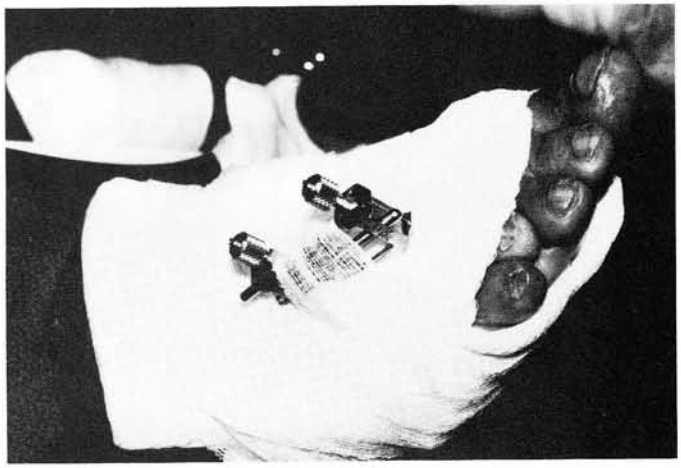

Fig. 7 Care is taken to apply extra padding around the fixation device during dressing changes.

Approximately three weeks after the initial procedure, the second surgery is performed. The original incision is again used, applying the same principles of anatomic dissection and layer preservation. The involved ray is isolated by carefully stripping all soft tissue along the sides including the interosseous muscles. The long extensor tendon is identified at this time and is lengthened in an open z-type or sliding fashion. (Fig. 8) Distally at the level of the metatarsophalangeal joint, the deep transverse intermetatarsal ligament is resected on each side of the involved metatarsal head. This maneuver will be important to facilitate in distal displacement of the capital fragment. When reflecting the periosteum, the more proximal portion of the metatarsal is included to prepare for the osteotomy. As the external fixator is removed, the additional length of the dorsal soft tissues is readily apparent.

Fig. 8 As part of the second surgery, the long extensor tendon is identified and lengthened.

A frontal plane Z-osteotomy is then performed using power instrumentation. The longitudinal portion of the "Z" is oriented parallel to the shaft of the bone and is approximately centered in the midshaft of the metatarsal. (Fig. 9) A dorsal-proximal exit, and a plantar-distal exit are created to complete the "Z" configuration. The distal fragment may then be lengthened in a sliding fashion to the desired length. If the soft tissues have been adequately addressed in the first procedure, the needed correction is easily obtained. With the metatarsal in its corrected position, temporary fixation is afforded with a bone clamp. Using the techniques described by the AO/ASIF group, one 2.0 cortical screw is delivered perpendicular to the fracture site. (Fig. 10) As the distal fragment is distracted, a defect will be evident at the proximal and distal portions of the osteotomy. To accelerate repair of this defect, an onlay graft is applied and fixated to the intact plantar portion of the shaft with a second 2.0 cortical screw. (Fig. 11) The layers are then closed as previously described with special attention directed at repair and maintenance of the periosteum.

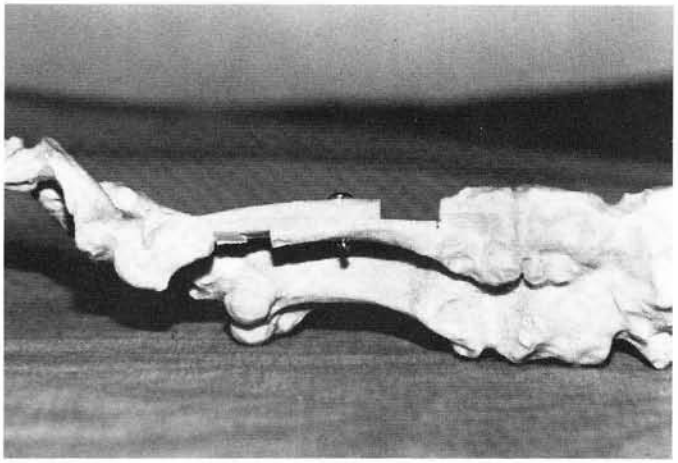

Fig. 9 Proposed frontal plane Z-osteotomy using bone model.

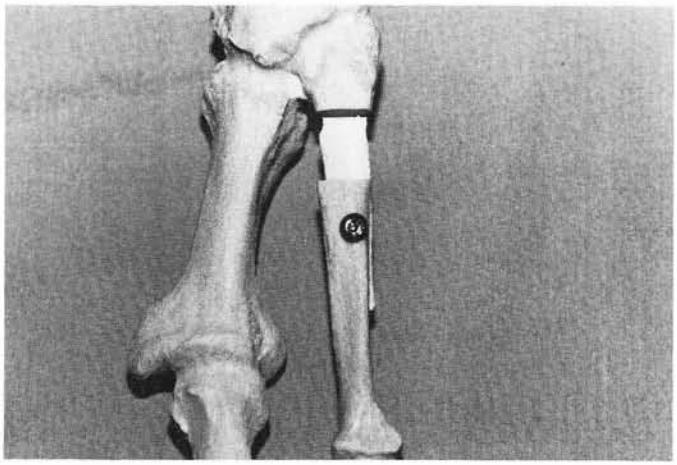

Fig. 10 The fragments are fixated with a 2.0 cortical screw delivered from dorsal to plantar.

A below the knee synthetic cast is applied following a sterile dressing. The patient is kept non-weight bearing until healing is complete (approximately 6 weeks).

RESULTS

Early results of this two-stage repair are encouraging (Fig. 12 A, B). However, because follow-up time has been minimal, it has not allowed adequate time to identify complications. Potential complications include delayed or non-union of the osteotomy or graft site, and fracture of the weakened diaphyseal portions of the shaft. This is readily appreciated when considering the tenuous nature of the osteotomy and the effects weight bearing could have on disrupting the fragments.

CONCLUSION

The technique described by the authors offer an alternative for the surgical repair of symptomatic brachymetatarsia deformities. The procedure takes into account the contracted dorsal tissues and the effects that the contracted tissue can have on limiting the amount of obtainable correction. The risk of neurovascular compromise is also minimized by using this technique. The described osteotomy facilitates stability by rigid internal fixation and permits primary bone healing. Although at this time it is too early to determine its true success, early results are encouraging.

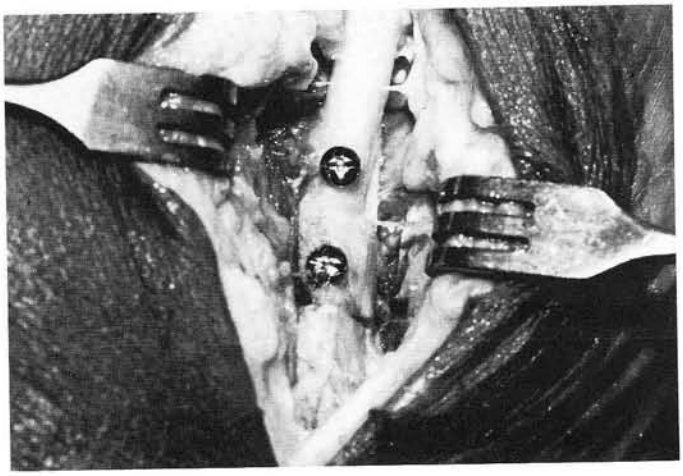

Fig. 11 An allogenic bone graft fashioned to fill and aid in repair of the proximal defect. The graft is fixated with a second 2.0 cortical screw delivered from dorsal to plantar.

Fig. 12A. Preoperative radiograph revealing a congenitally short fourth metatarsal.

Fig. 12B. Postoperative radiograph demonstrating a significant increase in length of the short fourth metatarsal.

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