ANATOMIC DISSECTION IN THE SURGICAL CORRECTION OF METATARSUS ADDUCTUS

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The purpose of this paper is to review the anatomy and the application of surgical dissection techniques to the complex anatomic region of the mid-foot in the deformity of metatarsus adductus. Anatomic dissection is the cornerstone of any successful surgical procedure and no more critically demonstrated than in the challenging deformity of metatarsus adductus.

The primary purpose of anatomic dissection is to provide adequate surgical exposure for the execution of multiple osteotomies at the base of all five metatarsals. The overlying soft tissues however, are fragile and easily traumatized. Anatomic dissection is a technique which preserves tissues layers and identifies the key components of pathologic anatomy. Specific anatomic structures and individual tissue layers are preserved. This allows anatomic reconstruction and closure and ultimately a more functional anatomic result.

Anatomic dissection is also the key to controlling bleeding in the extensive dissection process. Control of bleeding is based on identification of individual vessels before they are transected and dissection between tissue planes. Maintaining hemostasis through the techniques of anatomic dissection actually preserves the blood supply to vital structures and tissues. This concept and technique controls bleeding, reduces hematoma and minimizes postoperative edema, pain, and other complications.

HISTORIC REVIEW

Review of the literature for descriptions of surgical dissection in metatarsus adductus only reveals a brief discussion concerning skin incisions in the surgical approach to the mid-foot. Heyman and associates (1958) described a traditional transverse skin incision across the bases of the metatarsals for the soft tissue release in the infant deformity. Kendrik (1970) described the surgical approach through two parallel longitudinally oriented incisions; one between the first and second metatarsals and the second overlying the fourth metatarsal. He however preferred the transverse approach for ease of exposure.

The obvious reluctance to use a transverse approach to the midfoot for the surgical correction of metatarsus adductus is the danger of transection of vital structures, most of which run in a longitudinal orientation. These structures include; vessel, nerve, lymphatics, tendon and intrinsic muscle. The resultant "all in one" healing of the surgical wound creates a line of adhesion transversely across the dorsum of the foot which effectively binds all extensor function of the digits and may even lead to extension deformity. Sensory distribution is obviously disrupted to the dorsum of the forefoot while vascular supply and lymphatic drainage may not be as significantly affected because of plantar orientation.

The longitudinal orientation of skin incisions would obviously allow for a surgical dissection which would minimize transection of these vital structures. However, it introduces the need for medial and lateral excursion through tissue planes to provide exposure of the underlying target metatarsal bones. This excursion is the surgical technique that is found to be difficult and an obstacle to most surgeons not familiar with the intricate anatomy of the dorsum of the midfoot.

While a double longitudinal incision approach can be used, we have found the triple incision technique described by Johnson (1978) to be the most effective and useful approach to metatarsus adductus deformity (Fig. 1). It is also of great advantage in other mid-foot techniques such as reduction or arthrodesis of the LisFranc's joint.

TOPOGRAPHICAL ANATOMY AND PLACEMENT OF SKIN INCISIONS

Accurate placement of the three skin incisions for the approach to metatarsus adductus depends on the surgeon's ability to palpate and determine the location of the base of each individual metatarsal. The medial incision is a standard dorsomedial approach to the first metatarsal alone. The middle incision is more difficult to place and lies over the second and third metatarsals. The lateral incision will provide exposure to the bases

Fig. 1. Three incision approach to metatarsus adductus repair.

of the fourth and fifth metatarsals. There are a variety of other factors and findings that will play an important role in the placement and execution of these incisions.

The medial incision is made along the dorsomedial aspect of the first metatarsal. The incision should begin proximal to the metatarsocuneiform joint and course distally to the neck of the first metatarsal. The length of incision will facilitate reflection of underlying tissues and adequate exposure for osteotomy and fixation techniques. In marking the incision, the course of the medial dorsal cutaneous nerve and medial marginal vein should be anticipated. Both are likely to be encountered and are easily mobilized and retracted once identified.

The central incision is oriented for exposure of the second and third metatarsals. However, in the metatarsus adductus deformity it is often feasible to expose the three central metatarsals through this incision. The surgeon should initially palpate and identify the shafts of the individual metatarsals distally in the forefoot region. The individual shaft is then followed proximally by deep palpation and the junction of each adjacent metatarsal base is plotted.

By using this technique, each individual metatarsal base can be marked on the skin surface before the incision is created. In metatarsus adductus, the topographic location of the metatarsal bases can be quite deceiving. The individual metatarsal bases are located quite lateral to their apparent or anticipated position. An inexperienced surgeon may pursue the central incision thinking he is coming down on the third metatarsal base and actually find that he has exposed only the second metatarsal. The incision should begin proximally at the level of the navicular and extend distally over the contour of the third metatarsal.

The incision should be carried to the level of the neck of the metatarsal. The length of the incision will facilitate exposure of deeper structures. The added length will make it possible to readily expose both the second and fourth metatarsals through the central incision without excessive retraction or distortion of tissue layers. The primary branches of the intermediate dorsal cutaneous nerve are directly beneath the intended incision. The specific nerve branches may be palpated and marked on the skin before the incision is performed.

The lateral incision can be used to expose both the fifth and fourth metatarsals. The junction of the bases of the fourth and fifth metatarsals should be identified as far proximal as possible. The contour of the base of the fifth metatarsal must be clearly outlined and the exaggerated extension of its styloid process must not distort the planned incision. The incision should begin proximally over the cuboid and extend distally between the shafts of the fourth and fifth metatarsals. The course of the lateral dorsal cutaneous nerve should be anticipated.

EXPOSURE OF THE FIRST METATARSAL

A controlled depth incision technique is used to make the medial and first incision. The skin edges are allowed to retract and dissection is carried into the superficial fascia. A side-to-side blunt separation technique can be used to divide the superficial fascia. The technique can be easily accomplished with a Metzenbaum scissor or even a curved hemostat. Small superficial veins may be encountered and dispatched as necessary. The primary vein that will be identified is the medial extension of the dorsal venous arch as it comes off of the medial marginal vein. In most cases it is necessary to clamp, section and ligate this vessel to gain unrestricted access to the base of the first metatarsal. Occasionally, the position of the venous arch is proximal enough to allow retraction rather than transection. If this is the case, it is mobilized and preserved.

Once the dorsal venous arch is elevated, the separation of the superficial fascia from the well defined deep fascia begins to occur more readily. A moistened sponge may be used to literally peel the superficial fascia from the deep fascia throughout the entire length of the incision. Additional extension inferiorly and medially may require an instrument to facilitate exposure. The inferior flap of tissue, including the skin and superficial fascia, may be elevated and retracted with a Senn retractor to reveal the primary extension of the medial dorsal cutaneous nerve (Fig. 2). The nerve may be retracted within the superficial fascia and preserved.

With the superficial fascia fully reflected and the deep fascia cleanly exposed, the extensor tendons are readily visualized. The extensor hallucis longus tendon is seen clearly and is consistently accompanied by the vestigial slip of the extensor hallucis capsularis (Fig. 3). The deep

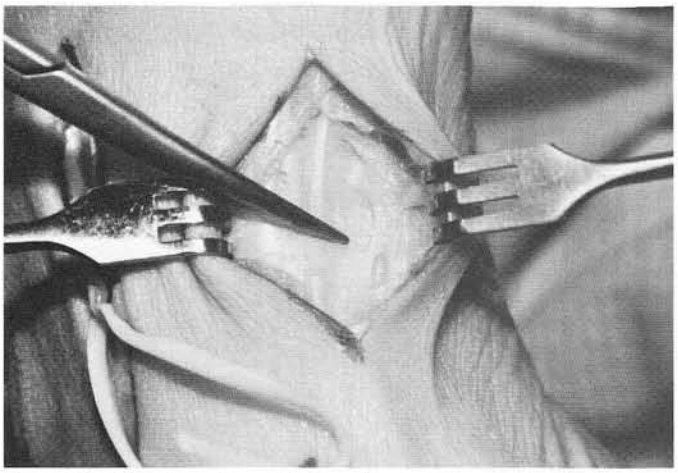

Fig. 2. Identification of medial dorsal cutaneous nerve within superficial fascia in medial incision.

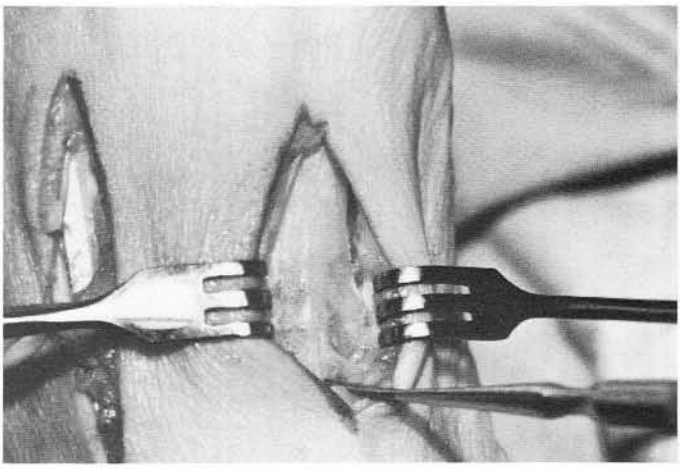

Fig. 5. Periosteal reflection and exposure of shaft and base of first metatarsal. Periosteal elevator demonstrating level of metatarsocuneiform joint.

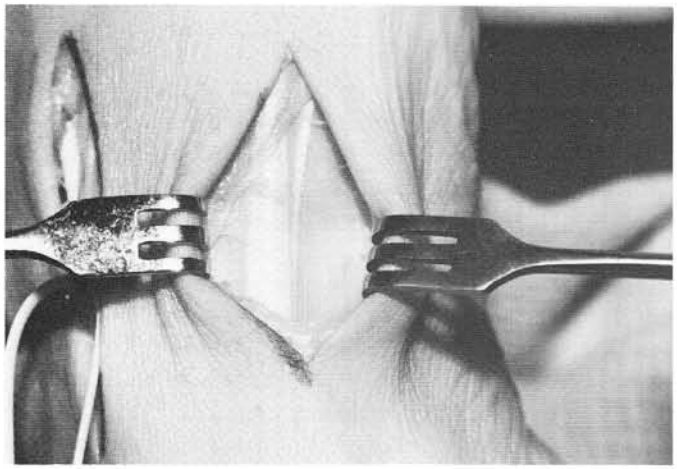

Fig. 3. Demonstration of deep fascia and underlying extensor hallucis longus tendon and extensor hallucis capsularis.

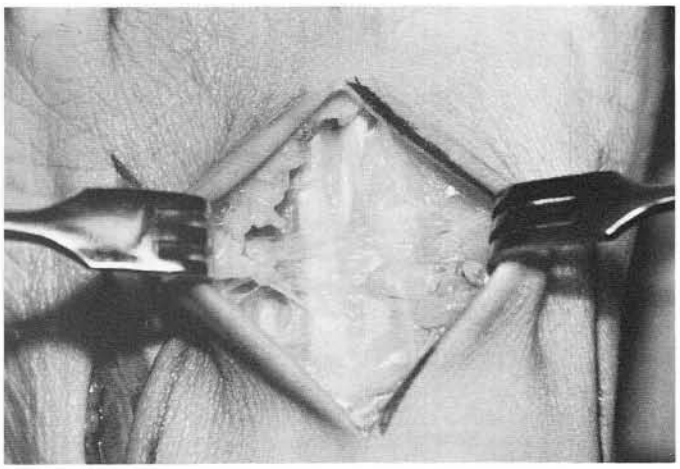

Fig. 6. Central incision demonstrating lateral branch of medial dorsal cutaneous nerve within superficial fascia.

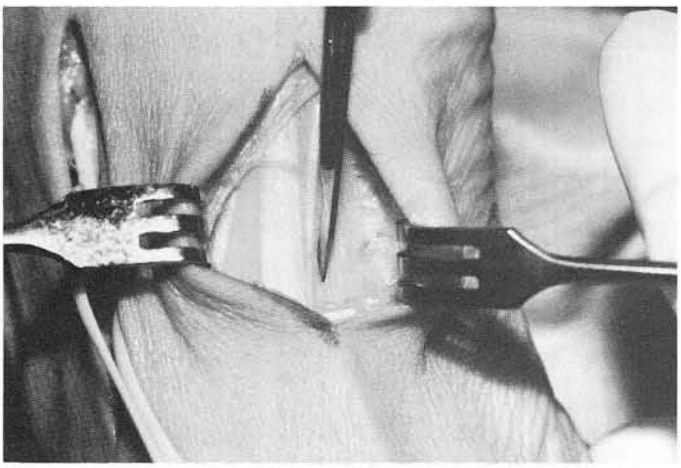

Fig. 4. Incision into deep fascia and periosteum over shaft of first metatarsal.

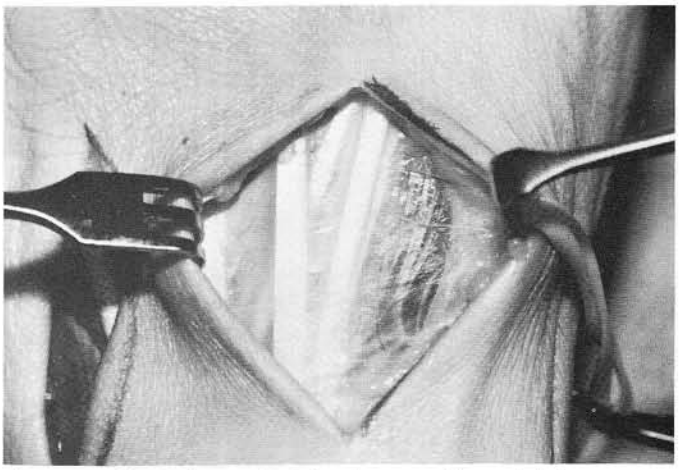

Fig. 7. Deep fascia of central incision demonstrating underlying extensor digitorum longus tendons.

fascia can be separately incised with a Metzenbaum scissor and the extensor tendons may be retracted laterally. Similarly, a deep incision may be made though deep fascia and periosteum together and sub-periosteal dissection used to expose the base of the metatarsal (Figs. 4, 5). Adequate reflection of periosteum must be performed to allow for both osteotomy and fixation techniques. The dissection technique for reflection of periosteum must be exacting and deliberate. If performed meticulously, the entire periosteal layer may be preserved and retained for complete closure following osteotomy and fixation. If the periosteum is shredded or destroyed, bone healing may be compromised.

Exposure of the first metatarsal base in the adult is quite similar to that for any base osteotomy. The child however, will demonstrate the physeal plate of growing bone. The physeal line must be identified clearly and great care must be taken to avoid its violation by the osteotomy or the fixation device.

CENTRAL INCISION: EXPOSURE OF THE CENTRAL METATARSALS

A controlled depth incision technique is very important in creating the central incision over the forefoot region. The superficial fascia or subcutaneous layer is often quite thin. In this area it is possible not only to lacerate superficial veins with a deep incision, but also to transect a dorsal cutaneous nerve as well. The skin edges are allowed to retract freely and then gentle separation of the superficial fascia is performed. Individual veins are ligated as necessary. A moistened sponge is readily used to peel the superficial tissues from the deep fascia over the long extensor tendons. This tissue plane separation should be created from one end of the incision to the other. Individual branches of either the medial or intermediate dorsal cutaneous nerves will be encountered and must be preserved and retracted within the superficial fascia (Fig. 6).

The deep fascia is a thin but well defined layer encasing the extensor structures over the dorsum of the foot. The tendons of the extensor digitorum longus are first visible through the deep fascia (Fig. 7). A Metzenbaum scissor is used to cleanly incise the deep fascia and provide an entrance into the superficial compartment over the base of the metatarsals (Fig. 8).

At this point, the surgeon can greatly facilitate his surgical technique by allowing his finger tips to see the anatomy of the area. The starting point for the deeper dissection is the dorsal surface of the shaft of the second metatarsal. Deep palpation can be used to clearly identify the metatarsal shaft, and once located, it is quite apparent that the dorsal ridge of the shaft is clearly visible and only covered by periosteum. The medial segment of the extensor digitorum brevis muscle and tendon will be seen coursing over the proximal shaft of the second metatarsal (Fig. 9) and may be easily retracted by cleanly separating it from the underlying periosteum.

The separation maneuver is usually accomplished by a gentle separation with the Metzenbaum scissor (Fig.10). Once the brevis is retracted, the full course of the dorsal shaft and base of the second metatarsal may be identified. There may be an isolated vessel coursing across the base of the metatarsal within the deep periosteal

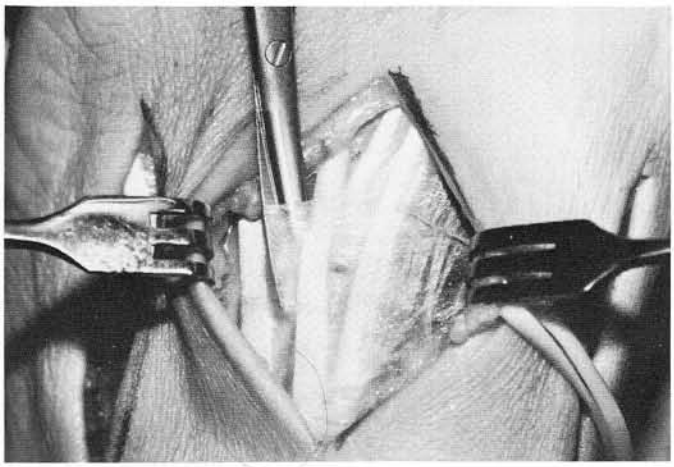

Fig. 8. Incision of deep fascia in central incision.

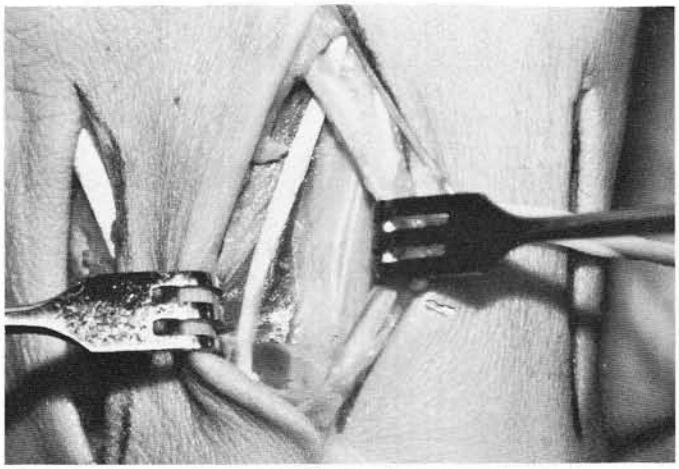

Fig. 9. Retraction of extensor digitorum longus tendons and exposure of extensor digitorum brevis segment.

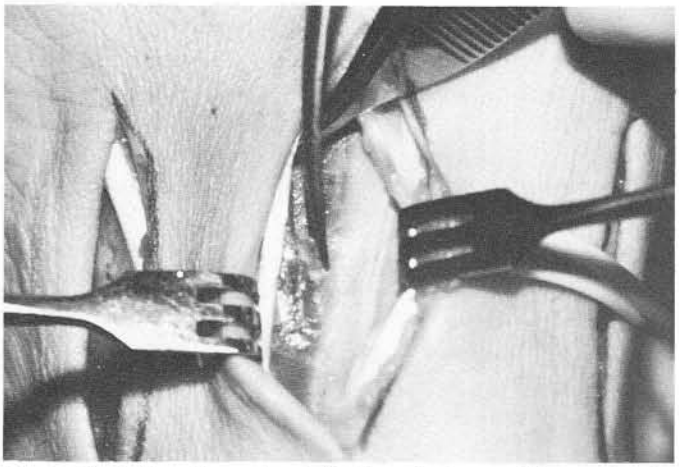

Fig. 10. Blunt dissection and mobilization of extensor digitorum brevis segment.

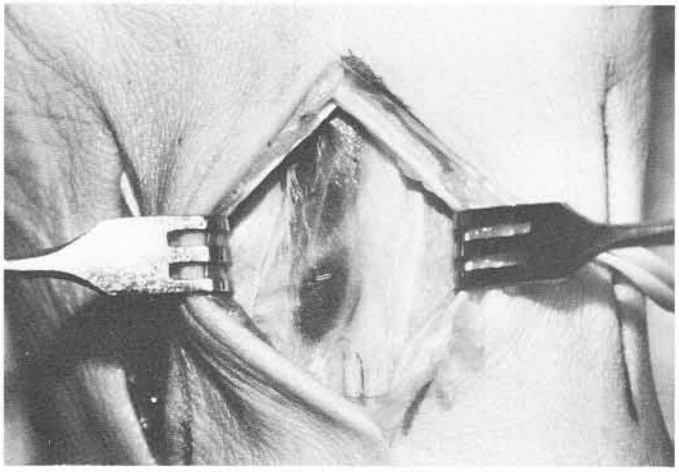

Fig. 11. Demonstration of dorsal aspect of shaft of second metatarsal with adjacent dorsal interossei muscle.

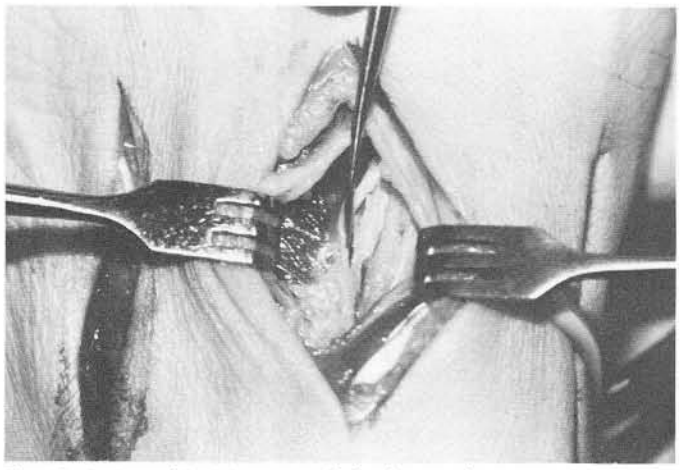

Fig. 12. Periosteal incision over shaft of second metatarsal.

covering, but the neurovascular bundle of the deep peroneal nerve and dorsalis pedis artery are usually found just medial to the shaft of the second metatarsal. The muscle tissue lying medial and lateral to the shaft of the second metatarsal represents the dorsal interosseii (Fig.11).

A clean periosteal incision may then be made along the dorsal ridge of the metatarsal shaft beginning distally and coursing proximally to the level of the metatarsocuneiform joint. A Freer periosteal elevator is used over the shaft of the metatarsal to cleanly separate the periosteum and interossei muscle from the medial and lateral surfaces of the metatarsal shaft (Fig.12). A sharp knife may be necessary to reflect the more densely applied tissues from the base of the metatarsal (Fig.13).

With the second metatarsal fully exposed, dissection is oriented along the shaft of the third metatarsal. The same basic technique is followed with palpation of the metatarsal shaft distally. The clean surface of the shaft is followed proximally between the individual slips of the extensor digitorum brevis to the level of the metatarsocuneiform joint. The brevis segments are separated along the intermuscular septa and retracted and the periosteum of the shaft of the third metatarsal is incised and reflected. The fourth metatarsal may be exposed through the central incision if there is adequate length of incision to allow for retraction and lateral excursion. If excessive force is required to expose the shaft of the fourth metatarsal, it should be approached through the lateral incision.

LATERAL INCISION: EXPOSURE OF THE FOURTH AND FIFTH METATARSALS

Dissection through the lateral incision will occasionally encounter a crossing or communicating branch of the lateral dorsal cutaneous nerve. The nerve should be protected and retracted if possible. The deep fascia over the shaft of the fourth and fifth metatarsals is exposed in a fashion similar to the previous two incisions. Incision through the deep fascia over the base and shaft of the fourth metatarsal will reveal the tendinous slip of the extensor digitorum longus to the fifth toe (Fig. 14). This tendon is readily retracted laterally to reveal the most lateral segment of the extensor digitorum brevis muscle to the fourth toe. The muscle is gently elevated and retracted to expose the periosteum along the dorsal lateral ridge of the fourth metatarsal shaft.

A longitudinal periosteal incision is then made in the periosteum to expose the shaft of the fourth metatarsal (Figs. 15,16). The fifth metatarsal is approached by reflec-

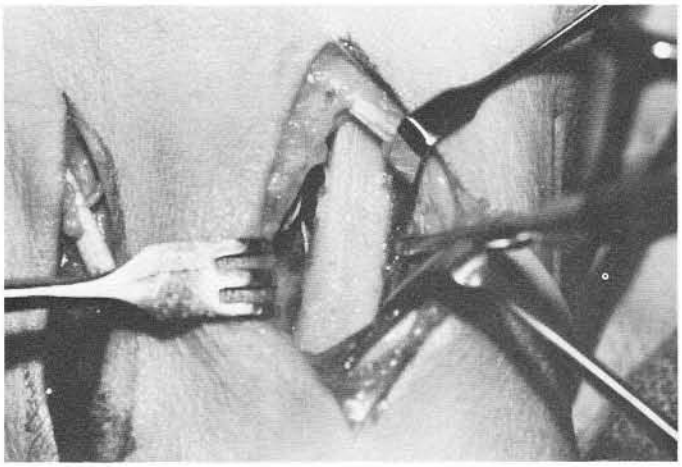

Fig. 13. Exposure of shaft and base of second metatarsal.

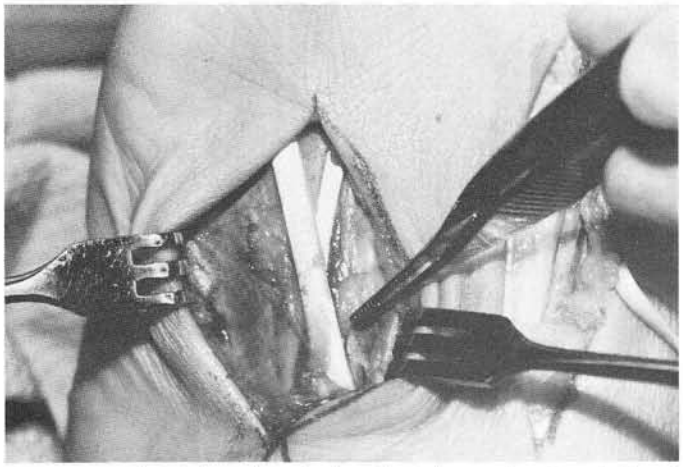

Fig. 14. Lateral incision; deep fascia reflected revealing lateral slip of extensor digitorum longus and underlying extensor digitorum brevis segment.

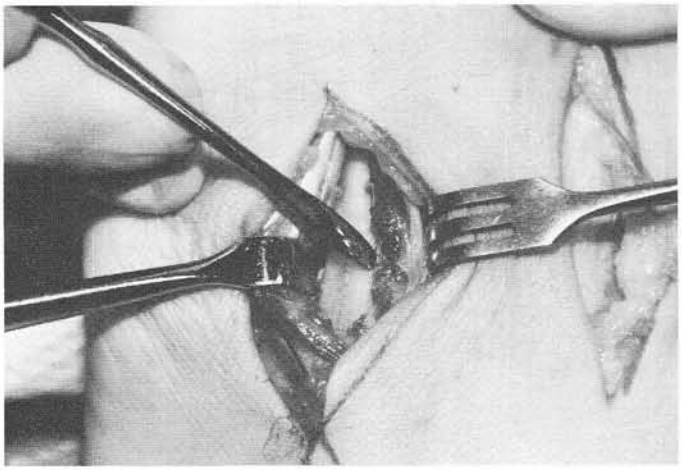

Fig. 15. Periosteal incision and reflection from fourth metatarsal.

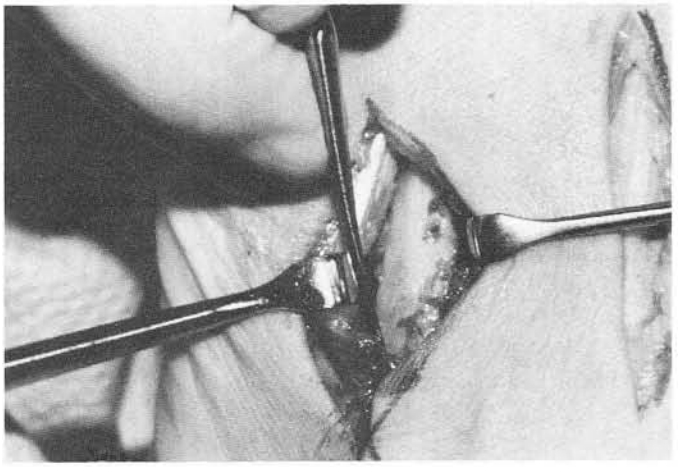

Fig. 16. Exposure of base and shaft of fourth metatarsal.

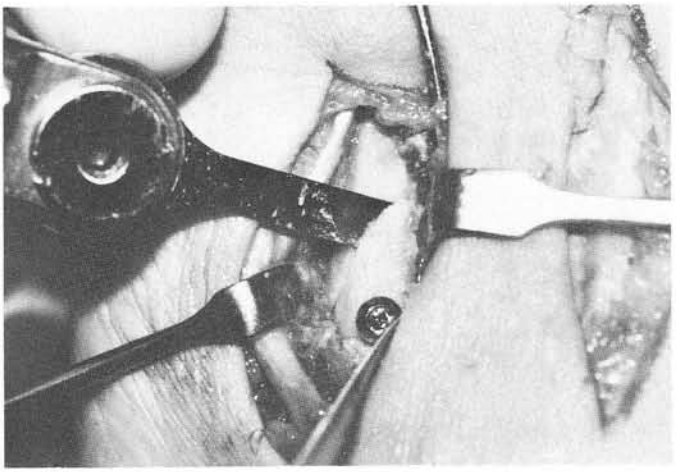

Fig. 17. Fourth metatarsal; completion of osteotomy with internal fixation device in place.

ting the digitorum longus tendon medially and identifying the shaft by palpation. The same subperiosteal reflection technique is used to expose the metatarsal.

OSTEOTOMY AND INTERNAL FIXATION

Once all five metatarsals have been cleanly exposed, the individual bones are osteotomized and fixated (Fig. 17). Frequent irrigation is recommended to avoid dessication of the fragile soft tissues and care must be taken with retraction to avoid mutilation of muscle by the oscillating saw blades and pressure injury from overzealous retraction. Radiographs should be taken to confirm position and alignment before closure is begun.

CLOSURE

The deeper tissues are closed in specific layers following completion of the osteotomies and internal fixation. The periosteum over each individual metatarsal is closed separately with 3-0 Dexon suture (Fig.18).

The intermediate tissues including the extensor digitorum brevis segments and the extensor digitorum longus tendons are allowed to fall back into place and are not sutured. The deep fascia is then apposed and sutured with a running 3-0 Dexon suture.

The superficial fascia or subcutaneous layer is closed with a running 4-0 Dexon suture with great care taken not to encircle one of the dorsal cutaneous nerves. The skin is finally closed in each incision with an intradermal technique using 5-0 or 6-0 Dexon and reinforced with Steri-strips (Fig. 19).

The use of closed wound suction or TLS devices is recommended to avoid hematoma and excessive edema. Edema is also controlled with the use of the standard Jones' compression dressing or splint. Drain tubes are usually removed within 24 to 48 hours and the primary surgical dressings are changed at 72 hours. If all incisions are clean and intact, a clean dressing and below-knee cast are applied.

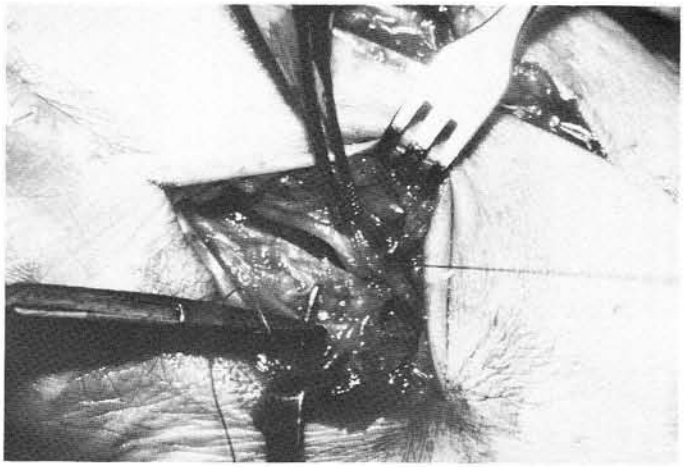

Fig. 18. Closure of periosteum over fourth metatarsal.

Fig. 19. Final skin closure.

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