THE INVERTED SCARF BUNIONECTOMY

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The "SCARF" osteotomy was first developed by the podiatric staff at the University of Chicago Medical Center in 1983. Gudas et al., modified the transverse plane osteotomy technique described by Mau and Lauber. The technique involved two additional cuts in the metatarsal which "Z-out" at the distal and proximal ends of the primary osteotomy. The primary osteotomy is created longitudinally in the mid-shaft region of the metatarsal creating an upper 2/3 and a lower 1/3 of the metatarsal shaft. This relationship is created to provide a strong dorsal shelf for weightbearing. The "Z" configuration was completed by cutting out dorsally at the distal end of the primary osteotomy and plantarly at the proximal end of the longitudinal cut. Each secondary arm was angled approximately 70-80 degrees from the primary osteotomy. (Fig. 1) The plantar portion of the metatarsal was then shifted laterally into the desired position and fixated with cortical bone screws.

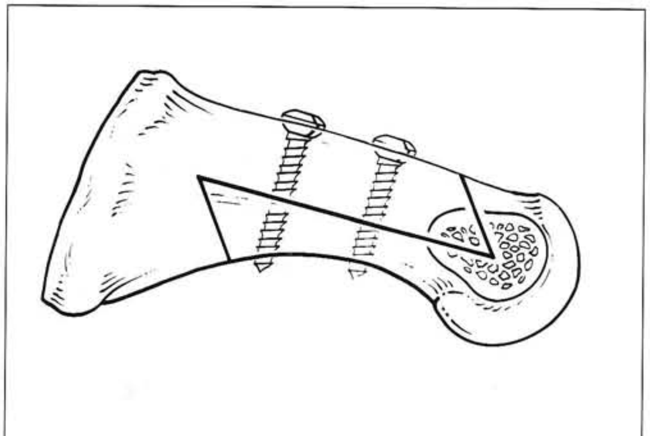

Fig. 1. Traditional SCARF osteotomy designed to provide a strong dorsal shelf for weightbearing.

Zygmunt et al., 1989 described the University of Chicago experience of 1,100 cases. In 1986, Glickman described a "short Z" and mentioned the importance of the dorsal shelf for weightbearing stability. Fixation was accomplished by 0.045 Kirschner wires. He also stated that an inverted osteotomy would require the additional stability of two 3.5 mm cortical screws to prevent elevation or fracture from weightbearing forces. In 1987, Schwartz reported his experience of over 230 procedures at Atlanta Hospital. Threaded 0.062 Kirschner wires were utilized with the traditional "Z" osteotomy.

RATIONALE FOR THE INVERTED "Z"

In analyzing the configuration of the classic "Z" osteotomy, it becomes apparent that the weakest point of the osteotomy is the stress riser created as the dorsal shelf joins the proximal plantar wing of the osteotomy. (Fig. 2) In actuality, the longitudinal cut and the distal arm do not even enter into the equation of stability of the osteotomy or its ability to resist the dorsiflexory forces of weightbearing. The originally described "Z" is only as strong as the proximal plantar osteotomy is shallow. One can imagine creating a plantar cut up into the base of the first metatarsal running at the angle of the proximal plantar cut of the "Z" osteotomy; the deeper the cut is carried into the metatarsal, the greater the stress riser and

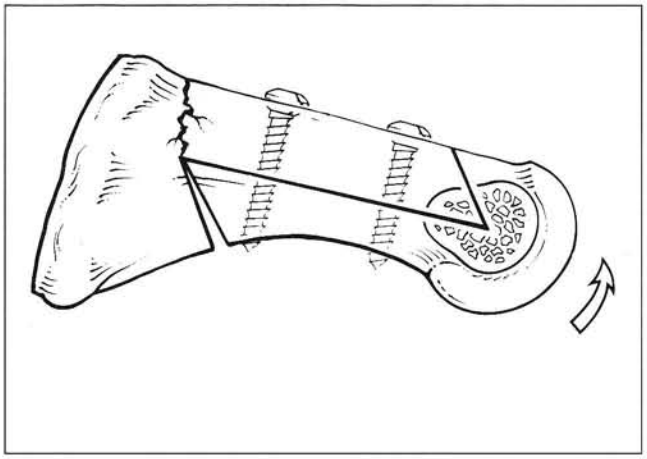

Fig. 2. Illustration of failure seen with the traditional SCARF osteotomy. The stress riser produced through the plantar cortex in turn propagates weightbearing forces through the dorsal cortex.

the thinner the intact dorsal section of the metatarsal; the thinner the dorsal section of the metatarsal, the weaker the bone and the easier it is to fracture the intact dorsal portion of the metatarsal base. The proximal plantar cut in the metatarsal is a notch, and the deeper the notch, the easier it is to break the branch. Hence, the original authors' valid recommendation for creating the longitudinal osteotomy in the lower 1/3 of the metatarsal "to create a stronger dorsal shelf" to resist fracture with weightbearing of the osteotomy.

The point however, is that the inverted "Z" cut is inherently stronger than the traditional "Z" even if it is cut in the lower 1/3 of the metatarsal bone.

The strength of the inverted "Z" lies in understanding the tension side of the bone. The long plantar shelf includes the anatomic tension surface of the first metatarsal. As weightbearing is transmitted through the first metatarsal head, pressure is transmitted through the opposing and interlocking surfaces of the distal plantar arm of the inverted "Z" osteotomy. Dorsiflexory loading is then transferred directly to the proximal metatarsal segment and is absorbed primarily along the plantar cortex, which is acting as a tension band. (Fig. 3) An intact plantar cortex is the cornerstone of this sound mechanical prin.:ple as it is applied to reconstructive surgery of the first metatarsal.

Experimental Model

A stress/strain device was utilized to assess the strength of the traditional SCARF versus the inverted SCARF osteotomy. (Fig. 4) The osteotomies were performed on plastic saw bones and each model was fixated with two (2.7 mm) cortical screws. With the metatarsal-cuneiform joint securely stabilized, dorsiflexory forces were incrementally applied to the first metatarsal-phalangeal joint. As predicted, the traditional scarf osteotomy fractured at the intersection of the horizontal and proximal arms. The stress riser created from violation of the plantar cortex propagated superiorly through the dorsal

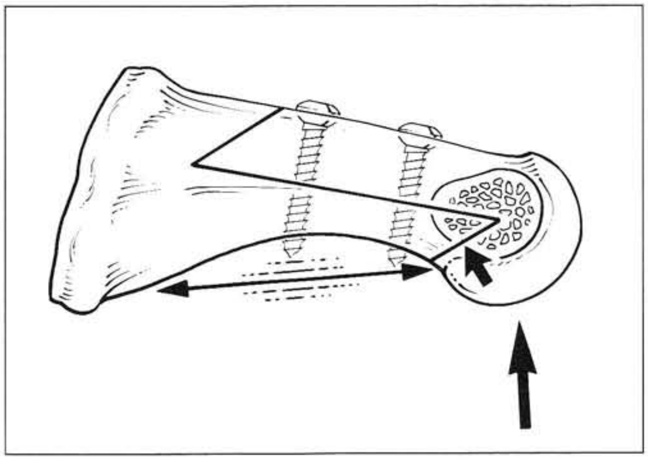

Fig. 3. The Inverted SCARF osteotomy. The intact plantar cortex functions similar to a "tension band" to resist weightbearing forces. Solid contact of the interface at the distal arm is essential for application of the "tension band" concept.

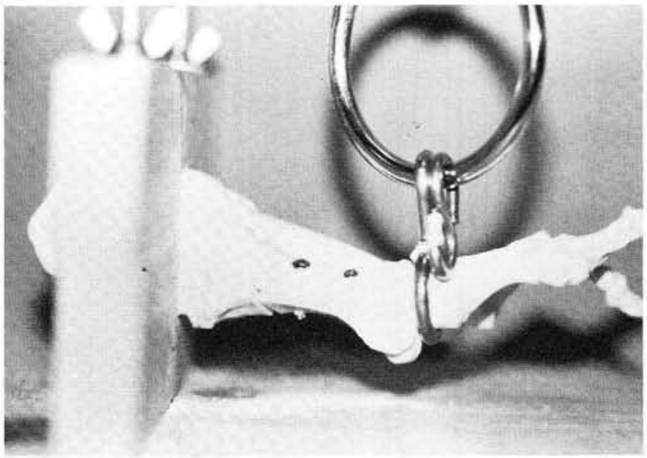

Fig. 4. Experimental model designed to quantify relative stress/strain properties in first metatarsal osteotomies. The midfoot is rigidly secured while dorsal forces are applied to the first metatarsal-phalangeal joint.

cortex. (Fig. 5) This fracture pattern was consistently repeated as the osteotomy failed with as little as four pounds of dorsiflexory force.

The inverted scarf was tested in the identical manner as described above. Interestingly, this osteotomy failed at approximately eighteen pounds of dorsal force. Due to the intact proximal plantar cortex of the first metatarsal, the potential stress risers created by the screw holes became the site of fracture. A consistent fracture pattern was created through the proximal screw hole from plantar to dorsal. This failure point was also expected because the interlocking bone interface at the distal plantar osteotomy was well opposed, and the dorsal pressure was transferred directly to the proximal metatarsal segment and absorbed by the plantar cortex. Forces are greater at the proximal screw hole due to the greater distance between the proximal hole and the metatarsal head. This creates a greater lever arm and more stress on the proximal stress riser which should theoretically fail earlier. Our experimental model confirmed this nicely. (Fig. 6)

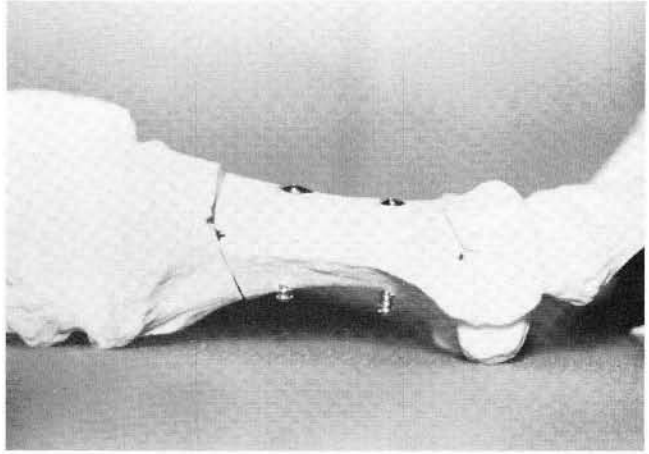

Fig. 5A. Failure of the traditional "Z" osteotomy; weightbearing force on the bone models consistently confirmed failure at this site.

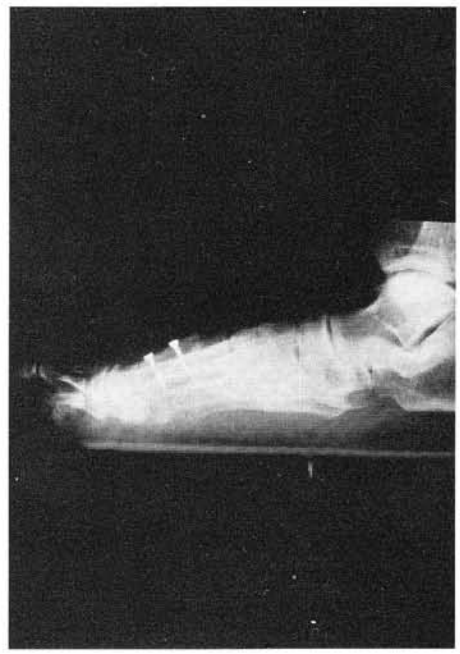

Fig. 5B. Postoperative radiograph of a traditional SCARF fracturing through at the dorsal cortex. Note the elevation of the dorsal cortical shelf.

CASE REPORT

A 40 year old female presented with the chief complaint of a painful bunion deformity of the left foot. She related having pain for several years with an aching and throbbing secondary to the bunion prominence. She had previously undergone surgical correction of a bunion deformity on the right foot (short Scarf) in 1986. She indicated that she was extremely pleased with the outcome of the surgery and had no postoperative complications. She had a rapid return to normal shoe gear including high-heeled shoes. Upon further questioning, she was aware of some calluses beneath the right foot, but these were essentially asymptomatic and were treated palliatively.

Her past medical history was unremarkable. She was in excellent health overall. She was taking no medications at the time and reported no allergies. Her review of systems was unremarkable and noncontributory as well.

Her physical examination revealed a medial bunion prominence of the left foot with a moderate hallux abductus deformity. There was minimal valgus rotation of the great toe. There was splaying between the first and second metatarsals of a moderate nature. Although her forefoot was much wider than her rearfoot, she had no complaints in this regard. Examination of the first metatarsophalangeal joint revealed approximately 60° of dorsiflexion and 20° of plantarflexion without crepitus. There was mild discomfort at the end range of motion. There was discomfort to palpation of the dorsomedial bunion prominence. The deformity was flexible in nature.

Examination of the right foot revealed a surgical scar overlying the first metatarsophalangeal joint. A residual bunion prominence was noted

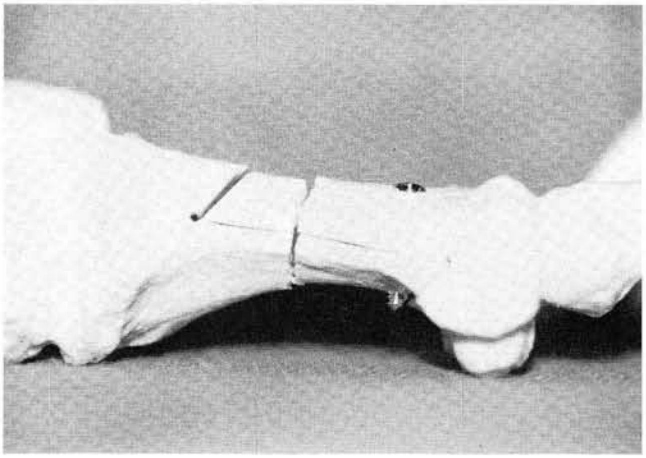

Fig. 6. Bone model illustration of fracture through the proximal stress riser created by the screw hole in the plantar cortex. The solid contact at the distal arm interface remains intact.

but was asymptomatic. A mild hallux abductus deformity was present. Range of motion was considered normal and without pain or crepitus. A diffuse tyloma beneath the second metatarsal head was noted. A similar lesion was not present on the left foot.

X-rays were taken of both feet and consisted of dorsoplantar, lateral, medial oblique, and forefoot axial views. The right foot showed a well-healed distal metaphyseal osteotomy consistent with a short "Z" or Scarf bunionectomy. A 4.0 cancellous screw was noted. Elevation of the distal fragment was noted, based on the lateral, oblique, and forefoot axial views. This was felt to be due to the "troughing" effect which has been previously reported with this type of osteotomy. Previous x-rays were not available for review and comparison.

The preoperative x-rays of the left foot were consistent with the clinical findings. A moderate hallux abductus deformity with a significant metatarsus primus adductus deformity was noted. Although the joint was in a deviated position, the overall architecture and configuration of the head of the metatarsal and base of the phalanx were felt to be normal.

Although a closing base wedge osteotomy would have been a preferable procedure, the patient elected to have a similar procedure to that performed on the right foot in light of the excellent clinical results. Because of her activities and employment, immediate postoperative weight-bearing was important to her. In September 1991, the patient underwent surgical correction of her bunion deformity. The surgical procedure consisted of a modified Scarf bunionectomy with internal cortex screw fixation. In order to decrease the troughing effect and potential for metatarsus primus elevatus, the osteotomy was performed in an inverted manner as previously described. One 2.7 and one 2.0 mm cortex screw were inserted to accomplish rigid internal compression fixation.

The patient's postoperative course was unremarkable. She underwent a very rapid return to normal shoe gear at 5 weeks with restoration of a full range of motion at 6 weeks postoperatively. The patient was ambulating in a surgical shoe for the first 5-1/2 weeks. A bunion night splint was maintained for 4 months. A foam spacer was used during the day while in shoes.

Although the patient has had some recurrence of the bunion similar to that of the right foot, the feet clinically are identical with the exception of the absence of any plantar lesion beneath the second or third metatarsals. There have been no complaints of metatarsalgia. Radiographic healing has been unremarkable. No complications of bone union including metatarsus primus elevatus have been noted. The patient is aware of the two small screws present in the first metatarsal bone. There is no plan to remove these unless they become symptomatic in the future.

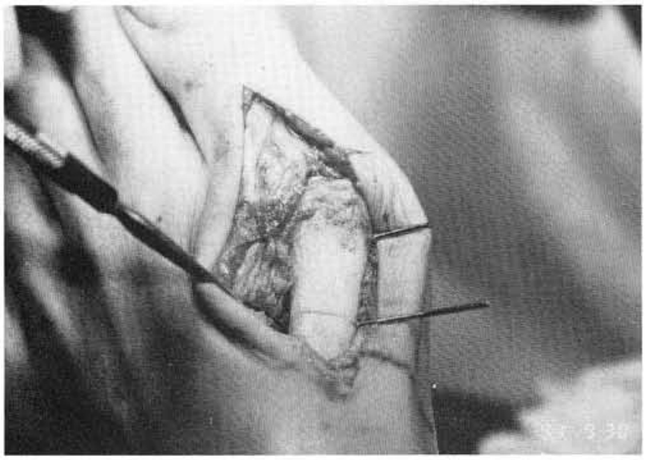

Fig. 7A and 7B. Two 0.045 Kirschner wires are utilized as an axis guide for the inverted scarf osteotomy. Note the parallel wires in

Fig. 7B.

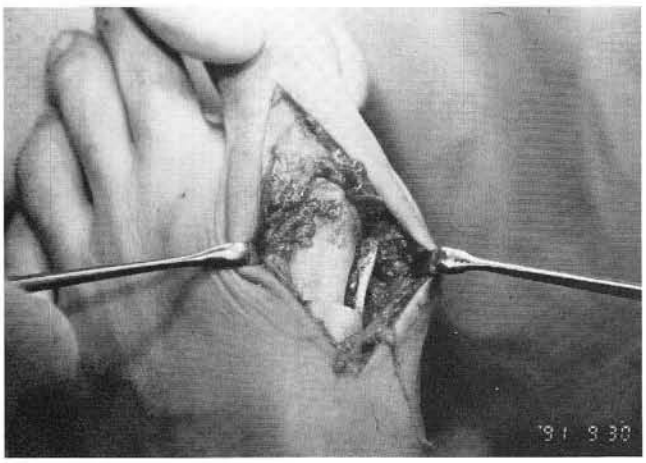

Fig. 8. Translocation of the capital fragment for correction of the intermetatarsal angle. Awareness of the medullary canal is important to avoid the "troughing" phenomena.

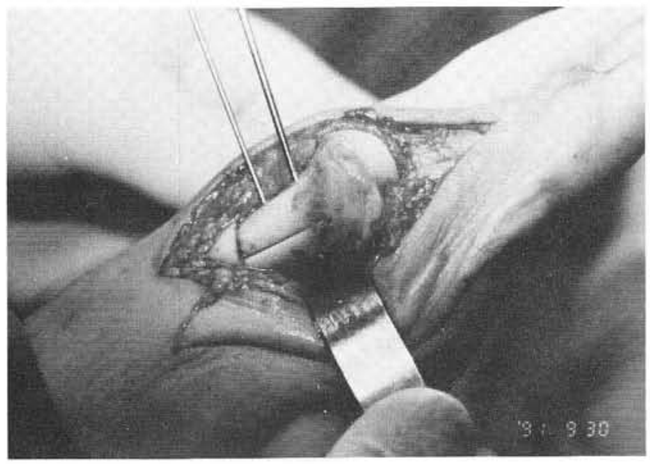

Fig. 9. Temporary fixation is established utilizing a 0.045 K-wire proximally and a 0.062 K-wire distally. These wires function as a pre-drill for the 2.0 mm and 2.7 mm cortical screws respectively.

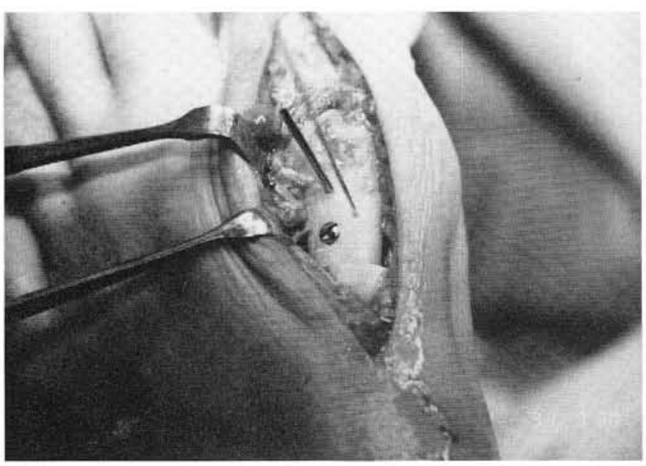

Fig. 10A and 10B. Screw sequence with the 2.0 mm screw in place first followed by a 2.7 mm screw. An extra K-wire has been placed medially to provide two points of fixation at all times during screw application to prevent any rotatory motion.

Fig. 10B.

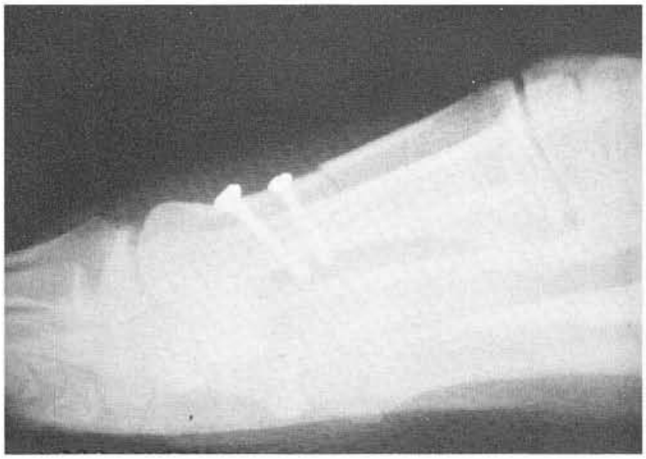

Fig. 11A and 11B. Postoperative radiographs of inverted SCARF bunionectomy fixated with two cortical screws.

Fig. 11B.

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