Surgical Treatment of Diaphyseal Stress Fractures of the Fifth Metatarsal in Competitive Athletes

Long-term Follow-up and Computerized Pedobarographic Analysis

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Background: Proximal diaphyseal stress fractures of the fifth metatarsal are common in athletes. Conservative treatment has been shown to result in high rates of delayed union, nonunion, and refracture, so internal fixation has become the treatment of choice in competitive athletes.

Methods: Twenty top-level athletes with diaphyseal stress fractures fixed with intramedullary malleolar screws were evaluated. Functional outcome was assessed by American Orthopaedic Foot and Ankle Society midfoot score. Static and dynamic maximum vertical force and peak plantar pressures were evaluated with a computerized pedobarograph.

Results: Mean follow-up from surgery to interview was 10.3 years (range, 3.5–19.0 years). Clinical healing was 95%, and there has been one refracture (5%). The mean time from surgery to return to sport was 9 weeks (range, 5–14 weeks). Twelve athletes (60%) returned to a higher level of training, 7 (35%) to the same level, and 1 (5%) to a lower level compared with the level of training before injury. Average American Orthopaedic Foot and Ankle Society midfoot score was 93.8 (range, 85–100). During the computerized pedobarographic evaluations, 18 patients (90%) presented with varus of the metatarsus and the midfoot and 2 (10%) presented with a normal plantigrade foot.

Conclusions: Intramedullary malleolar screws can yield reliable and effective healing of fifth metatarsal stress fractures in athletes. Varus of the metatarsus and the midfoot were predisposing factors for stress fractures in this population of competitive athletes, and all were recommended to wear orthoses until their competitive careers were completed. (J Am Podiatr Med Assoc 101(6): 517-522, 2011)

A diaphyseal fifth metatarsal stress fracture is defined as a stress fracture in the zone of the proximal fifth metatarsal immediately distal to the anatomical area of the Jones fracture.[1–6] These fractures are associated with a history of prodromal symptoms over the lateral aspect of the foot before the acute episode that leads the patient to seek medical care, radiographic evidence of stress phenomena in the bone, and no history of treatment for a fracture of the fifth metatarsal.[7]

Diaphyseal stress fractures of the fifth metatarsal occur often in athletes and are included in the group of "high-risk" stress fractures because of the difficulty in achieving union and the high rate of nonunion and refractures.[1–11] These fractures may have a protracted healing time of as much as 21 months, and nonunion can develop in up to 25% of nonoperated conservatively treated cases.[1, 3, 10]

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Therefore, many authors now favor surgical intervention for this fracture, especially in high-demand patients or athletes, but the optimal surgical treatment according to the literature has not yet been unanimously determined.[1, 6-11]

The purposes of this retrospective study were to evaluate the long-term results of diaphyseal stress fractures of the proximal fifth metatarsal treated by intramedullary fixation with a 4.5-mm malleolar screw in competitive athletes and to perform computerized pedobarographic analyses of the operated feet to determine whether any deformity is present that would predispose the athletes to sustain this type of fracture.

Materials and Methods

Twenty-four surgically treated patients with diaphyseal stress fracture of the fifth metatarsal were enrolled in this retrospective study. All of the patients underwent surgery in the Department of Orthopaedic Surgery, University Hospital Center Zagreb, School of Medicine, Zagreb University, between January 1, 1988, and December 31, 2003, by the senior authors (M.P. and I.B.). Four patients were not available for final follow-up (follow-up rate, 83.3%). The mean interval from surgery to the date of the final follow-up visit was 10.3 years (range, 3.5–19.0 years).

All of the patients underwent surgery by intramedullary fixation with a 4.5-mm AO malleolar screw (Instrumentaria, Zagreb, Croatia) without exposing the fracture site. Fluoroscopy was used routinely. A 3-cm straight incision was made parallel to the plantar border of the foot, beginning at the level of the tuberosity and extending proximally in line with the fifth metatarsal. The base of the fifth metatarsal was exposed. Once correct placement of the Kirschner wire in the medullary canal was confirmed, a 3.2-mm drill was inserted into the medullary canal in the same direction. The longest solid 4.5-mm partially threaded malleolar screw that fit into the medullary canal was selected. To achieve one of three stable fixation points, the longest screw possible was introduced into the medullary canal of the fifth metatarsal, and the cortex of the distal fragment was minimally (1–2 mm) penetrated by the tip of the screw (Fig. 1). Special attention was given to countersinking the screw head to minimize the chance of subsequent irritation of the lateral midfoot and to ensure that all screw threads were distal to the fracture site. Subcutaneous tissue and skin were subsequently closed.

All of the patients were immobilized with a short-leg cast for 3 weeks without weightbearing. After this, they were allowed weightbearing in a hard-soled shoe as tolerated. Running and jumping were restricted for the first 6 weeks postoperatively. The criteria for returning to sports participation included a painless physical examination of the fracture, full weightbearing without pain, and progressive radiographic findings of union.

Patients' clinical records were reviewed retrospectively for the date of surgery, radiographic findings, and complications. At the final follow-up visit, participants completed a questionnaire regarding their level of activity at the time of injury, the time needed for them to return to sports, their level of activity after returning to sports, and any problems resulting from the surgery. Participants' current status was evaluated by the American Orthopaedic Foot and Ankle Society midfoot scale. Pedobarographic analyses of the operated feet were performed with a mini-EMED platform (Novel GmbH, Munich, Germany), which consists of a matrix with three capacitive sensors per square centimeter. The signals produced from a maximum of 4,000 pressure sensors are displayed as a color picture (Fig. 2). Static and dynamic maximum vertical force and peak plantar pressures are shown in 22 segments, which allowed precise analysis of these parameters for the midfoot.

Results

The mean age of the patients (19 males and 1 female) was 21 years (range, 16–26 years). All of the athletes had recurrent or persistent prodromal symptoms (pain or discomfort) in the area of the proximal fifth metatarsal that is over the lateral aspect of the foot before the inciting injury.

Return to full activity after surgery took 5 to 14 weeks (mean, 9 weeks). Twelve athletes (60%) returned to a higher level of training than before the injury, 7 (35%) to an equal level of training, and 1 (5%) to a lower level than before their injury. The mean American Orthopaedic Foot and Ankle Society midfoot scale score at final follow-up was 93.8 (range, 85–100).

Clinical healing was 95%, and there has been one refracture (5%) that healed by nonoperative treatment. Healing of the fracture was seen on radiographs taken 4 weeks after the surgery. Refracture occurred a week later as a result of return to full sports activity despite the given medical advice. In the remaining patients, there were no more intraoperative or postoperative complications. There

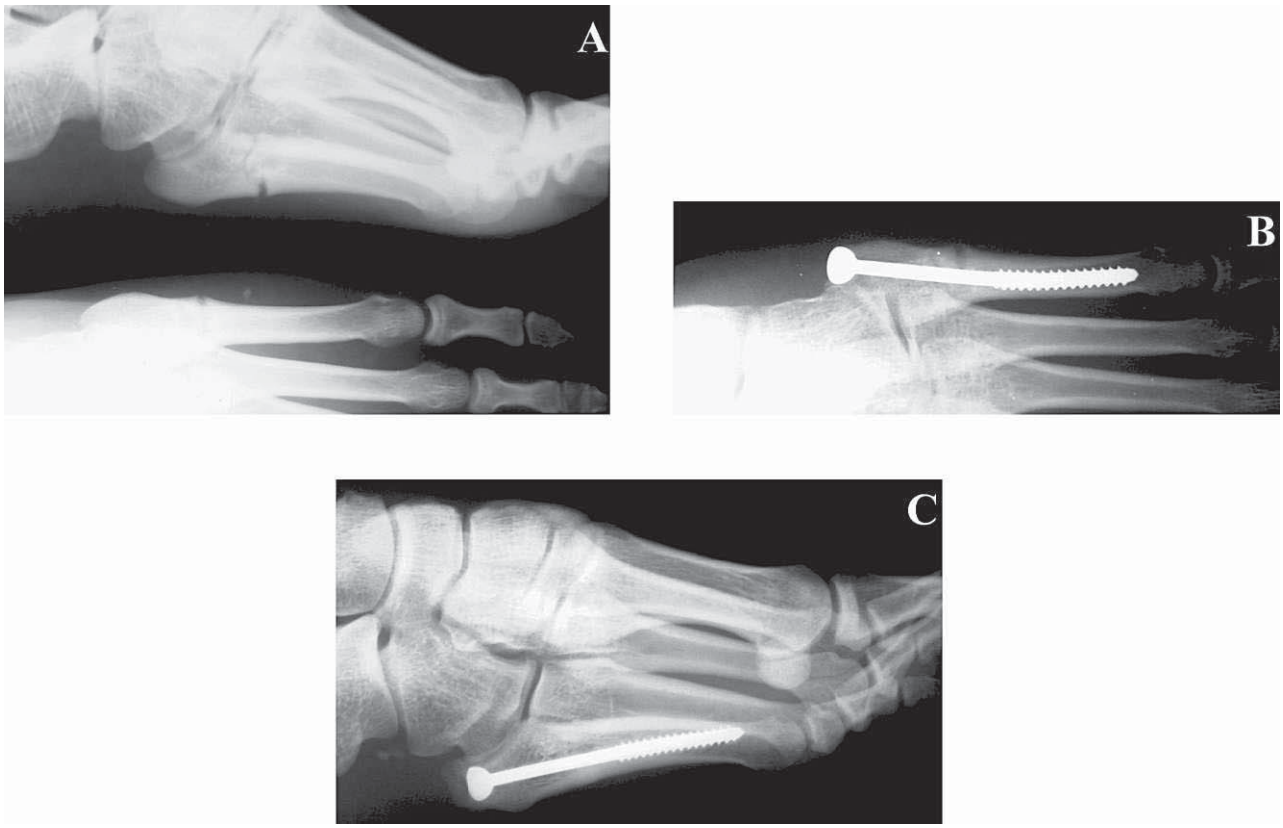

Figure 1. Radiographs of a soccer player (case 2). A, Preoperative radiograph showing periosteal thickening and intraosseous sclerosis; B, immediate postoperative radiograph showing proper placement of the screw; and C, radiograph taken at 18.5 years of follow-up.

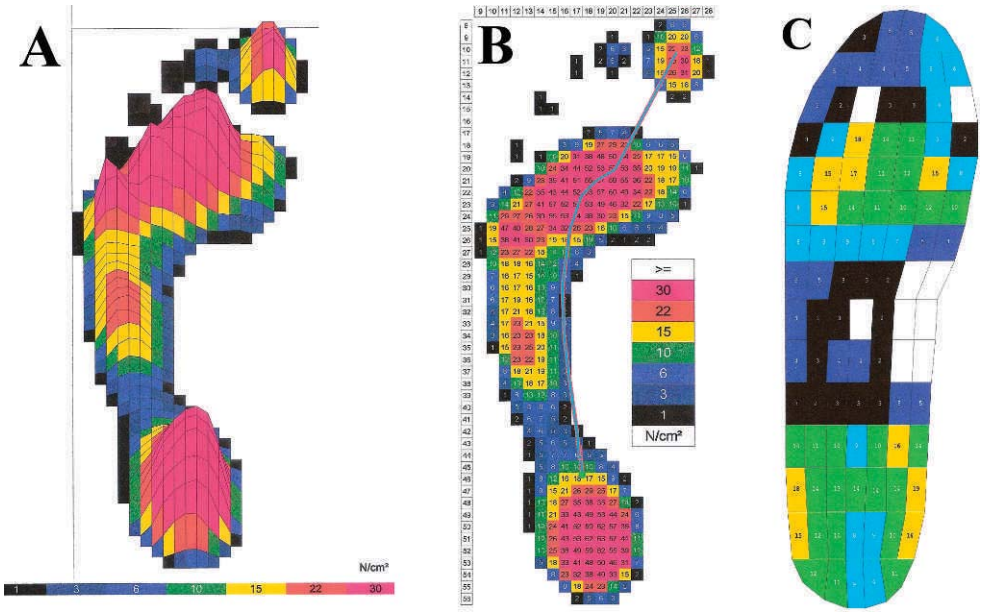

Figure 2. Pedobarograms of a soccer player (case 2) with a Jones fracture of his left foot. Three-dimensional analyses of the static (A) and dynamic (B) pedobarograms showing varus of the foot with the peak plantar pressures exerted on the lateral ray of the foot. C, Analysis of pressure distribution after the application of computer-aided design and computer-aided manufacturing of orthopedic insoles shows unloading of the lateral part of the foot.

were no wound complications in the early postoperative period. Lasting nerve injury was not detected at the last follow-up. There was no need for hardware removal.

At the final follow-up visit, computerized pedobarographic evaluations revealed midfoot varus in 18 patients (90%) (15 bilateral and 3 unilateral [injured side]). In bilateral cases, varus deformity was greater on the injured side (50%). There were only two patients (10%) with a normal plantigrade foot.

Discussion

Surgical treatment of diaphyseal stress fractures of the fifth metatarsal has proved to be a safe and effective treatment modality.[1–11] Compared with conservative treatment, surgical treatment offers quicker healing time, shorter time to return to full sporting activities, and a lower rate of complications.[1, 2, 6, 9, 11] Another advantage is the predictable time needed to return to full training, as this is one of the main issues in professional sports.[1, 2, 6, 9, 11]

The results of surgical treatment for diaphyseal stress fractures available from the medical literature are systematically presented in Table 1.[7, 11-17] Return to sports activities was 7.5 to 17 weeks after surgery, which is similar to the results obtained in the present group of surgically treated athletes.

Various methods of surgical treatment (intramedullary screw fixation,[7, 10-12, 15, 16, 18-20] corticocancellous bone grafting,[1, 3, 14, 17] and tension-band wiring[13]) have been proposed. The use of tension-band wiring was limited to one study only.[13] Because the technique demands a wider approach to the fracture site, we did not prefer it. Intramedullary screw fixation is the recommended method for treatment of diaphyseal stress fractures by most of the authors in the literature.[1, 6, 7, 9-12, 15, 16, 18-20] However, intramedullary screw fixation also has its drawbacks (symptomatic nonunion and refracture), as has been noted in some failure analyses.[19, 21, 22] Larson et al[19] found that the most significant difference between the group of failures and nonfailures was early return to play. A hybrid technique, intramedullary screw fixation associated with autologous cancellous bone grafting, seems to be a reasonable treatment for primary unsuccessful intramedullary fixation.[1, 14]

Although all of the cases in the study group had been operated on by use of intramedullary fixation with 4.5-mm malleolar screws, we now prefer 4.5-mm partially threaded cannulated screws. The main advantage of the partially threaded cannulated screws is the lower risk of misplacement through the small incision.[15, 20, 23] According to the initial stiffness and force required for final displacement, the biomechanical efficiency of the cannulated screw and the 4.5-mm malleolar screw are similar.[23] The fatigue strength characteristics of cannulated screws are deficient compared with those of solid ones, except in the larger screw sizes.[20] It is possible to use larger screws to get complete filling of the medullary canal.[18, 20] However, maximizing the screw diameter does not seem to be critical for fixation rigidity and may increase the risk of intraoperative fracture.[24]

It is well-known that early return to sports is a risk for refracture, and, thus, the athlete should be warned about this complication.[19, 21] In top-level athletes, computed tomography or magnetic resonance imaging should be considered before returning to training to avoid refracture.[21] Only one patient in the present study experienced reinjury, which healed on conservative treatment. This particular patient was noncompliant with instructions and returned to athletic training only a few weeks after the operation.

Pronounced cavovarus foot and flatfoot deformity are predisposing factors for an overuse injury of the fifth metatarsal in athletes.[14] If these deformities are recognized, shoe modifications/orthoses should be used after treatment of overuse injuries and before resuming sports.[14] Hindfoot varus may be another predisposing factor for these pathologic abnormalities and refracture; thus, proper varus-unloading orthotic inserts may be helpful to prevent refracture.[25] On the other hand, Hetsroni et al[26] concluded that athletes with proximal fifth metatarsal stress fracture were not characterized by an exceptionally static foot structure. Results of computerized pedobarographic analysis showed midfoot varus in most of the feet (90%). Varus position may increase dynamic and static peak pressure on the lateral ray. For these cases, specially designed orthopedic insoles that redistribute the forces acting on the foot may be helpful.[27] Computer-aided design and computer-aided manufacturing systems provide the possibility of three-dimensional design of individually created orthopedic insoles.[28] Furthermore, all athletes should be advised to wear the prescribed insoles until the end of their professional career. This study does carry some notable limitations. It is a retrospective study, and pedobarographic analyses were not performed before surgery.

In conclusion, because of the high risk of delayed healing, the fifth metatarsal diaphyseal stress reaction should be recognized earlier and aggres-

Table 1. Studies on the Surgical Treatment of Stress Fractures of Fifth Metatarsal Bones by the Year of Publication

Study (Year)	Surgical Treatment	No. of Reported Surgically Treated Patients	Time from Surgery to Return to Full Sports (Weeks)	Reported Complications	Follow-up (Months)
DeLee et al[7] (1983)	Intramedullary screw fixation (ASIF malleolar screw)	10	8.5	70% of patients complained of local pain over the screw head (or the fifth metatarsal head)	14.5
Torg et al[17] (1984)	Medullar curettage and autogenous corticocancellous inlay bone grafting	20	12.3	One persistent but asymptomatic nonunion; one noted vague discomfort in the foot	40.2
Hulkko et al[13] (1985)	Tension band fixation and two Kirschner wires	3	12	None	NA
	Drilling and a single thick Kirschner wire	1			
Quill[11] (1995)	Intramedullary screw fixation (4.5- or 7.0-mm cannulated screw)	9	6.5[a]	One nonunion	NA
Fernández et al[12] (1999)	Intramedullary screw fixation (AO malleolar screw)	9	9.5	One intraoperative (fracture of the lateral cortex of the tuberosity)	19
Portland et al[16] (2003)	Intramedullary screw fixation (AO 4.5-mm or a 5.0-mm cannulated screw)	7	8.8[a]	None	21
Porter et al[15] (2005)	Intramedullary screw fixation (4.5-mm cannulated screw)	24	7.5	None	22
Popovic et al[14] (2005)	Intramedullary screw fixation (4.5-mm malleolar screw)	10	12	Three refractures that underwent reoperation	38
	Intramedullary screw fixation (6.5-mm cancellous screw)	1	17	Intraoperative fracture of the distal medial cortex of the fifth metatarsal	
	Intramedullary screw fixation (4.5-mm malleolar screw) + ICBG	7	12	None	

Abbreviations: ASIF, Association for the Study of Internal Fixation; ICBG, iliac crest bone grafting; NA, not available.
[a]Only bone healing time was presented, ie, time from surgery to full return to sport was not reported.

sively treated. Intramedullary fixation of these fractures is the most widely accepted treatment modality due to its predictable and rapid union rate. Foot varus may be directly related to fifth metatarsal diaphyseal stress fracture. After treatment of these injuries, patients should use orthopedic insoles that decrease the loads at the proximal fifth metatarsal.

Financial Disclosure: None reported.
Conflict of Interest: None reported.

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