Injuries to the Midtarsal Joint and Lesser Tarsal Bones

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Abstract

Injuries to the midtarsal joint and lesser tarsal bones occur relatively infrequently and often present with a benign appearance on imaging studies. These facts may lead to failure of diagnosis and/or inadequate and improper treatment, with subsequent disability for the patient. The clinician with a general knowledge of the various injury patterns to the midfoot is able to approach these injuries rationally and with an appreciation of their potential severity. This article reviews the mechanism, clinical and radiologic presentation, and treatment of midtarsal joint injuries and midfoot fractures.

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The midfoot consists of the tarsometatarsal joint complex; the midtarsal (transverse tarsal) joint, which includes the talonavicular and calcaneocuboid articulations; and the lesser tarsal bones (tarsal navicular, cuboid, and cuneiform) that lie between them. Injuries to the midfoot can range from simple nondisplaced fractures and sprains to markedly displaced fractures and dislocations. These injuries are uncommon, but they may result in substantial disability for the patient, particularly if they remain undiagnosed and/or improperly treated.

In this article we will review injuries to the midtarsal joint and the lesser tarsal bones, which often occur simultaneously, and discuss diagnosis and treatment. Injuries to the Lisfranc joint, while mentioned in conjunction with injuries to the distal tarsal bones, have been covered in many excellent review articles and will not be considered in detail.

Midtarsal Joint Injuries

The midtarsal joint, also known as Chopart's joint, is a complex articulation that includes the talonavicular and calcaneocuboid joints. This joint lies in a plane transverse to the medial and lateral longitudinal arches of the foot. The lateral side of the midfoot is relatively rigid and stable, while the medial side is more dynamic and mobile.

Subluxations and dislocations of the midtarsal joint are relatively uncommon and often difficult to diagnose. They may be easily overlooked even after obtaining anteroposterior, lateral, and oblique weight-bearing radiographs. Thus, a high index of suspicion based on the presumed mechanism of injury must be maintained to avoid underdiagnosis of these injuries. Failure to appreciate these injuries can lead to significant disability and may necessitate late arthrodesis. Associated fractures of the foot are common, and the clinician must look carefully for them whenever an apparently isolated dislocation is identified. The entire foot must be carefully examined and palpated to appreciate the full extent of the injury. The neurovascular status of the foot must be assessed, and the possibility of a compartment syndrome should not be overlooked.

There have been numerous reports of midtarsal subluxations and dislocations in the literature.[1-7] The most extensive series is that reported by Main and Jowett,[1] who reviewed 71 midtarsal joint injuries. They identified five patterns of injury based on the direction of the applied force, the consequent direction of deformity, the presumed mechanism, and the extent of injury: medial, longitudinal, later-

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al, plantar, and crush. Although not a widely used classification system, it is very complete and can provide the clinician with a basic framework when evaluating these injuries.

Medial Injuries

Medial injuries were the second most commonly observed injury pattern in the series of Main and Jowett,[1] with a prevalence of 30%. They are divided into three subgroups: fracture-sprains (Fig. 1, A), fracture-subluxations (Fig. 1, B) and dislocations, and swivel dislocations (Fig. 1, C).

Fracture-Sprains

These injuries are caused by an inversion force applied to the foot. Radiographs show flake fractures of the dorsal margins of the talus or navicular and of the lateral margins of the calcaneus or cuboid. No dislocation is present. Although initial clinical examination and radiographic assessment may suggest that fracture-sprains are stable injuries, they have the potential for late displacement with unprotected weight bearing. They should be treated by use of a short-leg walking cast for 4 weeks, followed by use of a hard-sole shoe with a longitudinal arch support until the patient is free of pain in the foot.

Fracture-Subluxations and Dislocations

With these injuries, the forefoot is displaced medially as a result of injuries to both the talonavicular joint and the calcaneocuboid joint. The hindfoot remains in normal alignment with the tibia. Formal closed or open reduction with appropriate anesthesia is required. These injuries have a high potential to displace, and the safest treatment involves stabilizing the joint with Kirschner wires or other more rigid fixation methods, such as screw fixation.

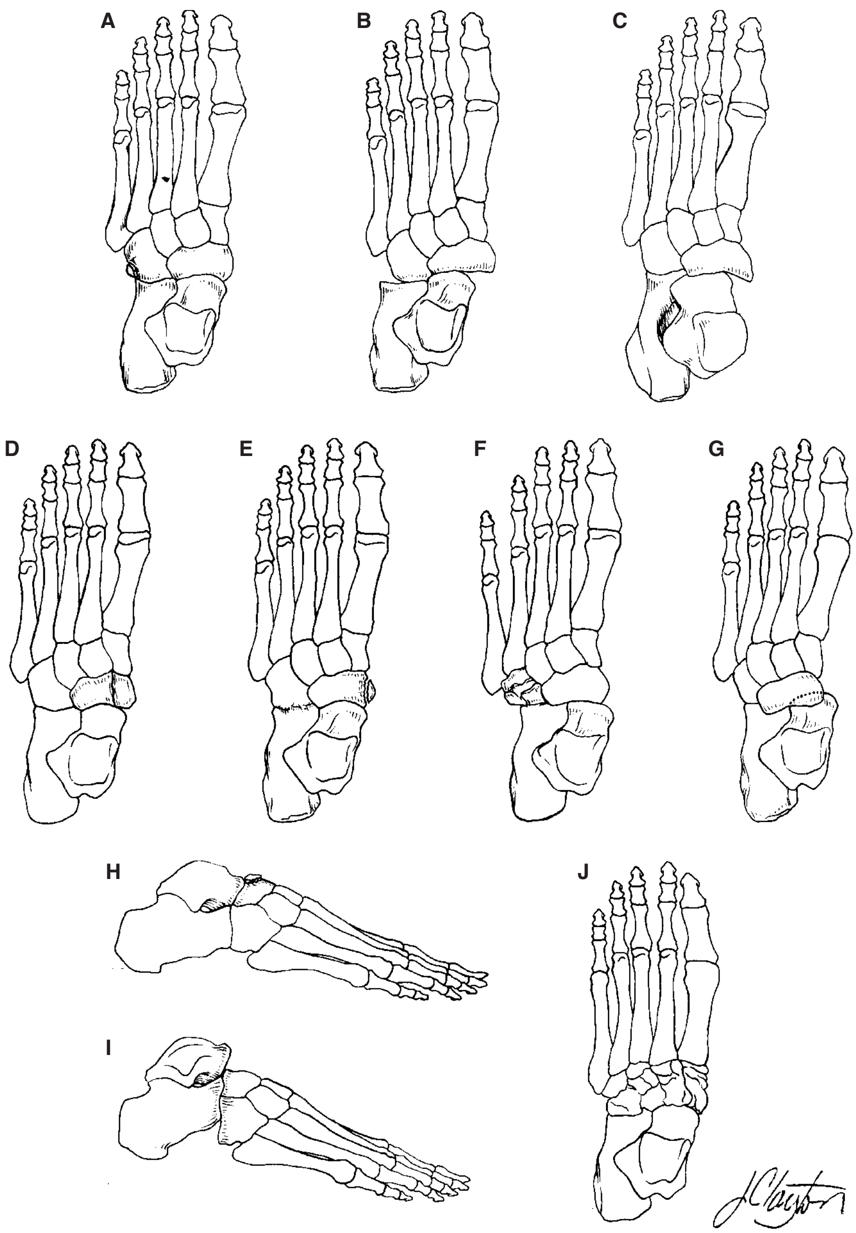


Fig. 1 Classification of midtarsal joint injuries, as described by Main and Jowett.[1] **A,** Medial fracture-sprain. **B,** Medial fracture-subluxation. **C,** Medial swivel dislocation. **D,** Comminuted longitudinal compression fracture of the navicular. **E,** Lateral fracture-sprain. **F,** Lateral fracture-subluxation. **G,** Lateral swivel dislocation. **H,** Plantar fracture-sprain. **I,** Plantar dislocation. **J,** Crush injury.

A short-leg non-weight-bearing cast is worn for 6 weeks, after which protected partial weight-bearing is begun in a walking cast or a cast-boot if rigid fixation with screws was used. If Kirschner wires were used for fixation, they should be removed at 6 weeks. An accepted practice is to use a non-weight-bearing cast or cast-boot for an additional 4 to 6 weeks to prevent redisplacement and allow the ligaments to heal more completely. If screws were used, they should be removed at 10 to 12 weeks. After this initial period, the patient is allowed to ambulate in a good shoe with a longitudinal arch support for an additional 9 to 12 months.

Swivel Dislocations

In this injury, first described by Main and Jowett,[1] a medial force applied to the forefoot disrupts the talonavicular joint but leaves the calcaneocuboid joint and the subtalar joint intact. The foot rotates medially but does not invert or evert. These injuries are treated in a manner similar to that for medial fracture-subluxations and dislocations.

Longitudinal Injuries

Longitudinal injuries (Fig. 1, D) accounted for the largest percentage of midtarsal joint injuries (41%) in the series of Main and Jowett.[1] With this injury, a force is applied at the metatarsal heads to the plantarflexed foot, compressing the navicular between the cuneiforms and the head of the talus. Fractures tend to occur vertically in line with the intercuneiform joints. Injuries of this type are usually severe, with a high incidence of associated fractures and significant residual displacement of the fracture fragments. Main and Jowett reported 24 displaced fractures; 18 patients had fair or poor results at long-term follow-up.

Nondisplaced fractures are treated in a short-leg walking cast for 6 weeks or until healing occurs. Displaced fractures are treated with open reduction and internal fixation (ORIF), followed by use of a short-leg non-weight-bearing cast for 6 to 8 weeks.

Lateral Injuries

Lateral injuries occur less commonly than medial injuries (prevalence, 17%). Like medial injuries, they can be divided into three subgroups: fracture-sprains (Fig. 1, E), fracture-subluxations (Fig. 1, F), and swivel dislocations (Fig. 1, G).

Fracture-Sprains

The mechanism underlying a fracture-sprain is application of an eversion force to the foot, which causes a small avulsion fracture of the navicular tuberosity or creates a flake of bone from the dorsum of the navicular or medial talus. An impaction fracture of the cuboid and/or calcaneus may be present. The treatment of a fracture-sprain is similar to that for a medial fracture-sprain.

Fracture-Subluxations

An abduction force applied to the forefoot produces lateral subluxation of the talonavicular joint, avulsion fracture of the navicular tuberosity, and collapse of the lateral column of the foot, with possible comminution of the calcaneocuboid joint. Tomography may be useful for fully evaluating the calcaneocuboid articulation. Any subluxation or dislocation should be reduced and held with Kirschner wires or screws. Open reduction and internal fixation with bone grafting of the cuboid may be necessary to restore the lateral column. If the avulsed navicular tuberosity is significantly displaced, it should be reattached to the navicular to prevent late planovalgus deformity of the foot as a result of tibialis posterior dysfunction.

Postoperatively, the foot should be immobilized in a short-leg non-weight-bearing cast for 6 weeks. Partial weight bearing should then be allowed in a walking cast or a cast-boot if rigid fixation with screws was used. If Kirschner wires were used, they can be removed at 6 weeks. A non-weight-bearing cast or cast-boot should be used for an additional 4 to 6 weeks, allowing the ligaments to more completely heal. This will decrease the incidence of late repeat subluxation. If screws were used for fixation, they should be removed at 10 to 12 weeks. After this initial period of immobilization, the patient should wear a good shoe with longitudinal arch support for 9 to 12 months.

Swivel Dislocations

In these injuries, there is a lateral dislocation of the talonavicular joint, but the calcaneocuboid and talocalcaneal joints remain intact, just as they do in the medial swivel dislocation. These are treated in the same manner as medial swivel dislocations and medial and lateral fracture-subluxations.

Plantar Injuries

Plantarly directed forces applied to the forefoot are rare. Plantar injuries constituted only 7% of the injuries reported by Main and Jowett.[1] They were divided into two subgroups: fracture-sprains (Fig. 1, H) and fracture-subluxations and dislocations (Fig. 1, I).

Fracture-Sprains

Fracture-sprains are characterized by avulsion fractures at the dorsum of the navicular or talus and from the anterior process of the calcaneus. Like medial and lateral fracture-sprains, they may appear to be stable on initial examination and radiographs; however, like those injuries, they should be treated in a short-leg walking cast for 4 to 6 weeks to prevent late subluxation and joint incongruity.

Fracture-Subluxations and Dislocations

Pure plantar dislocation of the talonavicular joint and the calcaneocuboid joint is known as a Chopart dislocation. The recommended treatment is similar to that for other midtarsal joint dislocations or subluxations.

Crush Injuries

In these injuries, the entire midtarsal joint is crushed, with variable patterns of comminution and displacement (Fig. 1, J). Soft-tissue injury may be significant. Closed reduction can be attempted, and the fragments can then be stabilized with Kirschner wires. Depending on the degree of comminution, ORIF may be necessary. For particularly severe crush injuries, external fixation may also be used to maintain the length of the medial and lateral columns.

After swelling subsides, a short-leg non-weight-bearing cast is applied. If Kirschner wires were used, they should be removed at 6 weeks, and a non-weight-bearing cast or cast-boot should then be applied for an additional 4 to 6 weeks. If screws were used, they should be removed at 10 to 12 weeks. The patient should then be instructed to wear a good shoe with a longitudinal arch support for 9 to 12 months. Late double arthrodesis may be required.

Other authors have also reported their experience with midtarsal fracture-subluxations. Dewar and Evans[4] suggested that the mechanism is forced abduction of the forefoot, resulting in an avulsion fracture of the navicular, with the fragment being attached to the tibialis posterior tendon. The forefoot, freed from its medial stay, swings farther into the abducted position, producing a compression fracture involving the calcaneocuboid joint. Similarly, Howie et al[7] proposed a mechanism of abduction and dorsiflexion at the midtarsal joint. Tountas[5] posited a trivial twisting of the foot from falling or missing a step as the mechanism of injury.

Although the Main-Jowett classification is not universally accepted, it can be useful, because it classifies injuries on a continuum of displacement from sprain to complete dislocation. This is important from a practical standpoint because often the clinician is not confronted with a grossly evident midtarsal dislocation, but rather a marginal fracture in the area of the talonavicular or calcaneocuboid joint. If the clinical examination suggests a fracture-sprain, subluxation, or dislocation that has spontaneously reduced, it is essential to evaluate the stability of the midtarsal joint with either stress radiography or examination under anesthesia if pain prohibits proper examination in the radiology suite.

Fractures of the Navicular

The tarsal navicular plays a major role in weight bearing during ambulation as a result of its strategic location in the medial longitudinal arch of the foot. Because of its position in the uppermost portion of the arch, it acts as the keystone for vertical stress on the arch.[8] Thus, proper restoration of navicular fractures is essential to prevent deformity and subsequent disability.

The navicular is largely covered with articular cartilage, and the surface area available for nutrient blood vessels is limited. It shares these characteristics with the talus, with which it articulates. For this reason, it is more susceptible to osteonecrosis than are the other bones of the midfoot. Torg et al[9] performed microangiographic studies that showed that the outer third of the navicular body has a good blood supply, but that the central third is relatively avascular.

The diagnosis of tarsal navicular fractures has been described as "sometimes obvious, frequently difficult, and occasionally elusive."[8] If such a fracture is suspected in a patient with midfoot pain and swelling, high-quality radiographs are needed to make an accurate diagnosis. As with other midfoot injuries, anteroposterior, lateral, and oblique radiographs are needed. The physician must also examine the films closely for subtle injuries to surrounding joints, particularly midtarsal joint subluxations. Failure to recognize and treat injury to this joint could necessitate later arthrodesis despite excellent healing of the navicular fracture. If plain radiographs are negative, persistent pain in the midfoot warrants further radiologic evaluation (computed tomography, magnetic resonance imaging, or bone scanning) to rule out an occult fracture.

Fractures of the tarsal navicular are relatively rare injuries; however, they occur more commonly than fractures of the cuboid or cuneiforms.[10] DeLee[11] has broadly classified navicular fractures into four groups: (1) avulsion fractures of the dorsal lip, (2) fractures of the tuberosity, (3) displaced and nondisplaced fractures of the body, and (4) stress fractures. Each has its own unique mechanism of injury and recommended treatment.

Dorsal Lip Avulsion Fractures

Two ligaments, the dorsal talonavicular ligament and the anterior division of the deltoid ligament, attach to the dorsum of the navicular. When the foot is inverted and plantar-flexed, the talonavicular ligament is stressed. When the foot is everted, the deltoid ligament is stressed. With sufficient force, either of these mechanisms can result in a cortical avulsion fracture of the navicular. In the largest series of tarsal navicular fractures in the literature, Eichenholtz and Levine[8] reported that the most common were cortical-rim avulsion fractures (31 of 66 [47%]).

Treatment of this injury is usually conservative. Radiographs must be examined carefully to be certain that an occult midtarsal subluxation is not present. Initial splinting should be followed by use of a short-leg walking cast for 4 to 6 weeks. Occasionally, a small, persistently displaced fragment may lead to pain when shoes are worn. If this occurs, the fragment should be excised. If the fragment is large (more than 25% of the articular surface), it should be reduced and fixed with Kirschner wires or small fragment screws to avoid late degenerative changes at the talonavicular joint.

Tuberosity Fractures

Fractures of the navicular tuberosity are avulsion injuries and are the result of an acute eversion or valgus injury to the foot, which leads to increased tension in the tibialis posterior tendon. Anatomic studies have shown that the strong attachment of the deltoid ligament by way of the plantar calcaneonavicular ligament (spring ligament) is a major factor contributing to injury by transmitting the stress that causes the fracture.[8]

There have been numerous reports of navicular tuberosity fractures associated with compression fractures of the cuboid or anterior calcaneus.[1,3-5] These represent injury to the entire midtarsal joint, and it is critical to ascertain that this joint is not subluxated during the course of treatment of the tuberosity fracture. Failure to restore anatomic alignment will result in late pain, stiffness, and ultimately the need for arthrodesis.

Local tenderness and pain with passive eversion or active inversion of the foot are typical findings on physical examination. Anteroposterior and oblique radiographs usually demonstrate the fracture. It is important to distinguish this fracture from an accessory navicular (os tibiale externum). This distinction is based on the characteristics of the line of separation; that of the os tibiale externum is smooth and regular compared with that of a fracture. Radiographs of the opposite foot may also be useful, as accessory naviculars are often bilateral.

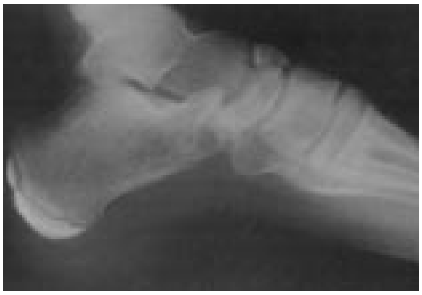
Treatment of nondisplaced or minimally displaced tuberosity fractures involves initial splinting followed by use of a short-leg walking cast with a well-molded longitudinal arch for 4 to 6 weeks. Should an asymptomatic nonunion occur, no additional treatment is required. However, if the nonunion causes discomfort, the tuberosity can be excised and the tendon reattached to the fracture bed under the same tension that was present before excision of the navicular tubercle. The lower leg is then placed in a short-leg cast for 4 to 6 weeks. If the fractured tuberosity fragment is significantly displaced, ORIF should be performed to avoid dysfunction of the tibialis posterior.

Fractures of the Navicular Body

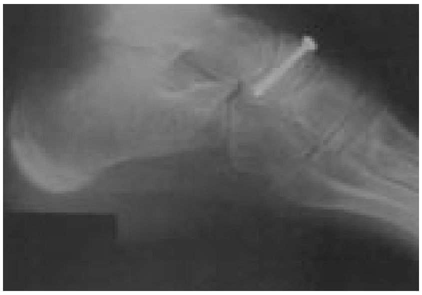
Fractures of the navicular body made up the smallest percentage of injuries in the series of Eichenholtz and Levine.[8] Such fractures can be secondary to either direct or indirect forces. A directly applied force typically results in a comminuted fracture. However, because the navicular possesses strong intertarsal ligaments, the fragments are usually not displaced.[11] Fractures resulting from an indirect force generally are the result of a fall from a height or a motor-vehicle accident such that a significant force is directed proximally up the forefoot with the foot in marked plantar flexion at the moment of impact.[1,8]

On physical examination, passive abduction/adduction and inversion/eversion of the foot produce localized pain. Tenderness on the lateral aspect of the foot should suggest an injury to the entire midtarsal joint, which should be confirmed radiographically and treated appropriately. Special attention should be paid to the neurocirculatory status of the foot. Since these injuries are often the result of a high-energy mechanism, the possibility of compartment syndrome should be considered and appropriately evaluated.

High-quality anteroposterior, oblique, and lateral radiographs should be obtained. Often the fracture will be demonstrated on only one of the views. Sangeorzan et al[12] devised a classification system for displaced intra-articular fractures of the navicular body based on the direction of the fracture line, the pattern of disruption of the surrounding joints, and the direction of displacement of the foot. In a type 1 fracture (Fig. 2, A), the primary fracture line is in the coronal plane (producing dorsal and plantar fracture fragments), and there is no angulation of the forepart of the foot. In a type 2 fracture (Fig. 3, A),



A



B

Fig. 2 Preoperative **(A)** and postoperative **(B)** radiographs of a foot with a type 1 injury treated with ORIF. (Reproduced with permission from Sangeorzan BJ, Benirschke SK, Mosca V, Mayo KA, Hansen ST Jr: Displaced intra-articular fractures of the tarsal navicular. *J Bone Joint Surg Am* 1989;71:1504-1510.)

A B

Fig. 3 Preoperative **(A)** and postoperative **(B)** radiographs of a foot with a type 2 injury treated with ORIF. (Reproduced with permission from Sangeorzan BJ, Benirschke SK, Mosca V, Mayo KA, Hansen ST Jr: Displaced intra-articular fractures of the tarsal navicular. *J Bone Joint Surg Am* 1989;71:1504-1510.)

the primary fracture line is dorsal-lateral to plantar-medial across the body of the navicular. The major fragment is dorsomedial and is displaced medially along with the forepart of the foot. The calcaneonavicular joint is not disrupted. In a type 3 fracture (Fig. 4, A), there is a comminuted fracture in the sagittal plane of the body of the navicular. The medial border of the foot is disrupted at the cuneonavicular joint. The forefoot is laterally displaced.

Nondisplaced fractures of the navicular body are treated with a short-leg weight-bearing cast worn for 6 weeks or until radiographic evidence of union is observed. If the fracture is displaced, attempts at closed reduction are likely to be futile because redisplacement is virtually inevitable.[8,11,13] Sangeorzan et al[12] recommend ORIF through an anteromedial approach in the interval between the anterior and posterior tibial tendons beginning just distal to the medial malleolus. This may be supplemented with an anterolateral approach if sufficient visualization cannot be obtained with a single approach.[14] The periosteum over the navicular is not divided, so the remaining blood supply to the bone is preserved. The articular surfaces of the talonavicular and calcaneonavicular joints should be inspected and reduced with a combination of direct and indirect reduction techniques. Bone graft taken from the iliac crest or distal tibia can be used as necessary to fill in any central defects once the articular surfaces have been elevated.

Displaced type 1 fractures should be treated with ORIF with lag-screw fixation (Fig. 2, B). The fracture pattern can be visualized well through a dorsomedial incision. In most cases, an anatomic reduction can be achieved and secured. Good results were achieved in all four patients treated this way in the series of Sangeorzan et al.[12]

Reduction is more difficult to obtain with type 2 fractures, which are often subsequently unstable because of comminution of the plantar lateral fragment. Use of a mini-external fixator can facilitate reduction. Screws are placed through the dorsomedial fragment into the other tarsal bones (Fig. 3, B).

Although difficult, an attempt should be made to restore normal anatomy in comminuted type 3

A B

Fig. 4 Preoperative **(A)** and postoperative **(B)** radiographs showing a type 3 injury treated with ORIF. Note that major fragments were secured to the cuneiforms. (Reproduced with permission from Sangeorzan BJ, Benirschke SK, Mosca V, Mayo KA, Hansen ST Jr: Displaced intra-articular fractures of the tarsal navicular. *J Bone Joint Surg Am* 1989;71:1504-1510.)

fractures; however, the chances of a good outcome are poor, as evidenced by only one good long-term result in the four patients with this injury in the series of Sangeorzan et al.[12] When insufficient bone stock remains to provide rigid fixation with a single screw, fixation may be supplemented with transfixion of the naviculocuneiform or talonavicular joint with a Kirschner wire.[14] If there is extensive nonreconstructible articular-surface damage, consideration should be given to primary arthrodesis of the talonavicular and/or naviculocuneiform joints.

After internal fixation, a short-leg non-weight-bearing cast is worn for 6 to 8 weeks. Hardware that crosses joints should be removed before motion or weight bearing is begun. Following this, the patient's shoes should be fitted with a custom medial arch support.

Complications of navicular fractures include malunion, posttraumatic arthritis, and osteonecrosis. If the navicular collapses secondary to osteonecrosis, the talus can be fused to the cuneiforms with tricortical bone grafting to maintain the length and plantar orientation of the medial column of the foot.

Stress Fractures of the Navicular

Stress fractures of the tarsal navicular are not uncommon,[15] and the clinician must remain alert for this potential diagnosis when a patient presents with a history of vague, diffuse midfoot pain of insidious onset, particularly if the patient is a runner. Early diagnosis and treatment are important, not only to minimize the athlete's period of disability but also to avoid progression of an incomplete fracture to a complete fracture or a nonunion. Complete fractures have a very good prognosis with nonoperative treatment; however, navicular nonunions often require ORIF and bone grafting.

One key to differentiating this injury from other overuse syndromes is that the pain increases during activity, not following it, as is seen with many soft-tissue overuse syndromes.[15] Patients may note that symptoms occur only with running on the forefoot at foot-strike, and that they abate rapidly with rest, often enabling jogging within a week.[16] Tenderness is often elicited directly over the navicular, but occasionally tenderness is not well localized.[9]

Plain radiographs are not sensitive in the detection of navicular stress fractures, particularly partial fractures.[17] Radionuclide bone scanning is effective in diagnosing a navicular fracture, and should be utilized when a fracture is suspected but not seen on plain radiographs. If the radionuclide scan is positive, plain tomograms (Fig. 5) or computed tomographic scans should be obtained to confirm the diagnosis, as the bone scan can show increased uptake due to a simple stress reaction (which may be the early first step before an actual stress fracture occurs). Stress fractures are typically in the sagittal plane, involving the middle third of the bone.

Treatment of navicular stress fractures is usually nonoperative. In a multicenter study, Torg et al[9] had a 100% union rate in fractures treated in a non-weight-bearing cast for 6 to 8 weeks. In that study, delay in diagnosis or persistent weight bearing appeared to lead to nonunion, delayed union, or fracture recurrence. Because of these problems, Fitch et al[16] recommend autologous bone grafting for all complete and comminuted fractures, for incomplete fractures that do not heal in a non-weight-bearing cast in 8 to 10 weeks, and for all nonunions characterized by marginal sclerosis or the presence of a medullary cyst.

Cuboid Injuries

The cuboid is an important stabilizer of the lateral column of the foot. It has numerous articulations—the anterior calcaneus, the lateral cuneiform, the fourth and fifth metatarsal bases, and occasionally the navicular—and is therefore involved in almost all motions of the midfoot. This complex arrangement makes the occurrence of an isolated injury unlikely.[18] An exception to this is a direct blow to the cuboid, which usually results in a nondisplaced fracture. The more usual mechanism, however, involves indirect force whereby the anterior foot is wedged or fixed in position while the weight of the body is transmitted through the foot held in exaggerated plantar flexion or abduction.[19] This leads to compression of the cuboid between the bases of the fourth and fifth metatarsals and the anterior calcaneus (the so-called nutcracker frac-

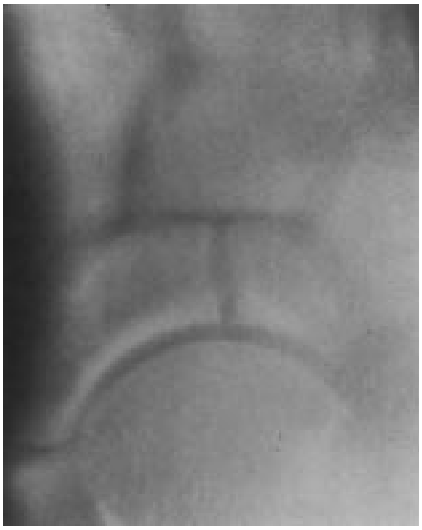


Fig. 5 Plain tomogram shows complete nondisplaced stress fracture of the tarsal navicular. (Reproduced with permission from Torg JS, Pavlov H, Cooley LH, et al: Stress fractures of the tarsal navicular: A retrospective review of twenty-one cases. *J Bone Joint Surg Am* 1982;64:700-712.)

ture), which is often associated with an avulsion fracture of the navicular tuberosity.

Cuboid stress fractures have been described in athletes.[20] In a case report, Drummond and Hastings[21] described a complete dislocation of the cuboid without an associated fracture after a fall from a height. Cuboid subluxation has also been reported in ballet dancers, who presented with lateral foot pain, weakness in push-off, and a feeling of inability to "work through the foot" while moving from foot-flat to demi-pointe or full pointe.[22]

Patients with fractures of the cuboid will give a history of direct or indirect trauma to the foot. The cuboid will be point tender. Injuries subsequent to indirect violence will often be tender medially as well, associated with significant swelling of the midfoot; these are Chopart joint injuries. Passive abduction-adduction and inversion-eversion accentuate pain, which aids in the diagnosis. The neurovascular status of the foot must be assessed, and the presence of compartment syndrome should be sought.

Standard radiographs of the foot facilitate diagnosis, with the oblique view being most helpful in determining not only the direction of the fracture line but also the presence or absence of displacement of the calcaneocuboid, cuboid-metatarsal, or talonavicular joints. With an associated avulsion fracture of the navicular, midtarsal joint injury and possible subluxation must be considered. A bone scan is useful for diagnosing cuboid stress fractures.

Nondisplaced fractures of the cuboid without evidence of medial injury should be treated with a short-leg walking cast for 4 to 6 weeks, followed by a longitudinal arch support.[11] Displaced intra-articular fractures should be treated so that the intrinsic mechanics of the foot are restored. A displaced fracture of the cuboid that heals with residual articular congruity can lead to persistent subluxation of the midtarsal joint and late degenerative changes. For this reason, Sangeorzan and Swiontkowski[23] performed ORIF with a structural iliac-crest bone graft and obtained satisfactory results in their series of displaced cuboid fractures (Fig. 6). With their suggested procedure, a longitudinal incision is made over the cuboid, superior to the peroneal tendons and sural nerve, and the muscle belly of the extensor digitorum brevis is retracted superiorly. The surgical incision should spare the stabilizing ligaments of the calcaneocuboid joint and the lateral two tarsometatarsal ligaments, which stabilize the distal articular surface to the metatarsals. A small distractor can be placed in the calcaneus and one of the lateral metatarsals to aid in indirect reduction of the articular surfaces. The cuboid is then held out to length with use of a buttress technique, with a small plate strutting the defect, which is packed with cancellous or cortical cancel-

A B C

Fig. 6 **A,** Preoperative radiograph shows compression of the cuboid and 8-mm shortening of the lateral border of the foot. **B,** Intraoperative film shows Kirschner wires placed into the subchondral bone of the proximal and distal articular surfaces. A laminar spreader was used to disimpact the fragments. **C,** Reduction maintained with 3.5-mm screws placed through a 2.5-mm buttress plate. Bone defects were filled with iliac-crest bone graft. (Reproduced with permission from Sangeorzan BJ, Swiontkowski MF: Displaced fractures of the cuboid. *J Bone Joint Surg Br* 1990;72:376-378.)

lous bone graft.[14] Postoperatively, the foot is immobilized in a below-knee non-weight-bearing cast for 6 weeks. Displaced fractures that present late with established degenerative arthritis are best managed with arthrodesis of the involved joints.

Rarely, cuboid fractures can occur from a shearing force in which the lateral plantar aspect of the cuboid is sheared off the medial dorsal aspect.[23] This longitudinal fracture allows rigid fixation with lag-screw technique.

Dislocation of the cuboid has been successfully treated with closed reduction and percutaneous pinning.[21] Cuboid subluxation in ballet dancers can be treated with manual reduction and taping, as described by Marshall and Hamilton.[22] Cuboid stress fractures heal much more readily than navicular stress fractures and can be treated with a removable walking-cast boot.[20]

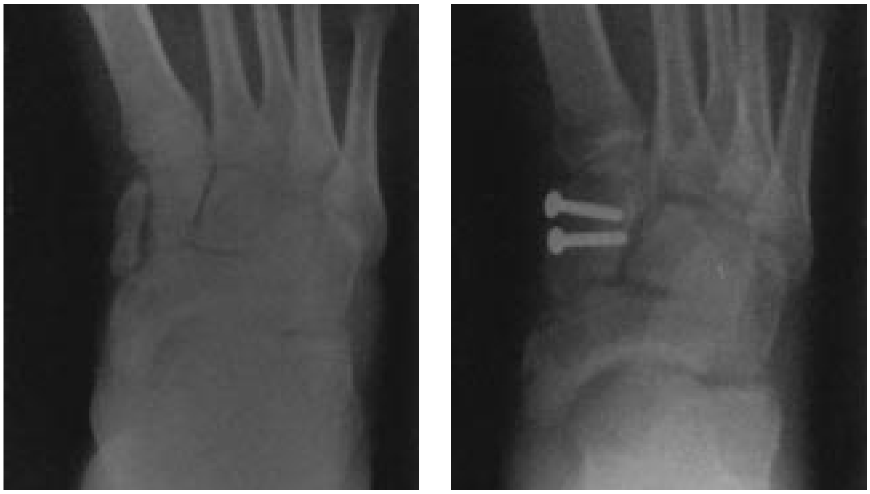


Fig. 7 Preoperative **(A)** and postoperative **(B)** radiographs show an isolated fracture of the medial cuneiform treated with ORIF. (Reproduced with permission from Patterson RH, Petersen D, Cunningham R: Isolated fracture of the medial cuneiform. *J Orthop Trauma* 1993;7:94-95.)

Cuneiform Injuries

As with injuries of the cuboid, it is important to ascertain the mechanism of injury when dealing with fractures of the cuneiforms (Fig. 7). Direct injuries are the most common and are rarely displaced.[11] Indirect violence involves force being transmitted proximally up the metatarsals, across the tarsometatarsal joint, and into the cuneiform. These are essentially Lisfranc fracture-dislocations and should be treated as such, even if the radiographic appearance does not demonstrate the requisite displacement.

After a history of the mechanism of injury has been obtained, the entire foot should be palpated. Special attention should be paid to the neurovascular status of the lower extremity. As with other midfoot injuries, compartment syndrome is not an uncommon sequela of cuneiform injuries. With direct injuries, it is important to be cognizant of the possibility of soft-tissue trauma, which may be initially apparent. Standard anteroposterior, lateral, and oblique radiographs should be obtained.

Nondisplaced fractures that are the result of direct trauma are stable due to the presence of strong intertarsal ligaments. They can be treated in a short-leg walking cast until asymptomatic, after which a good shoe with longitudinal arch support should be worn. Nondisplaced fractures resulting from indirect mechanisms are usually accompanied by significant pain and swelling due to ligamentous injury. If there is no evidence of tarsometatarsal subluxation on high-quality radiographs, such fractures can be treated in a well-molded, short-leg non-weight-bearing cast with frequent, intermittent radiographic evaluation to make sure that the foot alignment remains anatomic under weight-bearing stresses.

There are numerous reported cases of cuneiform dislocations, displaced fractures, and fracture-dislocations.[24-29] These occasionally can be reduced closed, but usually require open reduction. The medial cuneiform is draped by the anterior tibial tendon on the medial side. The lateral side is obscured by the dorsal neurovascular bundle. For this reason, the approach must be done cautiously. Sangeorzan et al[14] describe a combined medial-dorsal approach.[14] The medial approach is directly medial, overlying the anterior tendon along the medial side of the foot and dorsal to the posterior tibial tendon. A second incision on the dorsal side of the foot, medial to the neurovascular bundle, is used to help visualize the reduction. After reduction, cuneiform fractures can be stabilized with screws or Kirschner wires. Dislocations should be reduced and held with at least two orthogonally placed Kirschner wires.

Postoperatively, a non-weight-bearing short-leg cast should be used for 6 weeks, after which the Kirschner wires are removed. If the injury is simply a displaced fracture without associated ligamentous injury, the patient can then begin unprotected weight bearing. However, if the injury involved an indirect mechanism, with cuneiform dislocation and/or injury to the Lisfranc joint or intertarsal joint, protected weight bearing in a cast for an additional 3 to 4 weeks is recommended to prevent subluxation due to incomplete healing of ligaments.

Summary

Injuries to the midtarsal joint and fractures of the lesser tarsal bones are not common. Occasionally they are quite obvious; however, more frequently they present in a deceptively benign manner, with a radiographic appearance that belies their severity. For example, what appears to be a small avulsion fracture of the navicular tuberosity may actually be a reduced dislocation of the talonavicular and calcaneocuboid joints. Failure to recognize the extent of this injury and treating it with premature unprotected weight bearing could result in late midtarsal subluxation and/or posterior tibialis dysfunction. Because of the rarity and often subtle presentation of these injuries, the clinician must maintain a high index of suspicion when evaluating trauma to the midfoot. Failure to diagnose and treat these injuries appropriately may lead to the need for late arthrodesis and increased disability.

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