Midfoot Arthritis

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Abstract

Foot and ankle complaints are commonly encountered in orthopedic practice. Midfoot arthritis has the potential to cause a significant amount of pain and disability. A variety of conditions can cause or lead to midfoot arthritis. Treatment consists of either conservative management or surgical arthrodesis of the painful joints.

In this article, we review the midfoot (its basic anatomy and biomechanics) and midfoot arthritis (its clinical presentation and etiology, radiographic evaluation, and treatment options).

Midfoot arthritis, a specific complaint in adults, has the potential to cause a significant amount of pain and disability. Yet, the literature specifically on midfoot arthritis is scant. A variety of conditions can cause or lead to debilitating arthritis in the midfoot. Understanding the process and progression of this disease allows orthopedic surgeons to select appropriate treatment options.

In this review, we describe basic anatomy of the midfoot, biomechanics of the midfoot, clinical presentation and etiology of midfoot arthritis, radiographic evaluation, and treatment options.

Midfoot Anatomy

The anatomy of the midfoot is complex. Medially, the navicular articulates with the medial, middle, and lateral cuneiforms. To optimize bony conformity, the distal surface of the navicular has 3 facets, 1 for each cuneiform. The medial, middle, and lateral cuneiforms in turn articulate with the first, second, and third metatarsal bases, respectively. Laterally, the cuboid articulates with the fourth and fifth metatarsal bases. The cuboideonavicular joint is a fibrous joint reinforced by a strong, broad interosseous ligament and by dorsal and plantar cuboideonavicular ligaments; in some cases, a true synovial joint is present rather than this syndesmosis.[1]

The joints between the cuneiforms and the first to third metatarsal and between the cuboid and the fourth and fifth metatarsals collectively comprise the Lisfranc joint. At this location, both the proximal and distal bones comprising the joint are arranged in the coronal plane in the form of an arch. Formation of this arch is mediated both by bony anatomy and by soft-tissue reinforcement. All the cuneiforms are wedge-shaped, with their narrow portions being plantar, thus allowing for the arch configuration. The corresponding arch configuration of the metatarsal bases is depicted in Figure 1. As shown, the second metatarsal base assumes the position of keystone. This geometry gives the midfoot inherent stability. In addition to strong ligamentous support, the entire configuration receives soft-tissue support from the peroneus longus tendon, the attachments to which allow it to function as a strong tie beam for this transverse metatarsal arch. The flexor hallucis brevis, adductor hallucis, plantar fascia, and the anterior and posterior tibial tendons also contribute to this soft-tissue support.[2]

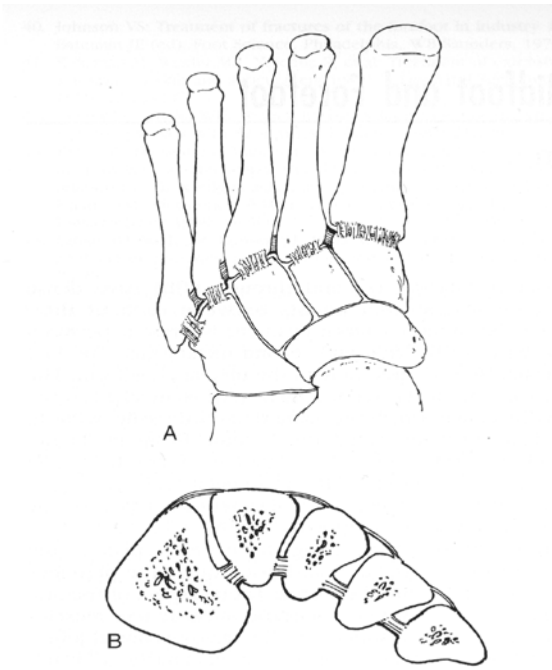

Figure 1. (A) Anteroposterior view of the bony and ligamentous anatomy of the tarsometatarsal joint complex. I through V = metatarsal bones. (B) Coronal section through the metatarsal bases illustrates the Roman arch configuration. Adapted with permission from: Lenczner EM, Waddell JP, Graham DJ. Tarsal-metatarsal (Lisfranc) dislocation. *J Trauma*. 1974:14:1012-1020.

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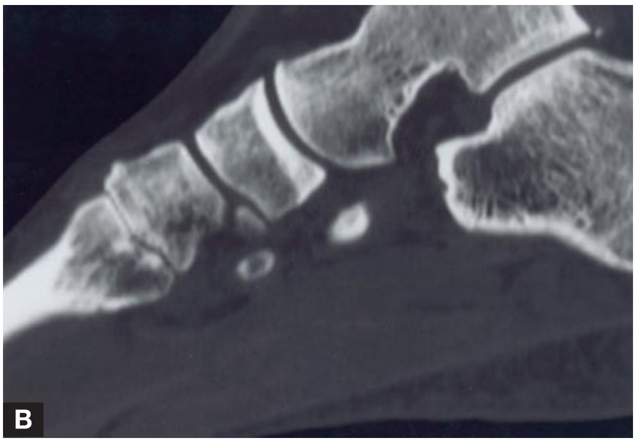

Figure 2. Images of a woman in her mid-40s with significant foot pain in the second tarsometatarsal joint. Clinical examination revealed localized tenderness in this area. (A) X-ray shows degenerative changes in the second tarsometatarsal joint with marked obliteration of the joint space and subchondral sclerosis. (B) Computed tomography scan shows extensive arthritis in the second tarsometatarsal joint with preservation of the adjacent joints. After conservative treatment failed, the patient underwent a second tarsometatarsal joint arthrodesis. (C) X-rays 1 year after surgery show solid fusion of the joint. The patient was pain-free and had returned to all activities.

Tight ligamentous connections also exist between the metatarsal and tarsal bones. There is a strong set of interosseous ligaments linking the bases of the metatarsals to one another. The exception to this is between the first and second metatarsal bases, where no intermetatarsal ligament exists. Instead, the powerful ligament of Lisfranc extends obliquely plantarward from the medial cuneiform to the medial side of the second metatarsal. This ligament is the strongest in this constellation of interosseous ligaments and is the key ligament for stability of the midfoot. The second metatarsal base also extends further proximally than the base of either the first or third metatarsal. This configuration provides a recess in the tarsometatarsal joint line at the point of the second tarsometatarsal articulation. These 2 anatomical features of the second metatarsal, along with its position as the keystone of the transverse arch, provide it with a relatively high degree of rigidity.

In this review, the aforementioned bones and articulations will be considered as constituting the midfoot. The midfoot is further defined by 3 longitudinal columns (view Figure 1 dorsally). The medial column is composed of the first metatarsal and the medial cuneiform, the middle column is composed of the second and third metatarsal articulation with the middle and lateral cuneiforms, and the lateral column is composed of the cuboid and fourth and fifth metatarsal articulation.

Midfoot Biomechanics

The midfoot is less mobile compared with the hindfoot and forefoot. The function of the midfoot is to “connect” the

Figure 3. Images of a man in his early 70s with a Lisfranc injury of the left foot. (A) X-ray at time of injury. The patient was treated with open reduction and internal fixation. He later developed activity-limiting pain and arthrosis around the first, second, and third tarsometatarsal joints; 1 year after failing conservative therapy, he underwent first, second, and third tarsometatarsal joint arthrodesis. (B) X-ray 3 years later shows solid fusion of the first, second, and third tarsometatarsal joints. The patient was pain-free and had resumed normal daily activities.

hindfoot to the forefoot. The midfoot functions as a beam, transforming the flexible foot at heel strike to a rigid lever arm at toe-off. At toe-off, the foot is supinated, locking the transverse tarsal joint. Locking of the transverse tarsal joint allows the midfoot to transfer the force generated during gait from the hindfoot to the forefoot for locomotion. Cavanagh and colleagues[3] found that the peak weight distribution in the standing barefoot adult was 60.5% at the heel, 7.8% at the midfoot, 28.1% at the forefoot, and 3.6% at the toes. Hutton and colleagues[4] reported on the load distribution under the foot during gait and the transfer of the center of load on the foot; the center of load progressed linearly on the medial aspect of the heel toward the medial aspect of the ball of the foot during gait.

Ouzounian and Shereff[5] quantified midfoot motion by using an in vitro technique in 10 fresh-frozen below-knee amputation specimens. By instrumenting the specimens with reference pins and putting them through simulated range of motion, they determined motion throughout the midfoot. Dorsiflexion/plantar flexion motion was greatest at the cuboid-fourth/fifth metatarsal articulation (means, 9.6° and 10.2°, respectively), followed by the navicular-middle cuneiform (mean, 5.2°) and the navicular-medial cuneiform articulation (mean, 5.0°). Supination/pronation motion was greatest at the cuboid-fourth/fifth metatarsal articulation (means, 11.1° and 9.0°, respectively), followed by the navicular-medial cuneiform (mean, 7.3°) and the navicular-middle cuneiform articulation (mean, 3.5°). At the tarsometatarsal joints, the middle cuneiform-second metatarsal articulation had the least motion in dorsiflexion/plantar flexion (mean, 0.6°) and supination/pronation (mean, 1.2°). The limited motion at the cuneiform-second metatarsal articulation is again thought to be limited by the strong ligament of Lisfranc and the geometry of the second metatarsal as the keystone in the transverse arch.

In 2001, Lakin and colleagues[6] reported on the contact mechanics of the normal tarsometatarsal joints. They subjected 6 cadaveric lower legs and feet to 4 different axial compressive loads in 5 different anatomical positions and found that the second/third tarsometatarsal joints bore the majority of the force in all positions of the foot compared with the first and fourth/fifth tarsometatarsal joint articulations. In inversion/eversion and in dorsiflexion/plantar flexion, the first and fourth/fifth tarsometatarsal articulation contact area increased, as well as the amount of force borne in these articulations. They hypothesized that this adjustment of the contact area keeps the pressure distribution among the midfoot joints relatively constant. In addition, the force transferred from the second/third tarsometatarsal joints to the first and fourth/fifth tarsometatarsal joints was greatest in plantar flexion. This appears to be the mechanism by which the midfoot limits pressure on the second/third tarsometatarsal joints and allows the midfoot to adapt to varying loads and repetitive stresses.

Further, one can take Lakin and colleagues' results and apply them to normal gait. When the midfoot becomes rigid in toe-off (plantar flexion), the stresses are assumed to be the greatest at this point and need to be offloaded, as was found in the study. Furthering the theory that the second/third tarsometatarsal joints bear the majority of the force of the midfoot, Johnson and Johnson[7] reported that the most commonly degenerated joints in their study, and the most commonly fused, were the second and third tarsometatarsal joints.

Clinical Presentation and Etiology of Midfoot Arthritis

A typical patient presents with aching over the midtarsal region, has pain that is aggravated by walking up stairs or pain with forced plantar flexion movement (eg, offensive linemen in professional football), and may have palpable bony prominences over the dorsum or plantar surface of the midfoot. One may be able to elicit a history of trauma (eg, Lisfranc injury), gout, rheumatoid arthritis, diabetes, or other autoimmune disorders. Mann and colleagues[8] reported that patients had pain that severely restricted their ability to walk and perform activities of daily living. None of the patients in their series walked for pleasure, and many reported shoe-wear difficulty secondary to deformity. On physical examination, patients may walk with an antalgic gait, have pain with toe walking, and report tenderness to palpation and pain with manipulation of the affected midfoot joints. In addition, as part of the physical examination, one must always check the position of the foot when specifically looking for deformity.

Several mechanisms contribute to the majority of cases of midfoot arthritis. Injuries to the Lisfranc joint appear to be the most common posttraumatic etiology. Myerson and colleagues[9] stated that anatomical reduction is required to minimize or delay onset of degeneration. Inflammatory causes include autoimmune disorders, gout, and rheumatoid arthritis. Neuropathic causes include diabetic neuropathy. Finally, primary degenerative changes occur in the midfoot, just as they occur in other weight-bearing joints.

With any of these mechanisms, midfoot collapse may ensue. The pattern of midfoot collapse has been well described as eventually leading to rigid flatfoot deformity, forefoot abduction and varus, longitudinal arch collapse, and dorsal/plantar osteophyte formation.[10,11] The foot is not mechanically efficient, and patients have shoe-wear difficulty secondary to residual deformity.

Radiographic Evaluation

Standard x-rays of the foot include standing anteroposterior and lateral views, plus oblique views (Figures 2, 3). X-rays are reviewed to determine which joints are involved, the extent of arthritic change, and the extent of midfoot deformity. Computed tomography (CT) scan can be used to further evaluate specific joints and assist in determining which joints are involved.

Treatment Options

Initial treatment is conservative. There are multiple nonoperative methods for treating midfoot arthritis, but they have not been evaluated in studies. Many orthopedic surgeons recommend corticosteroid injections under fluoroscopic guidance, anti-inflammatory medications, activity modifications, and shoe modifications and foot orthoses. Shoe modifications consist primarily of stiffening the shoe with a fiber carbon plate or steel shank. A rocker-bottom sole can also be added. All these modifications are designed to offload the midfoot region and provide stability for the painful joints. An orthosis commonly used at our institution is the University of California Biomechanical Lab insert, a rigid device with a high medial and lateral flange that extends from the heel cup to the metatarsal heads. This insert helps limit midfoot motion and thereby reduces pain.

> **"Fluoroscopy-guided joint injections can assist in determining which joints are symptomatic.[13,14]"**

Operative treatment consists mainly of arthrodesis of the medial and middle columns. More recently, use of tendon interpositional arthroplasty for the lateral column has been reported.[12] Operative treatment is performed only after all conservative measures have failed. In addition, the patient must have pain that is localized to an identifiable region in the midfoot. Fluoroscopy-guided joint injections can assist in determining which joints are symptomatic.[13,14] Arthrodesis should be performed only for these identifiable painful joints. Arthrodesis has been performed many times, often to treat posttraumatic arthritis. The reported incidence of symptomatic degenerative arthritis after tarsometatarsal fracture dislocation ranges from 0% to 58%.[7]

Johnson and Johnson[7] used a dowel graft arthrodesis technique in 15 patients with posttraumatic arthritis. A reduction was not performed, but instead a fusion in situ. Of the 13 patients available (mean follow-up, 37 months), 11 had subjective satisfactory pain relief, and 2 were dissatisfied. Good to excellent objective results were reported in 9 (69%) of the 13 patients. Union was achieved in 10 (77%) of the patients. In addition, correction of initial deformity with fusion seemed not to have significant advantages over arthrodesis in situ. The authors did not recommend performing a reduction of joint deformity at time of fusion.

Sangeorzan and colleagues[15] reviewed the cases of 16 patients who underwent arthrodesis for failed initial treatment of tarsometatarsal fracture dislocations. Mean follow-up was 28 months. The technique used was open reduction and internal fixation (ORIF) with lag screws. The authors reported good to excellent results in 11 (69%) of the patients and fair to poor results in the other 5 patients (31%). Of the 11 patients who reported good to excellent results, only 4 were pain-free, and 1 of those 4 had a pain-free nonunion. There were 2 other patients with nonunions. Fifteen of the 16 patients reported improved subjective results. The authors agreed that reduction is more likely to lead to good to excellent results and stated that it was the most important predictor of a good outcome. Although the number of subjects in their study was small, the authors tried to determine if fusion of the lateral rays was needed for a good result. They found that fusion of the lateral rays was not a factor in determining a good outcome.

Horton and Olney[16] reviewed the cases of 8 patients (9 feet) who underwent arthrodesis with a medial plate technique for posttraumatic or degenerative arthritis. Mean follow-up was 27 months. The authors reported that 7 (77%) of the 9 feet had good to excellent results and that all patients were subjectively improved. Union was achieved in all feet. Residual deformity was corrected in 6 of the 9 feet before arthrodesis. The authors noted that, in correcting residual deformity, they restored the normal longitudinal arch of the foot and achieved a more mechanically sound plantigrade foot. This is important when considering that many midfoot injuries are associated with midfoot collapse.[15,17]

Komenda and colleagues[11] reviewed the cases of 32 patients who underwent arthrodesis for intractable pain after traumatic injury to the tarsometatarsal joints. Mean follow-up was 50 months. The authors used a lag-screw technique for fusion, but only after attempting conservative management for 3 to 6 months. They performed both in situ arthrodesis (8 patients) and arthrodesis with realignment and bone grafting (24 patients). Their indications for in situ arthrodesis were slight deformity and osteoarthritis limited to the medial or middle column, or both. However, for patients with residual displacement and deformity of the forefoot, the authors favored arthrodesis with realignment. They used this algorithm for patients with 3 mm of displacement or at least 15° of malalignment. Their results showed that mean American Orthopaedic Foot and Ankle Society (AOFAS) score improved from 44 to 78. The authors could not determine and therefore did not report which treatment provided better results—in situ arthrodesis or arthrodesis with realignment—as in situ arthrodesis was used when no obvious malalignment was present. In addition, the authors recommended not performing arthrodesis of the lateral column and suggested that decreased motion in the lateral column could affect patient outcome. They also stated that the lateral column is important for optimal function and that many times lateral rays are asymptomatic despite radiographic evidence of degenerative changes.

Mann and colleagues[8] reviewed the cases of 40 patients (41 feet) who underwent midtarsal and tarsometatarsal arthrodesis for primary degenerative osteoarthritis (21 patients), posttraumatic arthritis (17), or inflammatory arthritis (2). Mean follow-up was 72 months. The authors used multiple techniques for arthrodesis, including plating, stapling, and lag screws. They used bone grafting in 11 patients. Union was achieved in 176 (98%) of the 179 fused joints. The authors reported a patient satisfaction rate of 93% (37/40). According to the authors' grading criteria for patient satisfaction, a score of 0 or 1 was unsatisfactory, and a score of 2, 3, 4, or 5 was satisfactory. These subjective and objective criteria placed more emphasis on the function of the patient rather than on radiographic findings. This grading scheme, developed to take into account that patients had functional results that did not correlate well with radiographic findings, has not been validated. The authors also agreed with other authors who have found that deformity correction has a large role in producing satisfactory clinical results.[11,15,16] The authors did not address whether lateral rays should be fused.[8]

Treatment of the Lateral Column. Treatment of the lateral column involves either arthrodesis or resection arthroplasty. Raikin and Schon[18] reported on arthrodesis of the fourth and fifth tarsometatarsal joints. They found that pain decreased, function increased, and 13 (57%) of 23 patients reported subjective stiffness on questioning. According to the authors, the patients were not concerned about the stiffness and felt it did not impair their overall function. The authors' final recommendation was not to include these articulations for routine tarsometatarsal arthrodesis. However, they stated that the lateral rays should be included for patients with uncorrectable lateral midfoot collapse and rocker-bottom foot deformity. In addition, they recommended arthrodesis for patients with intractable painful arthritis involving the lateral articulations. This recommendation is in contrast to leaving the lateral rays free, which was recommended by Komenda and colleagues[11] and Sangeorzan and colleagues.[15] Komenda and colleagues stated that, in most cases, these joints are asymptomatic even though there is radiographic evidence of degenerative change; in addition, painful stiffness may ensue. Many orthopedic surgeons, following Komenda and colleagues and Sangeorzan and colleagues, leave the lateral rays free when performing an arthrodesis. Berlet and Anderson[12] reported results from clinical evaluation of 8 patients with lateral column arthritis. Six of the 8 underwent a fourth/fifth tarsometatarsal resection arthroplasty, and the other 2 underwent an isolated fifth tarsometatarsal resection arthroplasty. At a mean follow-up of 25 months, the mean AOFAS score was 64.5 (the preoperative score was not reported). Patients' subjective pain (visual analog scale) had improved by a mean of 35%. In addition, 6 of the 8 patients deemed the procedure satisfactory and said they would undergo it again for a similar problem. The authors concluded that, when nonoperative measures fail to provide symptomatic pain relief, a lateral column tarsometatarsal resection arthroplasty with tendon interposition is an effective salvage operation.

Lisfranc Injuries. The role of primary arthrodesis in treating Lisfranc injuries remains controversial. Mulier and colleagues[19] reported the cases of 28 patients with Lisfranc injuries. Mean follow-up was 30 months. ORIF was performed in 16 patients, partial arthrodesis leaving the lateral rays free in 6 patients, and complete arthrodesis in the remaining 6 patients. The authors, who found that the ORIF and partial arthrodesis groups had similar (66%) good to excellent results, recommended either treatment.

Ly and Coetzee[20] conducted a prospective, randomized study of 41 patients with isolated acute or subacute primarily ligamentous Lisfranc injuries. Mean follow-up was 42.5 months. ORIF was performed in 20 patients and primary arthrodesis in 21 patients. Two years after surgery, mean AOFAS scores were 68.6 (ORIF) and 88 (primary arthrodesis). In addition, self-assessment of postoperative level of activities (vs preinjury level) was higher in the primary arthrodesis group (92%) than in the ORIF group (65%). The authors postulated that poor outcomes for ORIF-treated injuries correlated with removal of prominent or painful hardware. In primarily ligamentous injuries, soft-tissue healing after screw fixation did not provide enough strength to maintain the initial reduction. When the hardware was removed, the degenerative process in the midfoot was accelerated. Therefore, the authors recommended primary arthrodesis for primarily ligamentous Lisfranc injuries.

Conclusions Regarding Treatment Options

According to our review of treatment options, many authors have reported good functional results. Arthrodesis should be considered for primarily ligamentous Lisfranc injuries and should be performed for degenerative arthritis only after conservative measures have failed. Of the various operative techniques mentioned, the treatments of choice seem to be (a) a lag-screw technique that leaves the fourth and fifth tarsometatarsal joints free and (b) medial plating alone or in combination with a lag-screw technique. Medial plating is used to guide correction of abduction deformities. Current recommendations are to realign the foot and fuse the painful joints.[8,11,15,16]

Summary

Midfoot arthritis is commonly encountered in orthopedic practice. A variety of conditions cause or lead to degenerative changes in the midfoot. Understanding the bony and ligamentous architecture of the midfoot, and its biomechanics, can aid in understanding disease progression. Painful joints are treated with arthrodesis after conservative measures have failed. Lateral rays should be left free when performing an arthrodesis of the midfoot.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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This paper will be judged for the Resident Writer's Award.