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Original Research

Intraoperative Simulated Weightbearing Lateral Foot Imaging: The Clinical Utility and Ability to Predict Sagittal Plane Position of the First Ray in Lapidus Fusion

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ABSTRACT

The sagittal plane relationship of the first to second ray is a primary determinant of proper alignment in Lapidus midfoot fusion as assessed both clinically and on postoperative weightbearing lateral radiographs. The traditional approach to intraoperative fluoroscopic imaging allows for accurate assessment of fixation placement and intermetatarsal angle correction but only a crude evaluation of final sagittal plane alignment. Surgeons have used various methods in an attempt to load the foot during lateral imaging. This had led to inconsistent results and the potential for poor outcome. Skepticism exists regarding the ability of simulated weightbearing fluoroscopy to predict the final outcome, and evidence is lacking to support this practice. A prospective investigation was performed to assess the correlation of the first to second ray sagittal plane alignment as demonstrated on intraoperative simulated weightbearing lateral foot imaging studies and the 10-week postoperative lateral weightbearing radiograph. A consistent simulated weightbearing technique was used prospectively with 50 consecutive cases of Lapidus midfoot fusion with the goal of achieving parallel sagittal plane alignment of the first and second metatarsals with no divergence. Although 47 cases had no divergence and 3 had divergence with mild first ray elevatus, all 50 cases demonstrated a direct correlation between the intraoperative simulated and postoperative full weightbearing images. In conclusion, we believe the findings from our intraoperative imaging technique are a reliable predictor of first ray sagittal plane alignment in Lapidus midfoot fusion.

The Lapidus midfoot fusion procedure involves fusion of the first metatarsocuneiform joint, which corrects both the sagittal and transverse plane instability and the deformity associated with moderate to severe hallux abductovalgus (HAV) among other conditions (1–3). The procedure is used for a wide range of disorders, including cavus deformity, pathologic pronation and posterior tibial tendon dysfunction, primary and post-traumatic degenerative arthritis, and Lisfranc injuries. Ensuring proper first ray alignment in the transverse and sagittal planes is imperative to avoid a multitude of potential postoperative complications, including recurrent hallux valgus associated with undercorrection of the intermetatarsal angle, hallux varus from overcorrection of the HAV, hallux limitus or second ray overload from inadvertent first ray elevatus, and sesamoiditis from excessive plantar displacement of the first ray (2–12). Objective radiographic measurements have been described to analyze the biomechanical structure of the foot in the sagittal plane, including Meary's angle, the cyma line, talar declination, and the calcaneal inclination angle. The first ray position in the sagittal plane has also been described by both Meyer et al (13) and Seiberg et al (14), as the first to second metatarsal head elevation and the Seiberg index, respectively. These indicators of sagittal plane alignment are routinely used both preoperatively in the surgical planning phase and postoperatively for assessment and evaluation of deformity correction. Intraoperative assessment of sagittal plane alignment is performed by fluoroscopic imaging and clinical assessment; however, limitations have been noted owing to the non-weightbearing (WB) position of the patient. The utility of fluoroscopy has also been limited by the narrow window, which does not allow the surgeon to view the entire foot and ankle on 1 image. Meary's angle, for instance, is difficult to assess on the small fluoroscopy units commonly used in forefoot surgery.

Sanner (15) described the standard lateral WB radiographic technique with the patient standing in a natural angle and base of gait, with the film parallel to the medial side of the foot, the tube head

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angulation position at 90° from vertical, and the central ray directed at the lateral cuneiform and cuboid. Visual assessment for proper lateral alignment involves a single talar dome, clear visualization of the fifth metatarsal styloid process, and mild superimposition of the navicular on the cuboid (Fig. 1) (15). Consistent lateral imaging at various stages of care allows the surgeon to properly evaluate sagittal plane alignment and accurately compare the preoperative and postoperative studies. Capturing a true WB lateral image during an operation is impossible; however, attempting to load the foot for lateral imaging is commonplace in trauma and reconstructive surgery. The utility of intraoperative lateral imaging is further complicated by the lack of ability to perform angular measurements as one might on standard radiographs. The surgeon is scrubbed and does not have time for complex evaluations of each image. Visual reference standards allow intraoperative confirmation of the desired alignment. This process requires consistent and reproducible intraoperative images that ideally correlate with the postoperative WB radiographs. A standardized method for obtaining simulated WB imaging has not been described, and the variable techniques have led to skepticism about the clinical utility of attempting to simulate WB foot alignment.

The primary objective of our intraoperative simulated WB lateral foot imaging protocol for Lapidus midfoot fusion is to evaluate the first to second ray sagittal plane alignment. The operative goal is to achieve parallel alignment along the dorsal cortex of the first and second metatarsals, viewing from proximally to distally. We attempt to avoid divergence, unless indicated by the clinical situation. A reliable and reproducible imaging technique allows the surgeon to confirm the desired result before and after placement of final fixation. The hypothesis of the present investigation is that our standard intraoperative simulated WB lateral foot imaging protocol produces images that correlate with the 10-week postoperative WB lateral radiographs when assessing first to second ray sagittal plane alignment in Lapidus midfoot fusion.

Surgical Technique and Imaging Protocol

The surgical technique for Lapidus midfoot fusion was consistent for all 50 cases. Access to the first tarsometatarsal joint was achieved with the use of a joint distractor. A sharp osteotome was initially used to remove most visible articular cartilage on both joint surfaces. The remaining cartilage was then removed with a bone curette. The rotary bur was lightly passed over the joint surfaces, ensuring removal of the calcified cartilage layer to expose the subchondral bone plate. Additional burring was performed along the base of the first metatarsal or the lateral aspect of an atavistic cuneiform to augment intermetatarsal angle correction or elevated first ray. No case involved plantar transposition of the metatarsal on the medial cuneiform. A 2.0-mm drill was then used to fenestrate the subchondral bone plate, producing a cancellous autograft, which was left within the joint to augment healing. Fixation was achieved with 2 crossing 3.5-mm cortical screws inserted using a standard AO technique to capture to the far cortex. Plate fixation was only added to this fixation construct for cases involving soft bone or cases involving global medial column fusion. Postoperative care involved non-WB for a 6-week period, followed by progressive WB until the 10-week postoperative radiographs confirmed union.

Intraoperative simulated WB lateral foot imaging was performed after placement of temporary pins and after final fixation. The image intensifier was placed against the medial aspect of the foot. The flat plate was positioned at 90° to the image intensifier, and the foot was loaded with the palm of the surgeon's hand with the ankle dorsiflexed to 90°. The opposite hand was used to support and position the leg at the level of the knee (Fig. 2). Immediate intraoperative evaluation of image quality ensured that positioning confirmed a true lateral view, which was then compared with the preoperative WB radiographs. Because the talar dome will not be visualized with this fluoroscopic technique, other attributes of a true lateral view are used, such as visualization of the styloid process of the fifth metatarsal, metatarsal overlap 1 to 5, and superimposition of the navicular and cuboid (Fig. 3). A comparison with the preoperative lateral view helps from this regard. A mini C-arm was used in nearly all cases, with the exception of those requiring additional rearfoot reconstructive procedures, in which case the large C-arm was used.

Patients and Methods

The present prospective study included 48 consecutive patients (50 feet) who underwent primary Lapidus midfoot fusion for correction of HAV, midfoot collapse, pathologic pronation, or arthritis. All procedures were performed by 1 surgeon from August 2014 to May 2015 at Regions Hospital (St. Paul, MN). Concomitant reconstructive procedures were not excluded. All intraoperative images were obtained with the foot positioned by the primary surgeon. Images were

Fig. 1. Standard weightbearing lateral foot radiograph. Note the single talar dome at the ankle, clear visualization of the styloid process of the fifth metatarsal, natural metatarsal overlap 1 to 5, and partial superimposition of the navicular and cuboid. The subtle changes regarding these finding might indicate the patient was imaged with the foot inverted or everted, although inherent varus or valgus foot alignment could also explain the abnormal alignment on lateral imaging.