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Angle and Base of Gait Long Leg Axial and Intraoperative Simulated Weightbearing Long Leg Axial Imaging to Capture True Frontal Plane Tibia to Calcaneus Alignment in Valgus and Varus Deformities of the Rearfoot and Ankle

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A B S T R A C T

The long leg axial view is primarily used to evaluate the frontal plane alignment of the calcaneus in relation to the long axis of the tibia when standing. This view allows both angular measurement and assessment for the apex of varus and valgus deformity of the rearfoot and ankle with clinical utility in the preoperative, intraoperative, and postoperative settings. The frontal plane alignment of the calcaneus to the long axis of the tibia is rarely fixed in the varus or valgus position because of the inherent flexibility of the foot and ankle, which makes patient positioning critical to obtain accurate and reproducible images. Inconsistent patient positioning and imaging techniques are commonly encountered with the long leg axial view for a variety of reasons, including the lack of a standardized or validated protocol. This angle and base of gait imaging protocol involves positioning the patient to align the tibia with the long axis of the foot, which is represented by the second metatarsal. Non-weightbearing long leg axial imaging is commonly performed intraoperatively, which requires a modified patient positioning technique to capture simulated weightbearing long leg axial images. A case series is presented to demonstrate our angle and base of gait long leg axial and intraoperative simulated weightbearing long leg axial imaging protocols that can be applied throughout all phases of patient care for various foot and ankle conditions.

The long leg axial view (LLA) is primarily used to evaluate the frontal plane alignment of the calcaneus in relation to the long axis of the tibia when standing. This view allows both angular measurement and assessment for the apex of varus and valgus deformity of the rearfoot and ankle, with clinical utility in the preoperative, intraoperative, and postoperative settings. Non-weightbearing (NWB) LLA imaging is commonly performed in the early postoperative setting or preoperatively for acute Charcot arthropathy or traumatic injuries involving the distal tibia, talus, and calcaneus. Intraoperative LLA imaging is also common for assessment of deformity correction, positioning of rearfoot or ankle fusion, and fracture reduction. The conditions and surgical procedures that involve frontal plane deformity of the rearfoot and ankle for which LLA imaging is useful are listed in Table 1.

The traditional imaging and patient positioning technique for the LLA view was first described by Kleiger and Mankin (1), with the patient leaning forward on the opposite foot and the imaged ankle dorsiflexed (DF) at 10°. Mendicino et al (2) described a similar patient positioning approach that is widely used in practice today. Having the patient lean forward with the imaged foot DF at 10° allows the tibia to be superimposed on the foot to capture the calcaneus and tibia on 1 cassette. The knee should be flexed on the imaged limb to aid DF through relaxation of the Achilles tendon, with the opposite foot placed forward for balance during imaging. The x-ray beam should be angled at 45° to the film cassette and at roughly 3 ft. posterior to the leg. This standard patient positioning protocol was loosely followed in a number of studies evaluating rearfoot alignment using the LLA view (1,3,4).

Lamm et al (5) contrasted the utility of the LLA and the hindfoot alignment view (HAV), with the LLA representing the relationship of the calcaneus to the leg with visualization of the subtalar joint (STJ). The HAV also evaluates the calcaneus to leg relationship, but with

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Table 1
Clinical utility of long leg axial radiograph for conditions that involve frontal plane deformity of rearfoot or ankle

Diagnosis	Procedure
Pes valgus and posterior tibialis tendon dysfunction	Midfoot and rearfoot osteotomy or arthrodesis
Cavus foot	Calcaneal osteotomy Rearfoot arthrodesis
Ankle arthritis	Ankle arthrodesis Supramalleolar osteotomy Total ankle replacement
Acute trauma of rearfoot and ankle	Open reduction internal fixation
Post-traumatic hindfoot or ankle deformity	Arthrodesis or osteotomy
Neuromuscular contracture (ie, stroke, cerebral palsy, traumatic brain injury)	Soft tissue lengthening or tendon transfer

visualization of the ankle joint. Cobey (6) defined the HAV with the intent to visualize the relationship between the calcaneus and the ankle joint and with the longitudinal axis of the tibia in the weight-bearing (WB) position. The HAV is taken with the film cassette at 90° to the long axis of the foot, represented by the second metatarsal, with the patient standing in the upright position (instead of leaning forward in 10° of DF in the LLA view) (6). This standardized technique provides some degree of consistency (7); however, it is difficult for the provider to determine whether the patient has been positioned properly simply by looking at the images because the bones of the foot will be superimposed.

The main shortcoming of the traditional LLA imaging technique (the patient leaning forward on 1 foot with 10° of ankle DF) is that the frontal plane alignment of the calcaneus to the long axis of the tibia is not typically fixed or rigid. The inherent flexibility of most rearfoot and ankle conditions, pronation in particular, makes patient positioning critical to obtain accurate and reproducible images at various stages of care, which is the focus of our report. Rigid deformity associated with previous rearfoot and ankle fusion, malaligned fractures, coalition, degenerative arthritis, rigid spasticity, and rigid cavus deformity are more easily captured using LLA imaging, which makes patient positioning less critical. Also, rigid deformity often involves the ankle and will not allow 10° of DF for standard LLA imaging.

Variations in patient positioning during LLA imaging has the potential to alter the amount of pronation or supination through the STJ, which ultimately will affect the frontal plane alignment of the calcaneus to the tibia. Transverse plane positioning of the foot in relation to the leg and the rotational position of the x-ray tube also greatly affects how the LLA view captures the calcaneus to tibia frontal plane alignment (Fig. 1). Capturing the true frontal plane position of the heel requires the patient to stand with both feet in angle and base of gait with the heels in the resting calcaneal stance position, which is not possible when the patient is leaning forward on 1 foot with the ankle in 10° of DF (8). The main advantage of the patient leaning forward is that the tibia and heel can be captured on the small film cassette commonly used in foot and ankle specialty practices. The use of digital imaging technology and larger film cassettes has become common, allowing the patient to stand upright on a large cassette with both feet in angle and base of gait in an effort to capture the true calcaneus to tibia alignment without the distortion caused by unnatural patient positioning.

The HAV is taken with the patient standing upright but not on the film cassette. The second metatarsal is used to represent the long axis of the foot. This same approach can be applied to angle and base of gait LLA imaging, with the patient standing upright with both feet in angle and base of gait and both heels in the resting calcaneal stance position. The patient is positioned to superimpose the tibia and the second metatarsal, which allows for consistent imaging for research and clinical comparison of results at various stages of treatment. The radiology technician's natural tendency is to have the patient move their foot into the transverse plane in an effort to bring the second metatarsal in line with the tibia. This is counterproductive

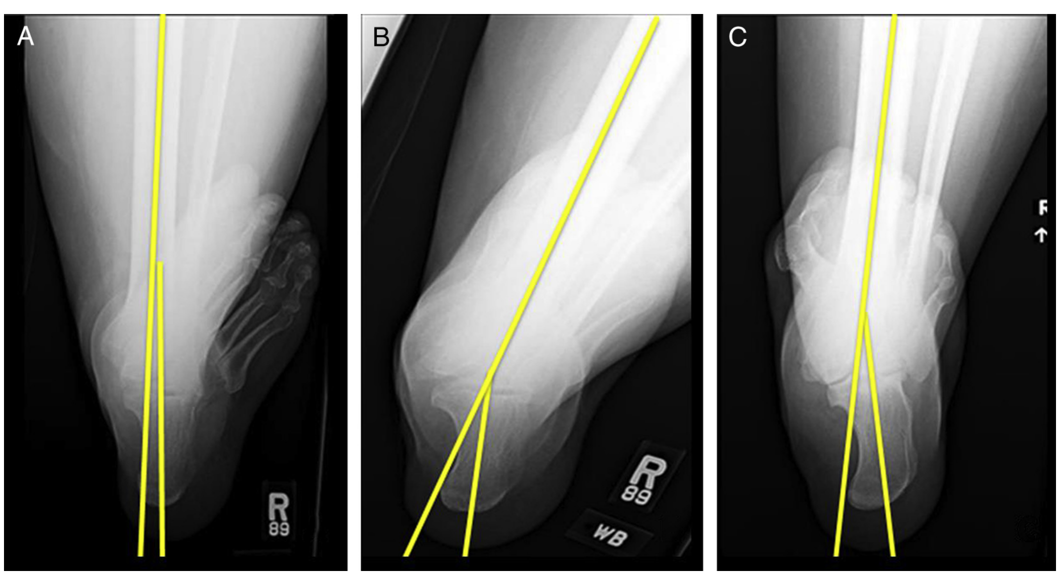

Fig. 1. Variable outcomes with long leg axial imaging of a pronated foot type without a standardized patient positioning protocol. These radiographs are of the same patient with posterior tibial tendon dysfunction standing in angle and base of gait. Variations resulted from changing the position of the x-ray tube and cassette in relation to the foot and leg. (*A*) The natural tendency with pronation deformity is to image the foot externally positioned in relation to the tibia, which inadvertently will not capture heel valgus. Note, the too many toe sign with the rectus heel. (*B*) The x-ray tube was then rotated to superimpose the tibia through the second metatarsal, properly demonstrating the valgus heel position. However, the tibia was angulated on the screen, which negatively affected visual assessment of the radiograph. (*C*) Angulation of the tibia was corrected by rotating or moving the patient's entire body to position the second metatarsal (or lateral edge of the imaged foot) with the edge of the cassette. This final image accomplished the desired goals of the tibia imaged through the second metatarsal, the tibia vertical on the screen, and the patient positioned in angle and base of gait with both heels in the resting calcaneal stance position.