

## **Optimal Placement of Calcaneal Pin for Ankle External Fixator**

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**Purpose:** There is no consensus on how external fixation should be applied to ankles for injuries such as pilon fractures. Some surgeons will place second metatarsal pins to keep the foot plantigrade, but they come with risks including fracture and pin pull-out. The purpose of the study is to identify the isometric point of the calcaneal pin placement in ankle external fixators to keep the foot plantigrade or dorsiflexed without using a metatarsal pin.

**Methods:** 11 cadaver legs, which included the distal femur and origin of the gastrocnemius muscles, were placed into a rig to accurately measure the calcaneal pin placement. The femur was secured to the apparatus and using a custom jig, 1.6-mm Kirschner wires (K-wires) were inserted into the calcaneus from 1 to 30 mm anterior to the most posterior aspect of the tubercle in 2-mm increments. A Kirschner bow and weights were attached to the K-wire and the excursion of the foot from resting to either dorsiflexion or plantar flexion was measured by digital photography and overlying a goniometer using an angle measuring app. Maximum passive dorsiflexion and plantar flexion were measured before and after hanging traction to assess whether the ligaments had stretched during our experiments. Measurements were performed with the knee in extension and flexion to assess the effect of the gastrocnemius on the measurements.

**Results:** The mean point of transition from dorsiflexion to plantar flexion was found to be 10 mm from the posterior skin edge of the calcaneus, with a range of 7 mm to 19 mm from the posterior skin edge. All of the legs had passive plantar flexion and dorsiflexion with ranges of 12° to 64° and 2° to 24°, respectively. Three legs were found to be outliers because they never dorsiflexed with traction, but one of the two stayed plantigrade until roughly 10 mm. Measuring the maximum passive range of motion before and after traction showed no significant change demonstrating that the ligaments and soft tissues did not relax during testing. Whether the knee was flexed or extended did not have predictable or significant effect on the isometric point.

**Conclusion:** The isometric point of the ankle or optimal external fixator calcaneal pin placement is 10 mm or less from the posterior skin edge of the calcaneus to keep the foot plantigrade or dorsiflexed without using a metatarsal pin.