

Integrity Of the First Metatarsal Head Vascularization and Soft-tissue Envelope Following Minimally Invasive Chevron Osteotomy for Hallux Valgus (hv) Deformity: A Micro-CT And Anatomical Assessment

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INTRODUCTION: Minimally invasive surgery (MIS) Chevron-osteotomy for HV treatment offers a surgical alternative to open surgery with minimal surgical dissection and a hypothetical decreased risk for soft-tissue complications. During this procedure, there is a concern regarding the injury to the blood supply of the 1st-metatarsalhead. The objective of this study was to assess the incidence of injuries: (1) to the soft-tissue envelope around the first metatarsal head complex and, (2) to the blood supply of the first metatarsal head and also by using Micro-CT, (3) looking for safe zones close to the first metatarsal head to perform MIS Chevron osteotomy. We hypothesized that the MIS Chevron-type osteotomy procedure would preserve the softtissue envelope of the first-metatarsal-head complex and the blood supply of the 1st-metatarsal-head.

METHODS: Sixteen HV deformity cadaveric specimens were used to perform MIS Chevron-type osteotomy of the first metatarsal head. Anatomical dissection of all specimens was then performed to assess macroscopic injury to the first metatarsal head complex soft-tissue structures, including Extensor Hallucis Longus (EHL) tendon, Extensor Hallucis Brevis (EHB) tendon, Flexor Hallucis Longus (FHL) tendon, Flexor Hallucis Brevis (FHB) tendon, Abductor Hallucis tendon, Adductor Hallucis tendon, Sesamoid complex, Dorsolateral and Dorsomedial digital branches of the first toe and the Dorsomedial digital branch to the second. Macroscopic injuries were classified using a calibrated digital caliper. Any chondral damage to the first metatarsal head was quantified in mm². To assess the amount of first metatarsal head blood supply, specimens were perfused with 200 ml of a low viscosity radiopaque polymer, MV 117 (Flowtech), preoperatively, followed by Micro-CT assessment. Descriptive statistics and percentages were utilized for categorical data.

RESULTS: We did not find injuries in the EHL, EHB, FHL, Abductor-Hallucis, and Adductor-Hallucis tendons. We found a 2mm injury in the FHB tendon in one specimen. No injuries were found in the Dorsomedial and Dorsolateral nerves of the first-toe, the Dorsomedial-nerve of the second-toe, and Medial branch of the dorsomedial-nerve of the first-toe. In 3 cases, we found an injury on first-metatarsal-head (1mm) due to the passage of the K-wire and, in 1 case, due to the inadvertent passage of the drill (4.41mm). Macroscopically and using Micro-CT, we did not observe injuries in the First-Dorsal-Metatarsal-Artery (FDMA), Lateral-DorsalBranch of FDMA, and Plantar-Metatarsal-Artery. Micro-CT helped estimate a safe distance to finish the proximal exit of Chevron-osteotomy (25mm from the most distal point of the first metatarsal head).

DISCUSSION: In this study, the minimally invasive Chevron osteotomy for treating HV seems to be a technically safe procedure, presenting a low rate of iatrogenic injuries with a low degree of severity. In addition, using Micro-CT promoted a better visualization of the microvasculature that nourishes the first metatarsal head. We observed that a proximal distance of 25 mm from the most distal part of the first metatarsal head could be a safe place to finalize the Chevron osteotomy, minimizing the risk of injury to the blood supply of the first metatarsal head.

SIGNIFICANCE/CLINICAL RELEVANCE: This study's identification of safe zones and minimal iatrogenic injuries in minimally invasive Chevron osteotomy enhances the procedure's safety and reliability for hallux valgus treatment. The research findings help surgeons to have precise guidance for minimizing complications and optimizing outcomes in minimally invasive hallux valgus corrective surgeries.

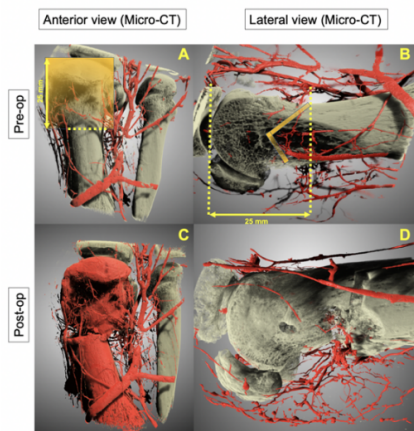


Figure 1. Blood Supply Micro-CT assessment. Pre-op (A) Vascular dorsal plexus of first metatarsal head (yellow square). (B) Estimate a safe distance to finish the proximal exit of Chevron osteotomy (25mm from the most distal point of the first metatarsal head). Post-op: Chevron osteotomy performed in a safe position. (A) Anterior view: Preserving vascular dorsal plexus of first metatarsal head. (B) Lateral view: Preserving vascular dorsal and plantar plexus of first metatarsal head.

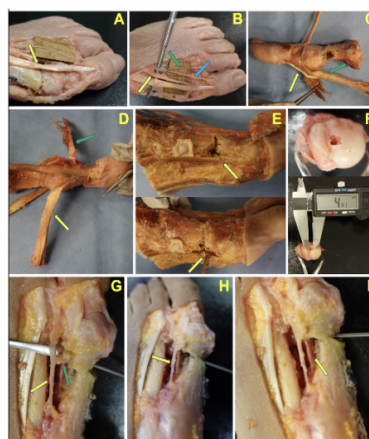


Figure 2. First Metatarsal Head Vascularization and Soft-Tissue Envelope anatomical assessment. (A) Extensor Hallucis Longus tendon (yellow arrow). (B) Extensor Hallucis Brevis tendon (yellow arrow). (C) Flexor Hallucis Longus tendon (yellow arrow). (D) Plantar view: Abductor Hallucis tendon (yellow arrow), Adductor Hallucis tendon (green arrow). (E) Injured Flexor Hallucis Brevis tendon (yellow arrow). (F) Injured First Metatarsal Head cartilage. (G) First Dorsal Metatarsal Artery (FDMA) (yellow arrow). (H) Lateral Dorsal-Branch of FDMA (green arrow). (I) FDMA (yellow arrow). (J) Plantar-Metatarsal Artery (yellow arrow).