

Lesser metatarsals load after minimally invasive surgery for hallux valgus correction: a finite element model

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Introduction: Minimally invasive Chevron-Akin (MICA) surgery is a popular treatment for hallux valgus (HV) correction. Our objective was to analyze the biomechanical consequences on the lesser metatarsals using different screw configurations for MICA osteotomy fixation through the finite element method (FEM).

Methods: An FEM model was developed from computed tomography (CT) data of a moderate HV deformity. Five different screw configurations were tested: Group 1, one intramedullary and one bicortical screw; Group 2, two intramedullary screws; Group 3, two bicortical screws; Group 4, one intramedullary screw only; and Group 5, one bicortical screw only. Maximum stress in the lesser metatarsals was measured for each screw configuration under physiological and supraphysiological loading conditions.

Results: The lesser metatarsals experienced the lowest loads when the first metatarsal osteotomy was fixed with one intramedullary and one bicortical screw, with tensile stress values ranging from 30 to 70 MPa under physiological loads and from 50 to 350 MPa under supraphysiological loads. Across all fixation techniques, the second and fourth metatarsals sustained the highest loads, particularly in Groups 3 (two bicortical screws) and 5 (one bicortical screw only), reaching up to 230 MPa and 600 MPa under physiological and supraphysiological loads, respectively. Regardless of the fixation technique, the region of the lesser metatarsals that experienced the highest load was the diaphysis.

Conclusion: After MICA surgery for HV correction, increased tensile stresses were observed in the lesser metatarsals, mainly in the second and fourth. Fixation of the first metatarsal with one bicortical and one intramedullary screw resulted in the lowest stresses in the lesser metatarsals. Additionally, under both physiological and supraphysiological loads, stresses were primarily concentrated in the metatarsal diaphysis, regardless of the fixation technique.

Keywords: Hallux valgus; Minimally invasive surgical procedures; Finite element analysis.

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