Stress Analysis as a Predictor of Hip Stability in Posterior Wall Fractures of the Acetabulum

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Abstract

Hip joint is an inherently strong anatomical structure but it is also susceptible to traumatic injuries, especially in high-energy incidents such as motor vehicle collisions or falls from significant heights. Among the various types of hip injuries, Posterior wall fractures are the most common acetabular fractures. Despite significant advancements in finite element modeling (FEM), the investigation of hip joint stability in acetabular fractures remains largely confined to computed tomography (CT) imaging and cadaveric studies. This study employs finite element analysis (FEM) to evaluate hip joint stability under varying fracture conditions in the posterior wall of the acetabulum, aiming to quantify the threshold percentage of fractured area at which the joint remains stable. A comprehensive methodology, including reverse engineering, 3D modelling, and stress analysis, is employed to evaluate hip joint stability and determine the maximum load-bearing capacity across various acetabular fracture configurations. A subject-specific acetabulum model was developed, and analyzed for different fractures which revealed stress distribution at the fracture site. The critical load leading to ultimate failure of the fractured acetabulum is evaluated to assess hip joint stability. The results indicate that the hip joint remains stable when the fractured area in the posterior wall of the acetabulum is 11% or less. The findings of this study provide critical biomechanical data that can enhance clinical decision-making for orthopedic surgeons managing acetabular fractures, including the ability to anticipate post-traumatic hip joint instability

Keywords

Posterior wall fractures, acetabulum, hip stability, finite element modeling (FEM), load-bearing capacity.