The Effect of Regional Hip Capsule Defects on Total Hip Dislocation Stability – A Finite Element Analysis

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INTRODUCTION
Instability/dislocation, a frequent short- and long-term complication of total hip arthroplasty (THA) has become the most common failure modality requiring revision surgery [1]. The hip capsule, a complex soft tissue structure, constrains the hip during articulation, significantly enhancing joint stability. To investigate the effects of capsule compromise on THA stability, a finite element (FE) model was developed to parametrically explore the role of various capsule defects on dislocation resistance.

METHODS
Using cadaveric imaging studies (Fig. 1A), accurate capsule major fiber bundle distributions were registered to a segmented hip capsule. Surfaces representing native hip anatomy (bony insertions, hip capsule) as well as THA implant constructs (28mm head diameter, 46mm outer diameter liner, metal shell) were preprocessed with TrueGrid (Fig 1B). One-hundred-nine individual capsule FE models were developed, parametrically simulating both capsular defects (circumferentially-varying incisions and attachment releases) and defect repair through simulation of placement of various numbers of sutures. A fiber-based anisotropic micromechanical material model [2] was applied to the capsule (Fig. 1C), with the necessary material coefficients for the soft tissue being inferred from capsule distraction data [3].

RESULTS:
For all considered variants of capsule compromise, computed dislocation energy was less than for the baseline intact-capsule simulation (Fig. 3). Stability compromise was greatest for defects located in the posterior regions of the capsule. For the most compromised situations, there was >50% decrease in stability. Repair of these defects significantly restored joint stability (Fig. 3).

DISCUSSION:
Localized compromise of capsule integrity can dramatically reduce construct stability. Appropriate repair of capsule deficits can recover near-normal dislocation resistance, although repair-site failure is a concern. Both the degree of stability compromise as well as suture tensile loading were highly technique- and location-dependent (Fig. 4); some variants involved average tensile loads exceeding the reported suture ultimate tensile strength (gray bar in Fig. 4).

Simulated suture tensile loads, arising from various repair techniques, were seen to be highly technique- and location-dependent (Fig. 4); some variants involved average tensile loads exceeding the reported suture ultimate tensile strength (gray bar in Fig. 4).

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REFERENCES:

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