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Finite Element Analysis to Detect the Acromion Fracture Risk Following Anatomic AC Joint Repair

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Summary:
The acromion fracture risk following transacromial tunnel placement for anatomic ac joint reconstruction was evaluated using a finite element analysis.

Abstract:
Purpose: An additional fixation to address horizontal instability for AC-Joints can be achieved by drilling transacromial and either brace the important AC-Capsule with a suture cerclage or reconstruct with tendon grafts. Such fixations may increase the risk of fracture of the acromion due to the specific shape of this bone especially in contact athletes. Our hypothesis was, that variation in tunnel placement and size results in a decreased risk for fracture.
Methods: A Finite Element Analysis (FEA) was utilized for this purpose. 26 cadaveric specimens mean age 59.4 years and a mean BMD of 0.31 g/cm2 measured in a 1x1 cm square on superior acromion surface were tested using a MTS 858 Servohydraulic test system (MTS Systems, Eden Prairie, MN) to receive the baseline data. Additionally, bone mineral density data of serial acromions sections from a previous study was incorporated into the simulation. A native control group of N=10 without the presence of any tunnel was also tested. Tunnels were placed in different directions according to common surgical procedures for anatomic ac-joint reconstruction: horizontal meaning an anterior-posterior orientation vs. a vertical inferior-superior orientation through the acromion. Two different tunnel diameters were drilled one being 2.4 mm as used in a acute repair situation to pass a suture cerclage and two being 4.5 mm to represent a chronic scenario to pass a tendon graft through it. Further more the tunnel length and distance between tunnels was also simulated. The FEA then analyzed tunnel diameter, location, length, orientation and direction of incoming force as independent risk factors for Acromion fracture.
Results: Acromions without tunnel drilling fractured in patterns similar to previously described traumatic Acromion fractures and resisted an ultimate load of 534 N ± 120. We found that the acromion is at higher fracture risk, with a superior to inferior directed incoming force compared to a simulated lateral hit. Further we found that hole position and orientation have greater influence on increasing acromion fracture risk than tunnel diameter. The FAE calculated a load to failure reduction to 83.2% of the native stability if a 2.4 mm horizontal tunnel was drilled transacromial and 70.55% with a 4.5mm tunnel of the same length and direction. When combining the results recommended No-Drill-Zones can be identified and should be avoid especially in contact athletes to ensure save tunnel placement.
Conclusions: The results of this FEA showed limited peak loads to fracture with increasing drill holes size compared to native acromions regarding tunnel orientation and diameter. However, fracture pattern and increased fracture risk was dependent on tunnel orientation and position. When avoiding penetration of the inferior cortex a horizontal drilled tunnel results in a lower reduction of ultimate load to failure and therefore is recommended especially with increasing hole diameters.