**Introduction**
Fractures of the proximal humerus are common, with an incidence similar to that of hip fractures. This injury is being increasingly encountered in our aging population because it is often related to weak, osteoporotic bone[1]. While the majority can be treated nonoperatively, approximately 20% are complex fractures which require surgical stabilization, either with internal fixation or by prosthetic replacement. The optimal method of internal fixation is not currently agreed upon. biomechanical rigidity is clearly an important factor in the functional outcome, as sufficient rigidity enables the patient to move the shoulder and maintain strength and range of motion during the perioperative period. A complicating factor in the surgical management of these injuries is that poor bone stock and comminution are commonly encountered, particularly in the elderly. Recent biomechanical studies have suggested that the use of a calcium phosphate cement was an effective load sharing adjunct to traditional fixation in cases of poor bone quality. The use of calcium phosphate cement has not been reported in the proximal humerus. Therefore, our objective in this study was to contrast the biomechanical fixation of two commonly used internal fixation devices (cloverleaf plate and 90° angled humeral blade plate) and to determine the effect of calcium phosphate cement augmentation (SRS Norian) on fixation.

**Methods**
Eleven paired human fresh frozen cadaveric humeri were used (ages 70-90). Each underwent DEXA scanning to evaluate the bone mineral density in the humeral head and shaft regions. A three part fracture was created with a microsagittal saw. The inferior third of the cancellous bone of the humeral head fragment was impacted to simulate a fracture void between the head and shaft fragments. The pairs were separated into two groups with similar bone density values with one group receiving cloverleaf plate-screw fixation (n=5) and the other 90° angled humeral blade plate fixation (n=6) (Synthes Canada). The humerus was potted in dental stone 150mm distal to the articular surface. Within each pair, one specimen was fixed with and the other without calcium phosphate cement augmentation (SRS, Norian, Cupertino CA). Both specimens were then immersed in a physiologic saline solution at 37°C for 18 hours. Each specimen was mounted in a biaxial servohydraulic testing machine (Instron 8874, Canton MA) and tested under three different protocols. The first was cyclic loading to simulate passive abduction using a custom loading apparatus. The glenohumeral force profile used was a joint compressive load varying from 0.22 to 0.5 times body weight[2] while the specimen was abducted through an arc of 60° at 0.1 Hz for 250 cycles. The second test was the cyclic application of an external rotation torque of 2Nm at 0.5Hz for 250 cycles. The third test protocol was loading to failure in external rotation at 1°/second with failure defined as the ultimate torque or torque at 30° of relative rotation, whichever occurred first. During each test, three dimensional position data were captured using an optoelectronic camera (Optotrak 3020, Northern Digital, Waterloo CAN). A set of four infrared markers was fixed to each of the three fragments and data was collected continuously throughout the test. The position of the DOF interfragmentary motions were then calculated. Differences in motion were assessed with a two factor analysis of variance at a 95% significance level. A paired t-test was used to detect differences across the paired humeri with and without SRS.

**Results**
Cyclic motion results were taken as the range of motion during the last five cycles. For the abduction test, interfragmentary motion was calculated as translation of the most medial aspect of the head-shaft fracture line, parallel to the shaft axis. There were no significant differences between implant types with or without SRS but the trend was for less motion in abduction with the cloverleaf plate (Table 1). Paired comparisons with and without SRS are shown in Figure 1. Motion in torsion was significantly less with SRS and torque to failure was significantly increased with SRS augmentation. Failure mode of the plate with SRS was primarily plate bending as opposed to screw pullout without SRS. The blade without SRS generally failed by the blade cutting though the head and with SRS several failures were by shaft fracture.

**Discussion**
Interfragmentary motion was small in all specimens tested in abduction. The addition of the calcium phosphate cement did seem to confer some added stability in abduction, but the difference was not significant. Good fracture reduction resulting in cortical bone contact and a transverse osteotomy between the head and shaft likely provided good compressive stability. In cyclic external rotation, SRS significantly reduced motion. The torsion and torsional failure testing rely more on the implant to transmit load across the fracture site and therefore additional stability is provided by improving the interface between the bone and either the screws or the blade within the cancellous bone of the humeral head. The ability of a calcium phosphate cement to negate the relationship between low bone density and low failure torques would be a valuable asset.

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**References:**

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