INTRODUCTION

Humeral fractures account for around 3-5% of all fractures. [1, 2] There are many different treatment options; however, conservative treatment has obtained satisfactory results in 96%-98% of cases. [1] Surgical intervention includes open reduction and internal fixation with plates, intramedullary nails or by the use of external fixators. Plating is one of the primary methods used for humeral shaft fracture treatment. Plate fixation reduces the likelihood of revision and the problem of shoulder impingement when compared to intramedullary nailing of the humerus. [3] However, there is controversy regarding the use of plates for the treatment of these fractures as they involve relatively greater exposure which leads to soft tissue damage. Furthermore, there is a real risk of iatrogenic injury to the radial nerve. Conversely, intramedullary nails have been shown to be weak in torsional rigidity contributing to the high rate of non-union with nails.

The purpose of this study is to assess the biomechanical characteristics of a locking plate versus a compression plate in treating fractures of the humeral shaft.

MATERIALS AND METHODS

Eleven fourth generation composite humeral sawbones (Research Laboratories, Inc. Vashon, WN) were used. The plates were obtained from Smith & Nephew (Memphis, TN) and include a 4.5mm 10 hole low contact locking plate and a 4.5mm 10 hole dynamic compression plate. Rosette strain gauges were used to measure the strain at the osteotomy site, which represents the fracture of the bone. Two gauges were attached to the anterior surface of the sawbones 20mm proximal and distal to the osteotomy. Mechanical testing was performed on a servo-hydraulic testing machine (MTS 858 Bionix, Eden Prairie, MN). The humeral sawbones were tested in torsion and 4-point bending in the anterior and lateral planes. All of the sawbones were initially pre-tested intact (state 1). The plates were then surgically attached and the sawbones, with implant in situ, were tested again (state 2). An osteotomy was then performed representing a transverse fracture with a 3mm gap, and the torsional and bending stability was again tested (state 3).

The protocol for the torsional loading included rotating the sawbone internally and then externally to a maximum of 12 Nm at 0.1 Hz. Each sawbone was tested three times, with three cycles per test. A 4-point bending jig was used for the mechanical bending of the specimens. The supports were located 77mm from the centre of the sawbone where the fracture was located. The load points were located 39mm from the middle of the fracture site. Therefore the fracture site and the two strain gauges were subject to a 15.2 Nm bending moment. A compressive load of 10 N was applied to the sawbone at the beginning of the test in order to keep the bone aligned in the correct plane. The protocol for the bending was then to load the sawbone to a maximum of 400 N at a rate of 50N/sec, hold for 2 seconds and then release back to 10 N at the same rate. Again, each sawbone was tested three times, with three cycles per test. Testing resulted in nine data points which were used to obtain the corresponding strain values for anterior, lateral and torsional testing for each specimen. The stiffness of each test was obtained from the linear region of the load-displacement graphs using MATLAB (Mathworks Inc., MA). Mechanical and strain data was analysed using an Analysis Of Variance (SPSS Inc, Chicago, IL) and significance considered where P<0.05.

RESULTS

There were no differences in stiffness between the plates in state 2. The internal rotational stiffness for both plates was similar to the sawbones only (state 1), whereas the external rotational stiffness of both plates were statistically different.

The stiffness of the sawbones with the osteotomy (state 3) for the locking plate as compared to the compression plate was significantly different in torsion and anterior bending. However, the stiffness in lateral bending was not statistically different. In both the torsion and anterior loading the stiffness of the locking plate was lower than the stiffness of the compression plate.

Less strain was observed on the distal side of the osteotomy (state 3) for the locking plate when compared to the compression plate during torsional testing. There were no differences between the strains obtained from the proximal gauge.

The stiffness of the sawbones with the osteotomy (state 3) for the locking plate was significantly different in torsion and anterior bending. However, the stiffness in lateral bending was not statistically different. In both the torsion and anterior loading the stiffness of the locking plate was lower than the stiffness of the compression plate.

Figure 1: Torsional stiffness for sawbones only, sawbones intact with plates and sawbones plus osteotomy with plates (States 1, 2, 3). *=p<0.05 for external and internal stiffness comparing plates in state 3. # =p<0.05 between state 1 and state 2 for external stiffness only.

DISCUSSION

Sawbones were chosen for this study over cadaveric tissues due to the benefits of less interspecimen variability, easy availability, simple and safe handling, non-degradable properties, and consistency for standardization in biomechanical analyses.

The stiffness of a fracture fixation device influences the fracture-healing process. Rigid fixation can lead to direct osteonal healing and flexible fixation with more interfragmentary movement to callus healing. Although interfragmentary movement can act as a stimulating factor in callus formation and the mechanical consolidation of fractures, it also has been reported as a principal cause of nonunion. [4]

The comparison between the locking plate and the compression plate after the osteotomy (state 3) showed that the compression plate was significantly stiffer than the locking plate. Also, the maximum principal strain on the distal side of the fracture site was significantly higher for the compression plate when compared to the locking plate. This suggests that the less rigid locking plate minimizes the peak stresses at the bone-implant interface and therefore reduces the maximum strain located at the fracture site. This indicates that the locking plate may be a more suitable internal fixator of humeral shaft fractures when compared to the compression plate.

REFERENCES