INTRODUCTION:
Locking plates have greatly improved the outcome of proximal humeral fractures, especially in osteoporotic bone. However, most recently, there are several reports describing an alarming rate of screw cutout through the subchondral bone of the humeral head and impingement under the acromion. A novel locking plate with smooth pegs was developed to reduce the risk of screw cutout and impingement with the acromion. This locking plate is characterized by its placement position, distal to the greater tuberosity, and intended to provide a three-dimensional scaffold with subchondral support. The purpose of this study was to compare the biomechanical stability of a conventional locking plate with threaded screws to this novel locking plate with smooth pegs in a human cadaver model.

MATERIALS AND METHODS:
Fourteen pairs of frozen, cadaveric proximal humeri (mean age: 76 years) were harvested. The bone quality of the humeri was assessed with use of dual x-ray absorptiometry prior to mechanical intervention. For testing, the articular surface of the humeral head was fixed to the mid-level of the anatomic neck in a plastic tube with use of spiked screws and resin. Comminuted fractures of the surgical neck were simulated by excising a 10-mm wedge of bone. Specimens underwent osteosynthesis using a locking plate with threaded screws (TS group) on one side of the humerus, and the smooth pegs (SP group) on the contralateral side.

The specimens were separated into four experimental groups with seven humeri in each: TS bending, SP bending, TS torsion, and SP torsion (Figure 1). A bi-axial servohydraulic test machine (Model 858 MTS Systems, Eden Prairie, MN) was used for mechanical testing (Figure 2). All the data were collected digitally and stored in a PC and on a secure server. Statistical analysis, graphic imaging and descriptive assessment were carried out with the mathematics and statistics program MatLab (The MathWorks, Inc., Natick, MA). Bending specimens were cyclically loaded from 0 to 7.5 Nm of varus bending moment at the fracture site. Torsion specimens were cyclically loaded to ±2 Nm of axial torque. The maximum displacement in bending and total (minimum and maximum) angular rotation in torsion were compared. Analysis of variance with repeated measures was used to compare the two methods of fixation at 1000-cycle increments over a 10,000-cycle testing period.

RESULTS:
There was no significant difference in bone quality between the TS and SP groups. No implant failure or cutout was noted in either the TS or SP group when subjected to cyclic bending and torsion. In cyclic bending, maximum displacement of the distal fragment significantly increased with increasing cycles (p < 0.001)(Figure 3). The SP group demonstrated significantly less maximum displacement of the distal fragment than did the TS group over 5000 cycles (6.03 ± 1.1mm in the SP group, 6.97 ± 1.1mm in the TS group at 10,000 cycles) (p = 0.039). In cyclic torsion, total angular rotation also increased with increasing cycles (Figure 4). The maximum total angular rotation was 5.85 ± 3.8° in the TS group and 4.03 ± 3.9° in the SP group at 10,000 cycles. However, no significant difference was detected between the TS and SP groups with regard to total angular rotation.

DISCUSSION:
The newly developed proximal humerus locking plate with fixed angle smooth pegs is a system intended to provide spatial subchondral support to resist varus stress and to prevent protrusion through the articular surface by the blunt-tipped peg. Since it is designed to be positioned more distal compared to a locking plate with threaded screws, the angle of between the plate and screws may be greater than that of TS group. Also, since smooth pegs are inserted until 2-3 mm below the subchondral bone, the length of smooth pegs may be longer than that of threaded screws. For these reasons, the moment arm of the SP group during bending motion may be greater compared to the TS group resulting in the stronger fixation. Thus, the SP group demonstrated superior biomechanical characteristics compared with TS when tested cyclically in cantilevered varus bending. Our results indicate that potential advantages for locking plate fixation with smooth pegs.

REFERENCES:

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