Osteosynthesis of Humeral Periprosthetic Fractures With a Stable Cemented Stem: A Biomechanical Assessment of 3 Different Methods

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Purpose: The aim of our study was to assess the biomechanical stability of 3 different techniques to proximally fix a locking compression plate (LCP) for treating a Worland type-C periprosthetic fracture after cemented total shoulder arthroplasty.

Methods: 27 synthetic humeri with left-sided geometry were used. A cemented anatomical shoulder prosthesis was implanted according to the manufacturer instructions. Following this, a transverse osteotomy 5 cm distal to the prosthesis was performed mimicking a periprosthetic fracture type Worland C. The fractures were then treated with a 14-hole LCP that was proximally fixed using one of the following methods: (1) 1x 1.5-mm cerclage wire and 2x locking unicortical screws, (2) 3x 1.5-mm cerclage wires, or (3) 2x locking attachement plates (Depuy Synthes) allowing bicortical fixation. The biomechanical investigations were carried out on a servohydraulic testing machine. To assess the torsional stiffness, the specimens were axially loaded with 5 N. Afterwards, an internal rotation moment of 5 Nm was applied. After reaching the maximum moment, the specimen was unloaded and an external rotation moment of 5 Nm at the same rate was applied. Axial stiffness as well as load-to-failure investigations were carried out in a cyclic test. A 50-N preload was initially applied. In the first load stage, a cyclic load was applied in sinusoidal form up to a load of 250 N. Afterwards, the upper load limit was increased by 50 N each time, until a maximum axial load of 2500 N was reached or specimen failure occurred. Relative movements at the plate-humerus interface were registered by motion tracking. Statistical differences were detected using Kruskal-Wallis Test.

Results: With regard to internal stiffness and after comparing the 3 groups, group 1 showed a median stiffness of: 0.5 Nm/deg, group 2 had a median stiffness of: 0.33 Nm/deg, while group 3 had a median stiffness of: 13.81 Nm/deg ($P < 0.05$). Regarding external stiffness the median values for the 3 groups were: 0.3 Nm/deg, 0.48 Nm/deg, and 12.85 Nm/deg, respectively ($P < 0.05$). Concerning axial stiffness, group 1 showed a median stiffness of 4464.25 N/mm, group 2 had a median stiffness of 6877.5 N/mm, whereas group 3 had a median stiffness of 6618.45 N/mm ($P < 0.05$). When comparing the energy needed until failure group 1 had a median of 1400 N, while groups 2 and 3 had median loads of 1675 N and 1500 N, respectively ($P = 0.109$).

Conclusion: Biomechanically, even though the 2x locking attachment plates with bicortical fixation displayed a significantly higher torsional stiffness in comparison to the other groups, the group with only cerclage wires displayed a higher load to failure and a comparable axial stiffness, providing the surgeon a cheaper and reliable alternative in treating such fractures.