Pinning fixation for 2-part proximal humeral fractures: a biomechanical study comparing different pin types and configurations

INTRODUCTION:
Percutaneous pinning fixation of proximal humeral fractures minimizes soft tissue stripping and should be considered for patients that require a low invasive procedure. Different pins and configurations have been biomechanically tested and compared to the locking plate (gold standard). We hypothesized that the fixation with 3mm fully threaded pins connected by a custom made external fixator would allow a higher stability of the construct, compared to traditional 2.5 mm terminally threaded pins.

METHODS:
A 2-part proximal humeral fracture was created in epoxy resin composite humeri (4th generation Sawbones, Pacific Research Laboratories Inc., Vashon, WA) and fixed with four different modalities: 1) four parallel pins (Box-configuration), 2) two pins from distal to proximal and two from proximal to distal (UpDown-configuration), 3) four convergent pins (Fan-like-configuration), and 4) a locking plate (AxSOS™, Stryker, Switzerland). Each configuration was tested with: 1) 2.5 mm terminally threaded pins, 2) 3 mm fully threaded pins and 3) 3 mm fully threaded pins combined with a custom made external fixator (figure 1). Each group consisted of 8 composite bones (total 72).

RESULTS:

Cyclic torsion tests: The plate showed the greatest torsional stiffness compared to all pin configurations without the external fixator. However, with the external fixator applied to the Box and the Fan-like configurations, the torsional stiffness was greater, but not significantly different, compared to the plate. The maximum displacement during the torsion test shown similar data compared to the torsional stiffness.

Cyclic varus bending tests: The locking plate did not confer greater compression stiffness compared to Box and Fan-like configurations. No statistical differences were demonstrated between the constructs (p>0.05) regarding axial displacement.

Load to failure: Unexpectedly, with some constructs, when the load exceeded approximately 2000N, failure occurred in the shaft and not at the fracture site. This phenomena occurred in all the locking plates, in 5/9 cases of the 3mmBox construct augmented with the external fixator and in 4/9 cases of 3mm Fan-like and 3mm Fan-like augmented with the external fixator. Hence, difference in strength over 2000N for these 4 constructs is not detectable. The other constructs failed at fracture site at lower loads.

DISCUSSION:
The starting hypothesis was confirmed and the use of external fixator applied to Box and Fan-like constructs improved the torsional and compression stiffness. Surprisingly, the new device showed many parameters comparable to the locking plates. The Box with external fixator was the stiffest pin construct (torsional and compression stiffness). Three mm fully threaded pins performed better than 2.5 mm pins. When pinning 2-part humeral fractures, we recommend using the Box or Fan-like configuration with 3 mm fully threaded pins and the addition of an external fixator.

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