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Distal Radius Plates: Why Stronger Is Not Always Better

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Introduction

Osteosynthesis systems featuring locking plates and screws have become the de facto standard for a wide range of indications. Their biomechanical advantages have led to new and easier surgical approaches such as the volar approach for dorsal comminuted fractures of the distal radius [1]. Because of their fracture bridging properties these systems offer an initial mechanical stability that allows for early postoperative rehabilitation that often translates into better clinical results.

While there is consensus that these systems must offer some mechanical stability it is unclear whether stronger is necessarily better. Most results published in the literature focus on so-called 'load to failure' tests to determine the maximum load at which catastrophic failure occurs.

In the present work we compare three different systems in an osteoporotic fracture model concentrating on the overall system performance in a fatigue test rather than just hardware failure. We are specifically interested in the secondary loss of reduction (SLoR) in the form of radial shortening, radial inclination and volar tilt.

Method and Materials

Three different types of volar locking systems for distal radius fractures were used (Figure 1):

- Medartis: APTUS Radius 2.5, A-4750.17/.18, a variable angle system
- Competitor 1: A leading fixed angle system
- Competitor 2: A leading variable angle system

6 plates per type were mounted according to IFU on osteoporotic cadaveric specimens matched for bone mineral density and shape. A 10 mm osteotomy was performed in all specimens 20 mm proximal to the articular margin of the radius at Lister's tubercle, representing a non-contact "fracture gap" (AO type 23-A3 fracture). Specimens were cut transversely 90 mm proximal to the distal joint surface and embedded in PVC pipes [2].

Testing was carried out at the Ludwig Boltzmann Institute for Experimental and Clinical Traumatology in Vienna using a MTS universal testing machine. Samples were loaded to 400 N for 2000 cycles [3] or until failure (mechanical failure or screw cut-out through the articular surface). Load and displacement were recorded at the point of load transfer. Radial shortening (residual deformation after unloading) as well as radial inclination and volar tilt were determined after testing using standardised photographs (Figure 2).

Results

Figures 3 and 4 show radial shortening as well as radial inclination and volar tilt. The Medartis plate also has the smallest SLoR. Looking at the failure mechanisms observed it becomes apparent why: failure occurred either through the formation of significant longholes in the bone around the distal locking screws or through breakage of locking screws (Figure 5). Both failure mechanisms were observed with competitor plates only and not with the Medartis plate.

Conclusion

It is generally believed that mechanically stronger osteosynthesis systems always perform better. However, in stiff systems all stresses must be absorbed by the bone-screw interface. The present tests illustrate that high stiffness and mechanical strength may turn out to be a disadvantage, especially in bone of poor quality. Due to the poor quality of osteoporotic bone and the non-physiologic properties of the implant, the bone's trabecular structure may be damaged by the repeated loading. While a single stress event would most likely not cause any problems, damage may accumulate over time leading to the formation of 'long holes' around the screws resulting ultimately in the penetration of the joint surface. This mechanism is well known from the proximal humerus but has also been described in the distal radius [4]. The long holes may lead to a loosening of the implant promoting screw fractures as observed in our tests (Figure 5).

While the competitor's plates have been used with fewer screws arranged in a single line, only Medartis specifically instructs its users to always use both distal rows. And even though previous studies seem to indicate that the use of a second distal screw row does not improve performance of other osteosynthesis systems [5] the Medartis system performs significantly better in this test than the competitors'.

Overall it seems that the comparatively elastic Medartis construct is better able to absorb the stresses occurring during loading thereby 'protecting' the weak bone. This proection means that almost no SLoR occurs, a finding that seems to be supported by clinical results [6, 7]. Ultimetly, the performance of an ostheosynthesis system is not just a function of a plate's or a screw's strength but depends on the carefull and skilled balancing of different properties of the bone, the anatomy and the implant.

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Wrist

Literature

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[3] Putnam M. et. al., *J Hand Surg Am*, **25A(3)**: 469, 2000.
[4] Knight D. et. al., *Injury*, **41(2)**: 184, 2010.
[5] Weninger P. et. al., *Wien Klin Wochenschr*, **123**: 4, 2011.
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[7] Esenwein P. et. al., *Arch Orthop Trauma Surg*, **133**: 1155, 2013.

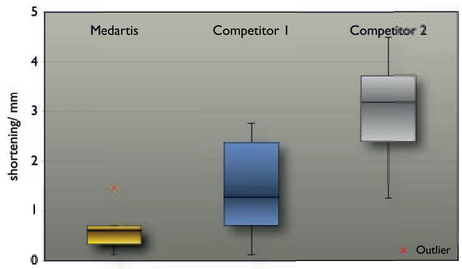

Figure 3: *Radial Shortening at the end of the test*

Figure 4: *Radial inclination and volar tilt at the end of test*

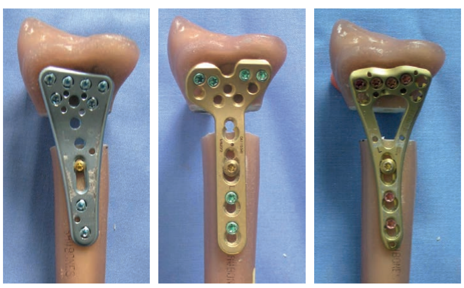

Figure 1: *From left to right Medartis, Competitor 1 and 2 (mounted on Sawbones)*

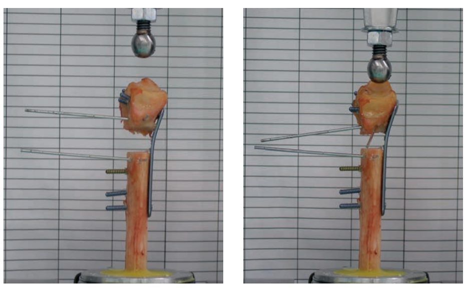

Figure 2: *Test setup; left: before, right: after test*

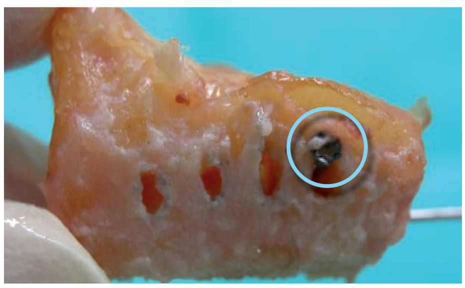

Figure 5: *Distal fragment post test after removal of plate 3 showing 'long holes' and broken screw (blue circle)*