Medartis AG
Hochbergerstrasse 60 E
4057 Basel / Switzerland
P +41 61 633 34 34
F +41 61 633 34 00

www.medartis.com

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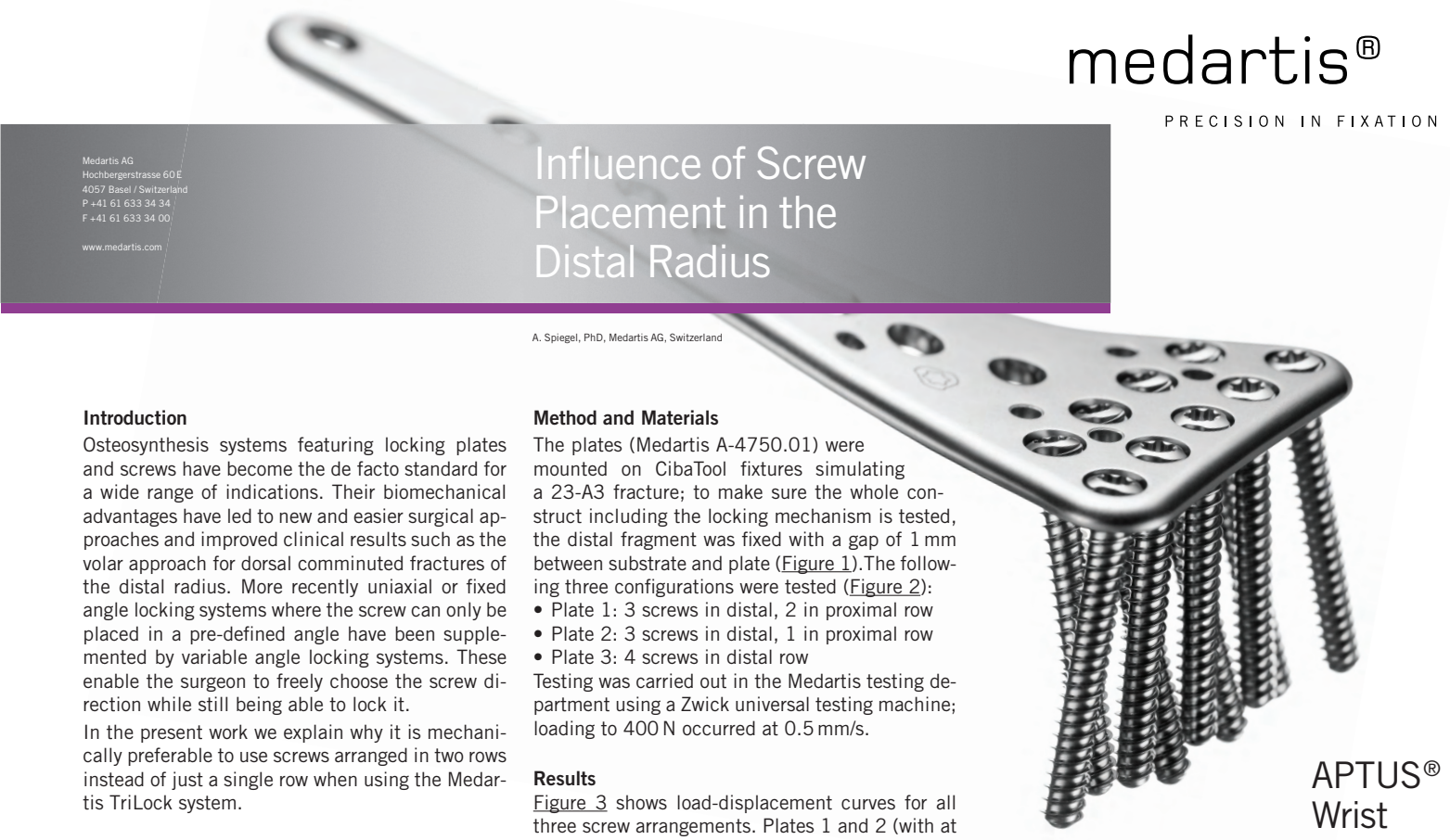
PRECISION IN FIXATION

Influence of Screw Placement in the Distal Radius

A. Spiegel, PhD, Medartis AG, Switzerland



APTUS® Wrist

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 and improved clinical results such as the volar approach for dorsal comminuted fractures of the distal radius. More recently uniaxial or fixed angle locking systems where the screw can only be placed in a pre-defined angle have been supplemented by variable angle locking systems. These enable the surgeon to freely choose the screw direction while still being able to lock it.

In the present work we explain why it is mechanically preferable to use screws arranged in two rows instead of just a single row when using the Medartis TriLock system.

Locking Mechanisms

Locking between plate and screw can be achieved by different principles. Usually, the connection between plate and screw is

- either a positive fit accomplished e.g. by a thread-in-thread solution like VariAx by Stryker. The screw deforms the plate hole, leading to an angular stable form fit.
- or friction locking employed by Medartis with the TriLock system. The TriLock multidirectional and angular stable locking is based on spherical 3-point wedge-locking and independent of plate or screw hardness.

While both systems have their distinct up- as well as downsides, it can generally be said that

- positive-fit systems offer higher resistance to bending moments but fail catastrophically by bending or fracture of plate or screw. Also, when locking is achieved by deformation of the plate hole, usually softer plate materials have to be used leading to bulkier plate designs.
- friction-locking systems are weaker when subjected to bending moments but fail more gracefully: a failure of the locking mechanism results in a 'partially locked' screw.

Method and Materials

The plates (Medartis A-4750.01) were mounted on CibaTool fixtures simulating a 23-A3 fracture; to make sure the whole construct including the locking mechanism is tested, the distal fragment was fixed with a gap of 1 mm between substrate and plate (Figure 1).The following three configurations were tested (Figure 2):

- Plate 1: 3 screws in distal, 2 in proximal row
- Plate 2: 3 screws in distal, 1 in proximal row
- Plate 3: 4 screws in distal row

Testing was carried out in the Medartis testing department using a Zwick universal testing machine; loading to 400 N occurred at 0.5 mm/s.

Results

Figure 3 shows load-displacement curves for all three screw arrangements. Plates 1 and 2 (with at least one screw in the second distal row) show a nearly linear behavior. Deformation remains elastic and the system's stiffness is equal to that of the plate. The respective inserts in Figure 3 confirm that the locking mechanism was not affected: a parallel gap remains between plate and substrate. Plate 3 shows a significantly reduced stiffness caused by the swiveling of the locking mechanism: At 80% displacement (arrow in Figure 3) stiffness increases, indicating that plate and substrate have made contact and the system's stiffness approaches that of the plate. Insert 3 in Figure 3 demonstrates the partial failure of the locking mechanism.

Conclusion

Medartis APTUS distal radius plates 2.5 were tested with three screw configurations: one plate had screws in the most distal row only, the other two plates had at least one screw in the second row.
Our results show that adding at least one screw to the second distal row significantly increases the system's stiffness and eliminates plastic deformation by 'protecting' the TriLock locking mechanism. We therefore suggest to always use at least one screw in the second distal row for optimal clinical results.

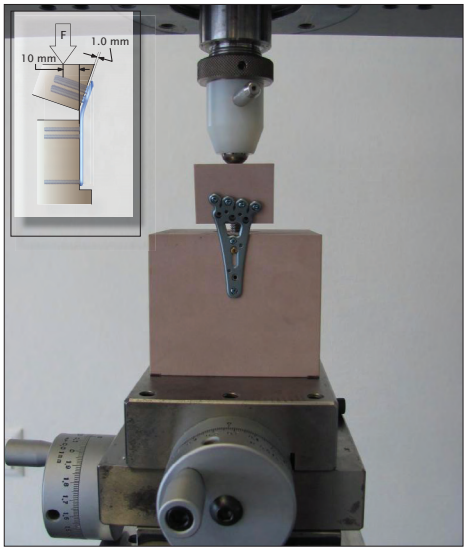


Figure 1: *Test setup; detail: plate placement*

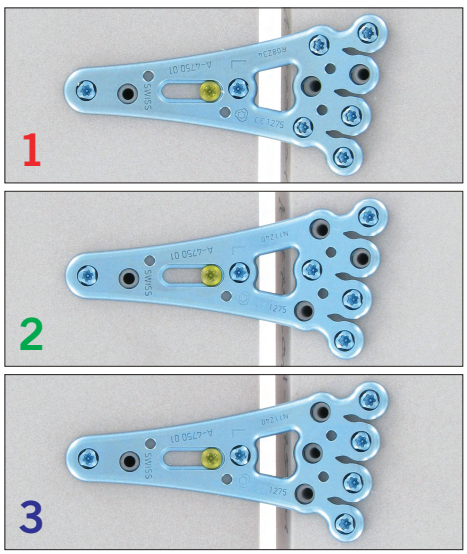


Figure 2: *From top to bottom: Group 1, 2 and 3*

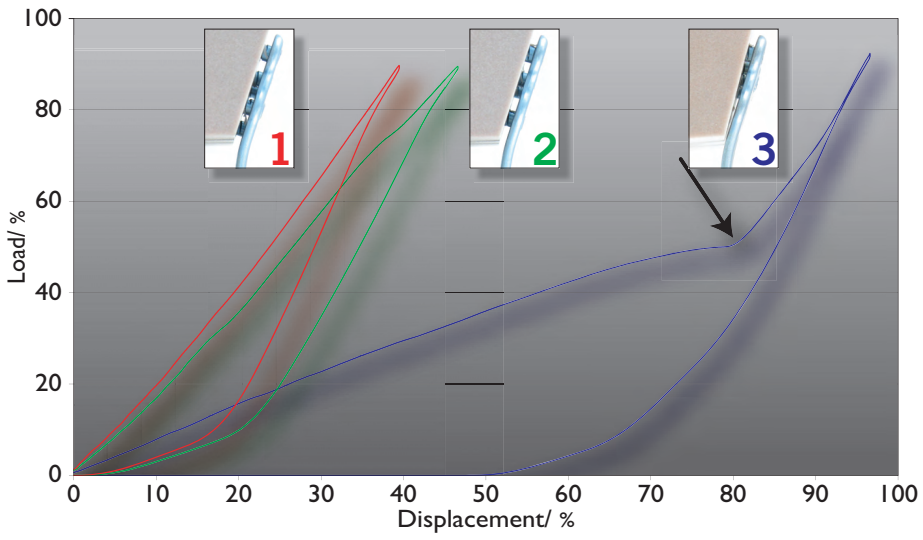


Figure 3: *Load-displacement curves of distal radius plates with different screw arrangements; inserts 1, 2 and 3 show locking mechanism after testing*