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# Mechanical Testing of Two Different Variable Angle Locking Systems for Treatment of Distal Radius Fractures

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## Abstract

**Background:** In recent years, the volar locking plating of distal radius fractures has become popular. Locking mechanisms have improved with the variable angle locking mechanism. The aim of the study was to evaluate the different behavior of different screw plate locking mechanisms and, furthermore, the influence on the stability in the fracture setting.

**Methods:** Distal radius plates Synthes VA-LCP Two-Column and Stryker VariAx were compared. The locking mechanisms were tested as cantilever bending tests ascyclic staircase loading tests in 0° and 15° screw angulation as well as relocking in 0° angulation after locking in 15° using the Zwick/Roell Z010 material testing machine. The stability in an extraarticular, dorsally comminuted fracture (AO 23.A3) with Sawbones was also compared.

**Findings:** The Synthes plate showed a load to failure of 834.1 N for 0°, 500.2 N for 15°. The Stryker plate showed a load to failure of 492.2 N for 0°, 202.9 N for 15°. In the relocking test a load to failure of 372.2 N was found for the Synthes plates and 155.3 N for the Stryker plates with high significance to 0° for both plates, no significance to 15°. In all three locking mechanism tests the difference between the two plates was significant.

The fracture setting showed no significant difference, but different failure mechanisms.

**Interpretation:** Higher screw plate angulation led to less stability. Relocking does not decrease the stability compared to 15°. Although Synthes plates were superior in the locking tests, a difference in the fracture fixation could not be found.



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## Background

Distal radius fractures are the most common fracture in adults with an incidence of about 2/1000 people per year [1,8,14]. Two injury peaks exist for young male patients with high energy injuries on one hand and for postmenopausal females due to the developing osteoporosis on the other hand [1,2,3,14].

Based on the increased availability of locking plates during recent years, the majority of the distal radius fractures are treated surgically nowadays. Moreover these fractures are mainly fixed with volar plates due to the evolved locking screw mechanisms including polyaxial designs providing stability even in dorsally comminuted fractures, combined with the less risk of complications like extensor tendon irritation, less range of movement and even higher risk of loss of reduction [10,16].

Several plates with differing screw-plate locking mechanisms have been developed and compared in recent studies [1,3,9,12,13,18]. However, a direct comparison between the latest polyaxial locking systems including the Synthes® variable angle plate and the Stryker®VariAx plate has not been done yet (Figure 1). The purpose of this study is to compare these two different variable screw locking mechanisms using a mechanical testing setup and Sawbones®.

## Materials and Methods

The required implants with the belonging instruments as well as the Sawbones® were provided by the companies. In summary, we had 12 volar distal radius plates of each company (Synthes® variable angle plate, 3 shaft holes, width 25.5mm; Stryker®VariAx Distal Radius Plate standard size) and each 6 Radius Sawbones® (item # 3407, 4th generation) were provided by Synthes and Stryker respectively. The Sawbones® were labeled and numbered and based on this randomized with the help of the Windows Excel® random function before testing the fracture setting.

**Figure 1**: Left plate Stryker® VariAx, right plate Synthes® variable angle.

**Figure 2:** Screws on a wooden block.

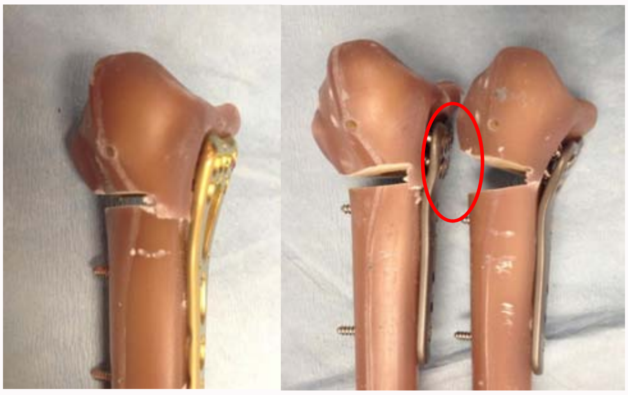
The use of Sawbones® has been validated in recent studies [3,4,12,17,18,20,21].

As a first series, the single screw interface of each implant system was mechanically tested in 0° as well as in 15° screw angulation using the Zwick/Roell Z010 material testing machine in cantilever bending pattern with a cyclic staircase loading. In addition, the same test was performed in a 0° relocked angulation after a locking in 15° angulation. The accuracy of the screw angulation was achieved with the help of Synbone® foam. First, we fixed the plate preliminarily with K wires on the foam, followed by drilling with the drill guide provided by the companies in the angle of 0° or 15° respectively. Finally, we applied the screw in the according angle and locked the screw in the way the companies recommend for their system.

A 20 mm locking screw was used as a standardized lever arm to create a bending moment in the locking interface. However, in order to imitate the short lever arm in a fracture situation, the loading point was located as close as possible to the plate allowing a test moving without interference between plate and loading plate. The load was applied perpendicularly to the screw. The plates itself were fixed with two 30 mm long fixed angle screws on a wooden block (Figure 2).

The cyclic staircase loading test started with a load of 5 N and increased with 5 N per cycle. The moving velocity was 0.1 mm/s. The load was discharged when a 20 percent loss of load was recognized. A plastic deforming of the locking mechanism or even of the screw itself did not show such loss of load and, thus, was not recognized by the machine. Nevertheless, this was well indicated by the position of the screw in relation to the loading plate. The test was manually stopped when the screw was not parallel to the lower surface of the loading plate.

**Figure 3:** Radiocarpal joint.



**Figures 4 and Figure 5**: Loss of reduction without bending of the plate on the left Synthes® plate; bending of the Stryker® plate.

As a second series, we simulated a fracture situation creating an extraarticular, dorsally comminuted fracture (AO classification 23 A3) on the Sawbones® and fixed these fractures with either the Synthes® plate or the Stryker® plate. In order to apply the screws in the same angle for all radii, the drill guide block was used for the Synthes® plates and the fixed angle drill guide was used for the Stryker® plates. A cyclic staircase loading test according to the screw plate locking mechanism test was performed with an applied load in the scaphoid fossa through a metal ball imitating the physiological load in the radiocarpal joint [6] (Figure 3). Again the endpoint of the test was a load loss of 20 percent and/or a loss of reduction of more than 2 mm.

## Results

Each trial consisted of seven tests. For every trial series an average value was calculated and with the help of the t-test all trials were compared. First, in the screw plate locking mechanism test a significant reduction of load to failure was recognized for both plates when the locking in 0° and 15° was compared. The Synthes® plate showed an average load to failure of 834.1 N (±223N) for locking in 0° angulation. For an angulation of 15°, the same plate had a load to failure on average of 500.2 N (±166.9N). Thus the reduction of load to failure was significant (p 0.014).

A higher decrease of load to failure was found for the Stryker®

plates when the similar trails were compared. An average load to failure was calculated with 492.2 N (±67.6N) for locking in 0° angulation and 202.9 N (±29.4N) for locking in 15° angulation, respectively. This difference was very significant (p< 0.001).

Secondly, comparing the results of the relocking trials, namely locking in 15° angulation followed by relocking in 0°, with the previous mentioned trials, a similar behavior for these two plates could be found.

A load to failure on average of 372.2 N (±96.2N) was shown for the Synthes® plates and 155.3 N (±57.4N) for the Stryker® plates. Therefore, a very significant difference was seen comparing the relocking trials with the 0° angulation trials in both plates (p< 0.001). The comparison of the relocking trials with the trials locking in 15° angulation showed no significant difference (p 0.104, Synthes®; p 0.075, Stryker®).

Comparing the two plates in all three screw plate locking mechanism trials, the Synthes® plate showed a very significant higher load to failure in all three trial (p< 0.001 for 15° and relocking, p 0.003 for 0°).

However, the comparison between the two plates in the fracture setting demonstrated no significant difference (p 0.779) in the average load to failure (Synthes®: 1766.6N±417.6N, Stryker®: 1716.5N±80.5N).

During the testing in the fracture setting, the type of failure was different for both plates, moreover. Whereas the failure in the Synthes® locking mechanism only was seen, the failure in the Stryker® plates was due to the failure of the locking mechanism itself as well as bending of all plates in the fracture zone occurred during the fracture setting tests (Figures 4 and 5).

## Discussion

In the last years, the palmar plating of distal radius fractures has become very popular based on the new design of the plates itself. Especially the development of locking plates has led to a major use of palmar plates. Recently, the locking mechanisms were improved with the variable angle locking mechanism. Different companies developed different designs [10,16].

The aim of the study was to evaluate the different behavior of different screw plate locking mechanisms for variable angle locking and, furthermore, the influence of the different behavior on the stability in the fracture setting of an extraarticular dorsally comminuted distal radius fracture.

As Synthes® as well as Stryker® are the main companies supplying our department with implants, we chose their locking mechanisms (“Discontinuous thread” - Synthes®, “Ti II/V” - Stryker®) to be evaluated. The inclusion of the “TriLock” mechanism of Medartis® in the study failed due to rejection of the company taking part in the study.

Similar behavior between the two plates was found in regard to the screw plate angulation. The highest resistance against failure of the locking mechanism for both plates could be demonstrated in the neutral position. Whereas a significant less load to failure was needed in 15° angulation in both plates compared to the neutral position, the difference between locking in 15° of angulation and relocking in 15° angulation after locking in neutral angulation was not significant. The influence of an increased locking screw angulation with following loss of locking strength has already been confirmed in previous studies [8,15,19].

To our knowledge, an investigation whether or not the relocking of screws in various angles influences the locking strength has not been done yet.

These results could influence the surgical treatment using polyaxial locking plates. The knowledge of higher locking strengths in neutral position compared to a higher angulation may lead to a major locking in a neutral position whenever possible. Also the positioning of the plate could be influenced in order to apply the screw in a more neutral position rather than a more angled position when aiming in particular fracture fragments.

Our results demonstrate that relocking of screws does not decrease the locking strength in comparison of the 15° of angulation. However, a relocking trial investigating the difference between relocking finally in neutral position and only locking in neutral position was not performed.

## Conclusion

In summary, the Synthes® plate showed a superior locking strength than the Stryker® plate in all screw plate locking tests. Nonetheless the higher single screw plate locking strength, the plate testing in the fracture setting did not show a difference between the two plates. In spite of the same strength, the reason for loss of reduction was different. Hence, the knowledge of different behavior of different plates helps the surgeon to focus for particular problems in specific plates. An obvious screw break may be found more easily than a plate bend.

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