Compression and Torque Comparison of Headless Compression Screws:

DePuy Synthes CCHS versus Acumed® Acutrak® 2 and Arthrex® Compression FT

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Abstract

Introduction: Previous studies[6-7] have evaluated the insertion torque and compression performance of Ø3.5mm Acumed Acutrak 2 and Arthrex Compression FT fully threaded headless compression screws. In those studies, compression was measured in a mechanical test where proximal and distal foam blocks were rigidly constrained together as screws were inserted. This paper is intended to reevaluate insertion torque and compression performance allowing for translation between the proximal and distal test blocks. The test setup represents a case where reduction was achieved, but bone fragments were not rigidly held together during screw insertion, which is a more appropriate model accounting for possible bone fragment movement during insertion.

Purpose: The purpose of this study was to assess and compare insertion torque and compression for Ø3.5mm x 30mm headless compression screws from DePuy Synthes Cannulated Compression Headless Screws (CCHS, Short and Long Thread), Acumed Acutrak 2, and Arthrex Compression FT.

Materials And Methods: Ø3.5mm x 30mm headless compression screws were inserted to 30mm depth (flush) into 30 pounds per cubic foot (pcf) foam using a proximal and distal foam block to simulate an osteotomy/fracture. Blocks were prepared with the appropriate drill bit and countersink before screw insertion, and n=10 of all devices were tested. The test fixture allowed the blocks to translate, while interfragmentary compression, insertion torque, and insertion depth were measured throughout testing. Test specimens and conditions were chosen to closely match the Acumed and Arthrex studies[6-7].

Results: The partially threaded CCHS Long and Short Thread screws generated the highest observed mean compression at flush. CCHS Short and Long Thread screws generated compression that increased as the torque input increased until the screw achieved full insertion depth. The Acumed Acutrak 2 screw required torque that fluctuated with the compression generated, and the compression at flush was slightly lower than the peak compression. The Arthrex Compression FT screw generated its peak compression before the screw was fully inserted, and as the screw was seated, lost approximately 48% of its peak compression while requiring additional insertion torque.

Discussion And Conclusion: The results of this study demonstrate that the DePuy Synthes Cannulated Compression Headless Screw (CCHS) Long and Short Thread generated the highest two observed mean compressions. The compression and torque increased together as the screw was fully seated. On the contrary, the Arthrex Compression FT lost nearly half of the peak compression it generated as the screw was fully seated, while requiring additional torque. The additional torque required to seat the Arthrex screw may be misconstrued by the user as generating additional compression. Acumed's 'window of compression' may not provide the perceived clinical benefit, as the CCHS screws generated higher mean compression when flush with the bone.

Introduction

Headless compression screws are a common solution to generate interfragmentary compression and stable fixation while limiting proximal screw prominence.

Acumed and Arthrex have released the results of similar studies[6-7] comparing the compression and torque performance of their Ø3.5mm fully threaded headless compression screws tested with the foam blocks representing proximal and distal bone fragments fully constrained. A rigidly fixed test method does not account for the forces imparted by the screw as it drills/taps into the distal block, which may result in motion of the bone fragments, potentially compromising the reduction.

Purpose

The purpose of this study was to evaluate the insertion torque and compression force for the Ø3.5mm x 30mm headless compression screws:

- DePuy Synthes CCHS Short Thread
- DePuy Synthes CCHS Long Thread
- Acumed Acutrak 2, Fully Threaded
- Arthrex Compression FT, Fully Threaded

Materials and Methods

Four Ø3.5mm x 30mm length headless compression screws were compared: DePuy Synthes CCHS Short Thread, DePuy Synthes CCHS Long Thread, Acumed Acutrak 2, and Arthrex Compression FT, shown in Figure 1 and listed in Table 1. Sample size n=10 of each screw were inserted using the appropriate guide wires, drill bits, countersinks, and screwdrivers[1-5].

30pcf (pounds per cubic foot) foam blocks per ASTM F1839-08[9] were prepared with a pre-drilled hole at each guide wire's nominal diameter to minimize wire deflection during insertion. Constructs consisted of a 14mm thick proximal foam block and a 40mm thick distal block.

All compressive load was transferred between blocks by a load cell resting on a post machined in the distal block as shown in Figure 2. The test setup started with no initial fracture/osteotomy gap between the proximal block and load cell to simulate full reduction achieved prior to screw insertion.

Insertion was performed using methods based on ASTM F543-17 Annex A2[8] with a fixture allowing for translation between the proximal and distal blocks. The proximal block fixture translated along smooth steel rods using plastic bushings, and the distal block was fixed to the test frame carriage. Screw advancement (displacement/insertion depth), insertion torque, and interfragmentary compression were recorded. A representative test setup photograph is shown in Figure 3. Screws were fully seated to a depth of 30mm, flush with the proximal foam surface.

Table 1 Headless Compression Screws Tested

Product*	Part Number
DePuy Synthes Ø3.5 CCHS Short Thread	04.333.330
DePuy Synthes Ø3.5 CCHS Long Thread	04.334.330
Acumed Acutrak 2 Mini (Ø3.5)	AT2-M30-S
Arthrex Compression FT Mini (Ø3.5)	AR-8730-30H

*It is assumed that the sterile and nonsterile part for each screw are mechanically equivalent.

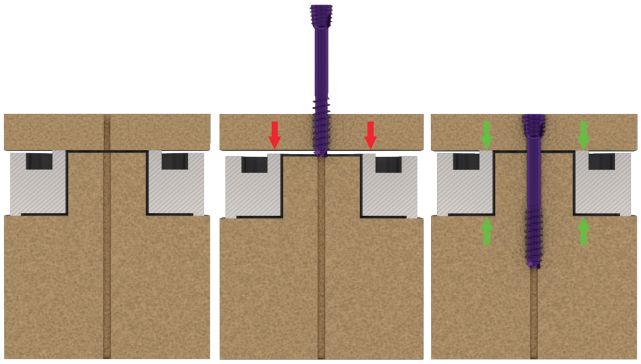

Figure 2 Midline fracture setup with no initial fracture gap (left), screw cutting into distal block (middle), and fully inserted screw (right). Load cell shown in silver.

Figure 1 Representative Screws Tested (left to right): DePuy Synthes CCHS Short Thread, DePuy Synthes CCHS Long Thread, Acumed Acutrak 2, Arthrex Compression FT

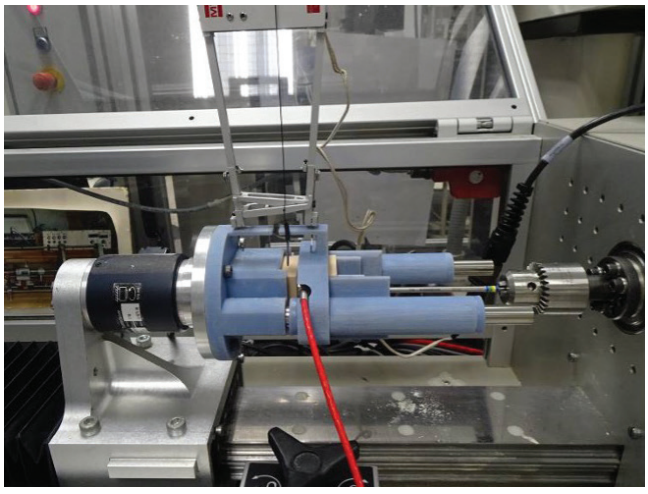

Figure 3 Representative Test Setup fixture.

Results

Overlaid representative compression profiles for each screw throughout insertion are shown in Figure 4. Data from 0mm - 12mm insertion is omitted from Figure 4 because there is no interfragmentary compression generated while the tip of the screw is in the proximal fragment, which is 14mm thick per *Materials and Methods*. The initial load (approximately 30N) is the preload on the system through the screwdriver.

The partially threaded DePuy Synthes CCHS Long and Short Thread generated the highest two observed mean compressions and the fully threaded Acumed Acutrak 2 and Arthrex Compression FT generated the two lowest mean compression values when fully seated[11].

Figures 5 through 8 show representative overlaid compression and torque curves for each screw during insertion. Figures 5 and 6 for the CCHS screws show torque increasing as peak compression was reached.

Figure 7 shows the 'window of compression' that Acumed claims for Acutrak 2, with the torque fluctuating with compression during insertion. Compression was generated over a longer portion of the insertion for the Acutrak 2 when compared to a partially threaded screw, driven by screw design.

Peak compression for the Arthrex Compression FT screw was attained while the screw was approximately 5mm proud of the bone surface, shown in Figure 8. While the compression dropped as the screw was fully seated, additional torque was needed. When the Arthrex Compression FT screw was fully seated, ~48% of the mean peak compression generated was lost (mean peak compression 246±11N, and fully seated compression 128±22.5N)[11].

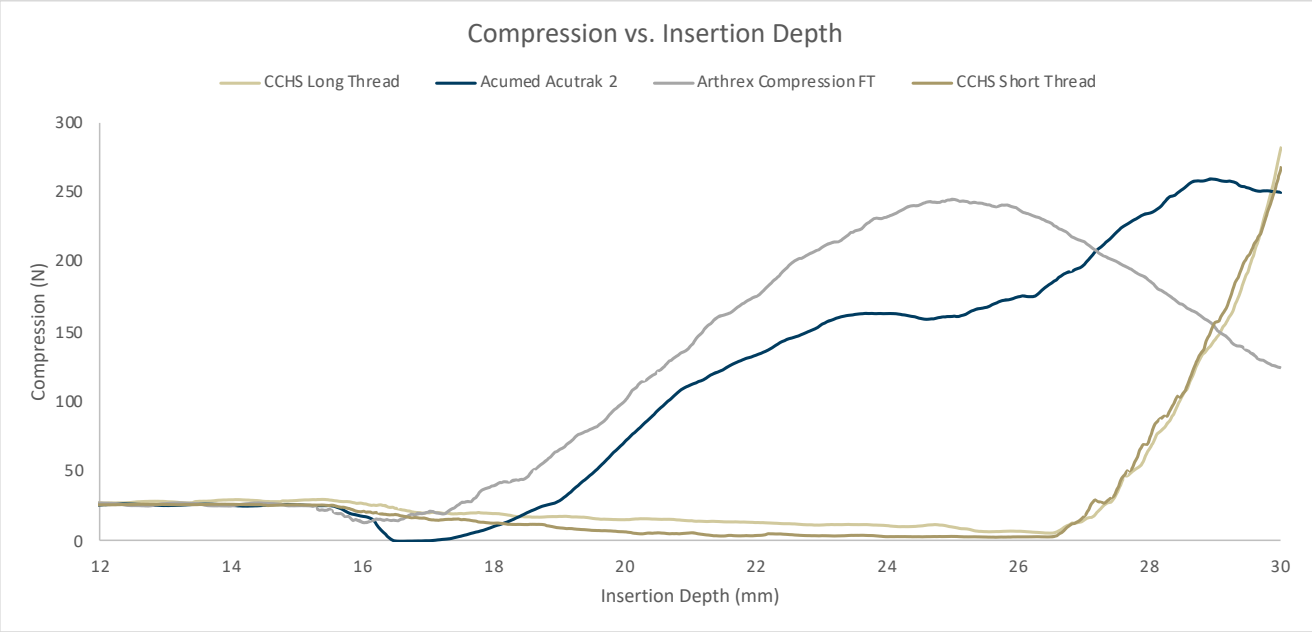

Figure 4 Overlaid representative compression curves from 12mm to 30mm.

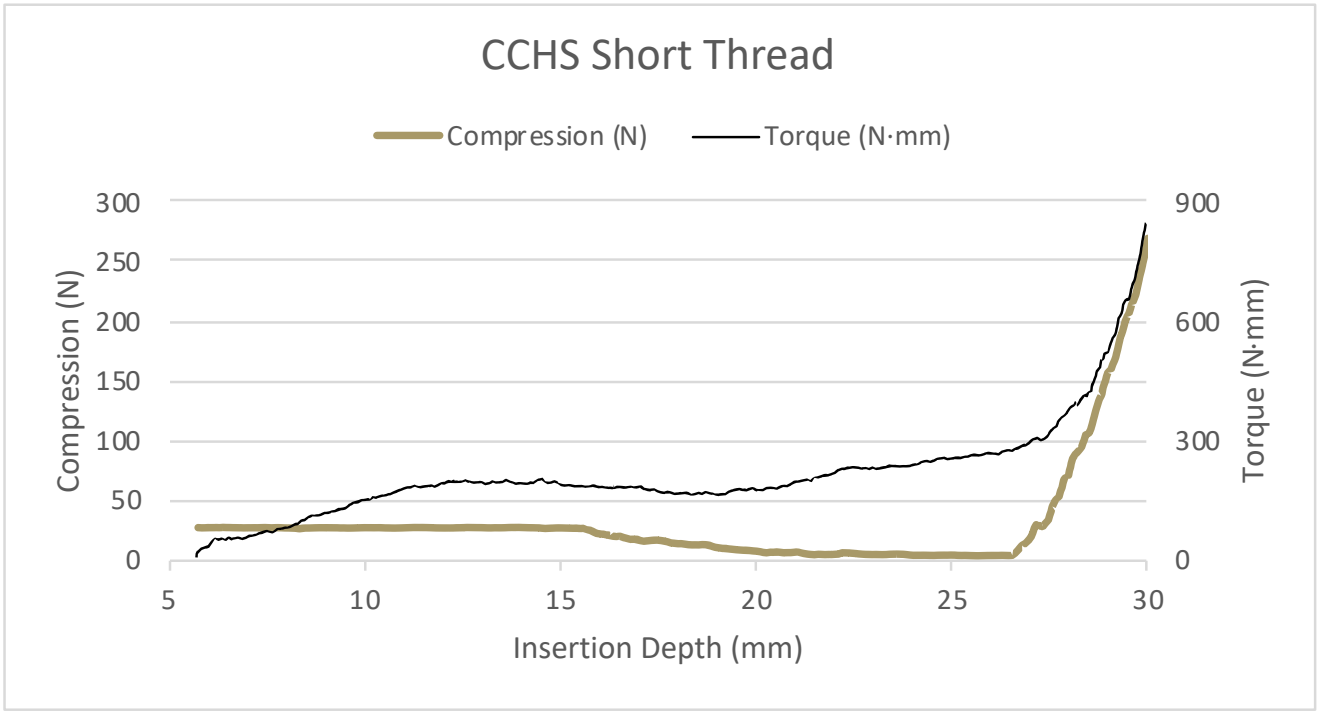

Figure 5 Representative CCHS ST Compression and Torque Performance

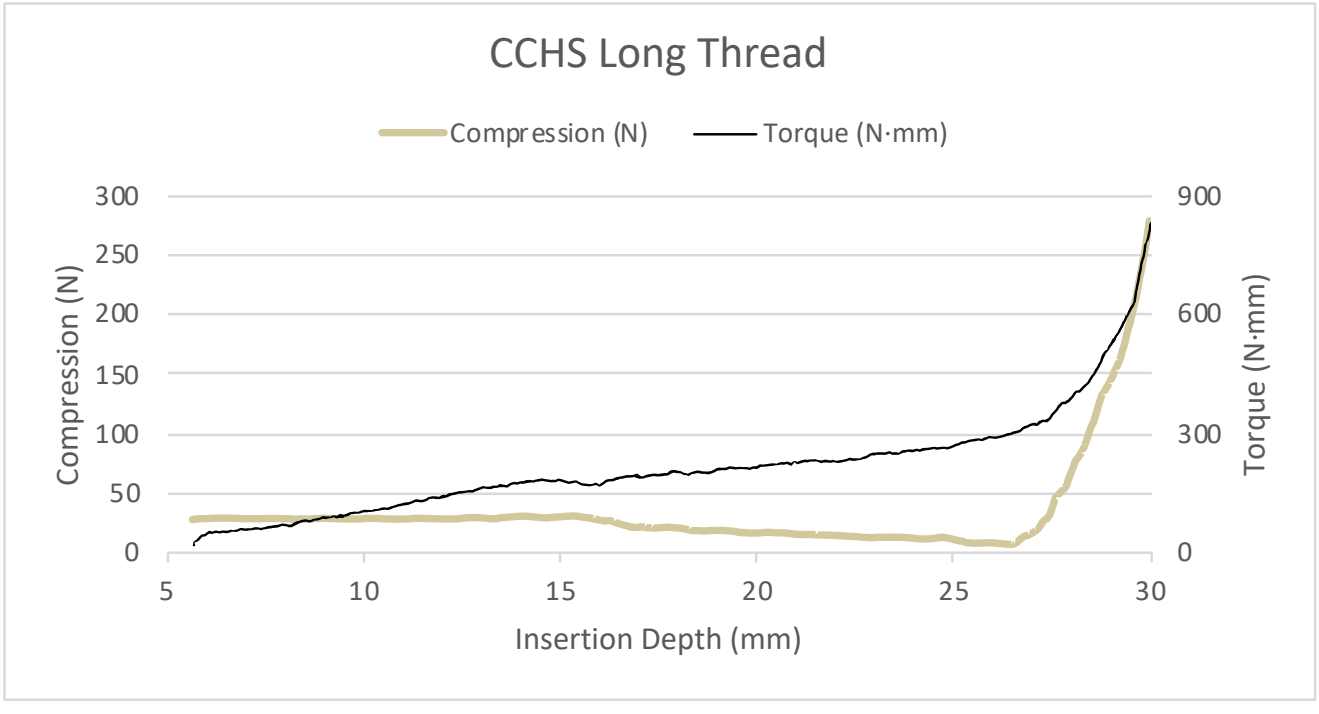

Figure 6 Representative CCHS LT Compression and Torque Performance

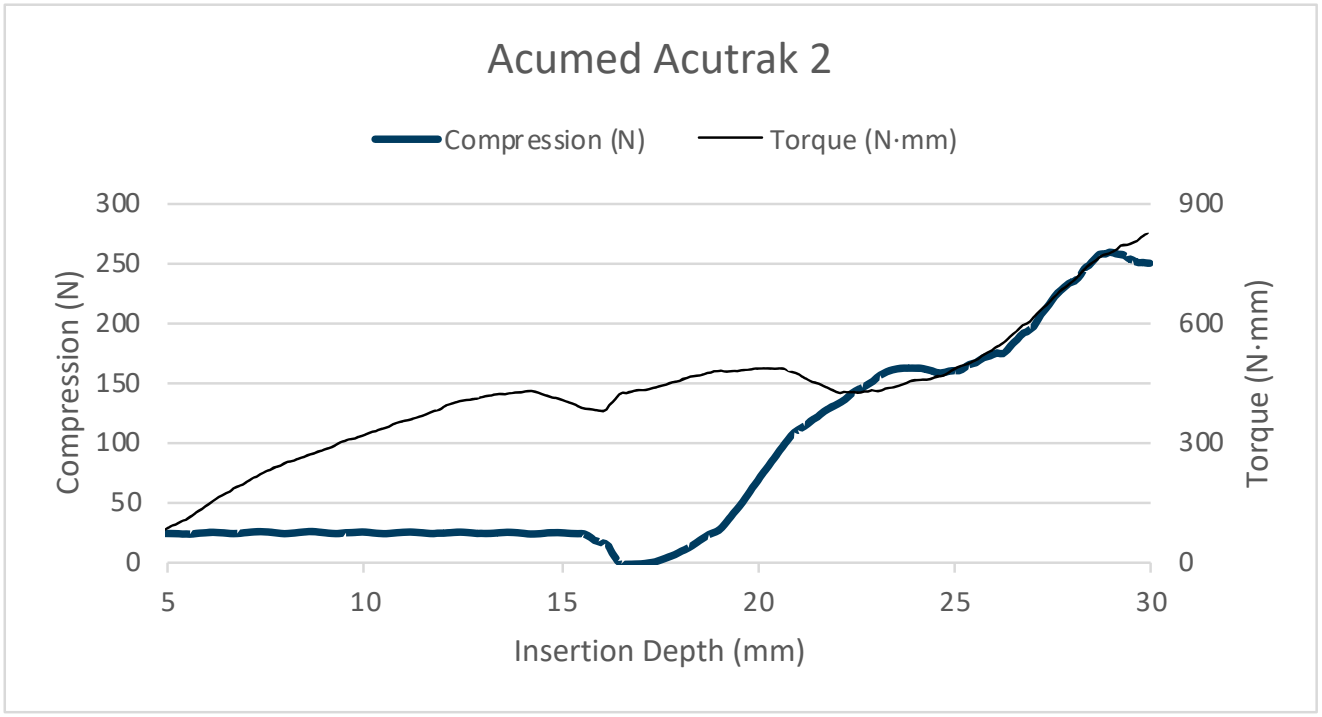

Figure 7 Representative Acutrak 2 Compression and Torque Performance

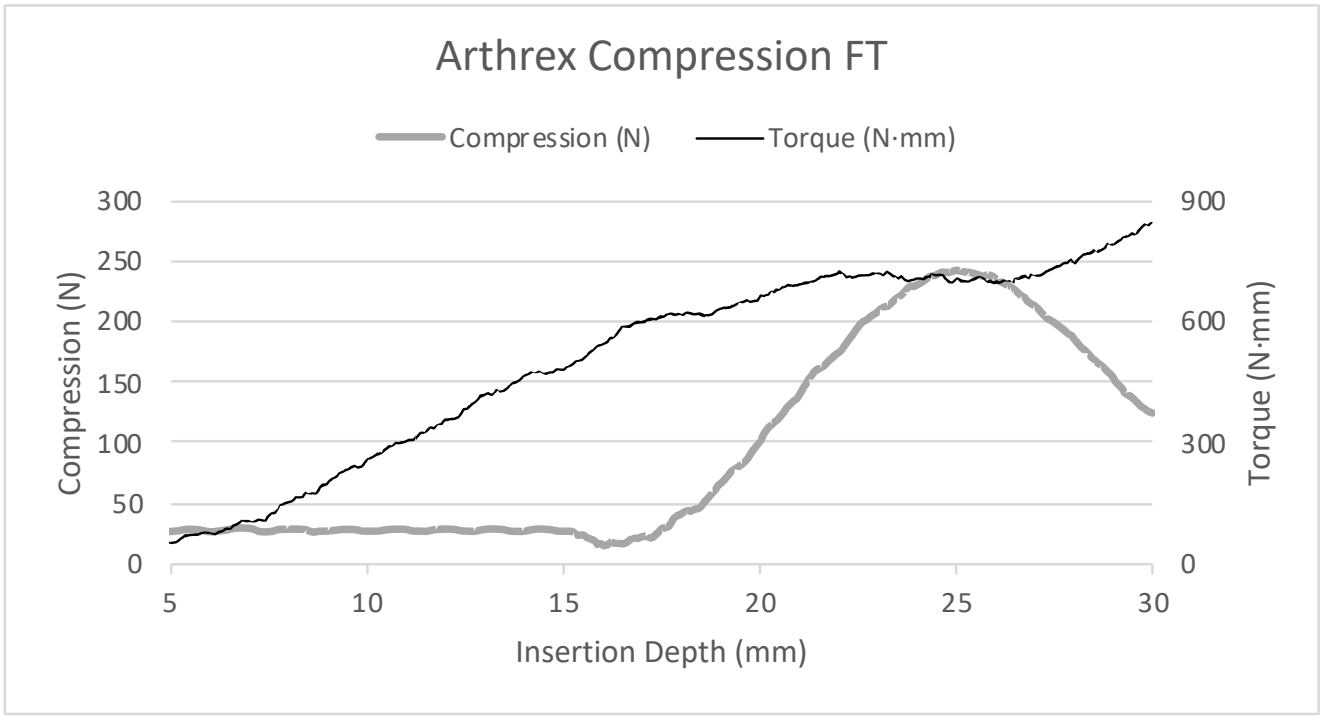

Figure 8 Representative Arthrex Compression FT Compression and Torque Performance

Discussion

Compression vs. Torque:

By tactile feedback only, a user may think that they are getting additional compression because of the torque increase felt through the screwdriver, but the results of this test show differently.

For the fully threaded Arthrex Compression FT, the torque to fully seat the screw increased all the way through insertion, while the screw lost compression during its final millimeters of insertion. Over the last approximately 5mm of insertion, the Arthrex Compression FT screw lost approximately 48% of the compression it generated, resulting in a final compression that was significantly less than that of the CCHS Short and Long Thread, as well as the Acutrak 2[11].

The fully threaded Acutrak 2 screw also demonstrated a reduction from peak compression before full insertion, while torque rose, as shown in Figure 7. In comparison, the DePuy Synthes CCHS Short and Long Thread screws both generated increasing compression as the torque input increased, resulting in peak compression at flush.

Window of Compression:

Throughout their product literature[2,4-6], Acumed discusses the 'window of compression' as a feature of the fully threaded Acutrak 2 screw. Their claim focuses on generating compression across a longer span of the insertion, as opposed to a partially threaded screw which, by design, generates its compression as the proximal end ('head') of the screw inserts into bone.

The 'window of compression' may not necessarily provide a clinical benefit, as all headless compression screws should be inserted to flush or countersunk. It does not matter how the compression is generated, but that the screw can maintain the compression that it generates, which all screws tested did successfully. The increase in torque and compression with the CCHS screws as the 'head' interfaces with the bone provides tactile feedback of screw insertion, as compared to the more gradual compression generation from the Acutrak 2.

Conclusion

This study showed that the two partially threaded screws, CCHS Long and Short Thread, generated higher observed mean compression than the fully threaded Acumed Acutrak 2 and Arthrex Compression FT.

The DePuy Synthes Cannulated Compression Headless Screw (CCHS) Short and Long Thread generated increasing compression as the torque increased to fully seat the screw, which is the expected user interface. On the contrary, the Arthrex Compression FT lost nearly half of the peak compression it generated as the screw was fully seated, while requiring additional torque to insert.

While the Acumed Acutrak 2 screw did generate compression over a longer period of insertion than the partially threaded CCHS, the observed mean compression generated by the CCHS screws at flush, is higher than that generated by Acumed Acutrak 2. As a result, the 'window of compression' that Acumed discusses may not provide the perceived clinical benefit.

It's at the surgeon's discretion when selecting a headless compression screw system how much compression they expect and what other features or benefits each device offers. While bench testing may not be indicative of clinical results, this study shines light on compression from headless compression screws, most notably that the torque feedback the user receives during insertion may not always correspond to interfragmentary compression.

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† Animal and bench testing results may not be indicative of clinical performance.

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