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Biomechanical Tests of Different Cannulated Compression Screws

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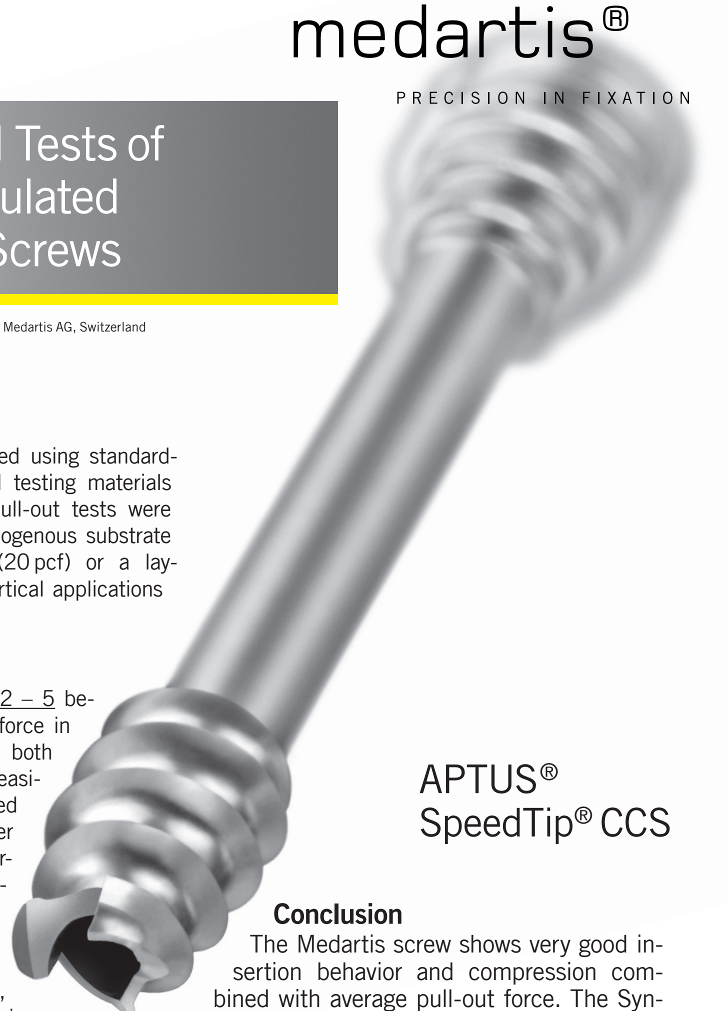

Introduction

Cannulated compression screws have become a state-of-the-art option for orthopedic surgeons and traumatologists for the treatment of fractures, osteotomies, as well as arthrodeses and elective surgeries. Developed originally by Timothy James Herbert, the “Herbert Screw” has been used in hand surgery since the 1980s [1].

By now compression screws have become a widely used tool for many different indications and a wide range of screws are available on the market. While technical differences between different types exist, they are all intended for the fixation of bony fragments. Primary stability is achieved by compressing the fragments against one another [2]. Therefore, the same key characteristics will define the clinical performance of all screw types:

- Ease of insertion
  Defined by the bite force, F_{bite}, i.e. the axial load needed for the screw’s initial grip in the bone, and the insertion torque, M. The easier it is for the surgeon to insert the screw, the less likely he is to displace the bony fragments upon insertion. A low biting force prevents axial movement of the distal fragment, which would distract the fracture gap.
- Prevention of secondary loss of reduction
  This depends on the screw’s ability to maintain the fragments’ relative position. High compression, F_{comp}, and high pull-out force, F_{PO}, will distinguish the superior screws. Although it has been shown that between 39% – 55% of compression is lost during the first 12 hours after fixation [3], good initial compression still remains important.

Materials and Methods

Three different cannulated compression screws (l = 30 mm) from leading manufacturers were compared (Figure 1):

- Medartis APTUS SpeedTip CCS 3.0, A-5880.30
- Acumed Acutrak 2 Mini, AT2-M30
- Synthes HCS 3.0, 04.226.030

Screws were tested for ease of insertion, F_{bite} and M, compression, F_{comp}, and pull-out force, F_{PO}.

All experiments were performed using standardized Sawbones biomechanical testing materials as substrate; insertion and pull-out tests were performed either using a homogenous substrate simulating cancellous bone (20 pcf) or a layered substrate simulating bicortical applications (50/20/50 pcf).

Results

Results are shown in Figures 2 – 5 below: Figure 2 shows the bite force in two different substrates: in both cases, the Medartis screw is easiest to insert while the Acumed screw needs significantly higher axial pressure and higher insertion torque (Figure 3). A similar behavior is observed for compression (Figure 4): while the Synthes and the Medartis screw show good compression, the Acumed screw’s compression is much lower. The pull-out force measurements (Figure 5) reflect the fully threaded design of the Acumed screw resulting in high values. The large error bars of the Acumed screw in the layered substrate (Figure 5, right) can be explained by the very high bite force observed previously: pull-out force varies depending on whether the screw was able to gain purchase in the second cortex or not.

APTUS®
SpeedTip® CCS

Conclusion

The Medartis screw shows very good insertion behavior and compression combined with average pull-out force. The Synthes screw with a design similar to the Medartis screw is average in all tests. The Acumed screw with its fully threaded design shows excellent pull-out force but is very difficult to insert (especially in the harder substrate); also compression was below average.

Literature

[1] Herbert T.J. et al., *J Bone Joint Surg Br*, **66-B**: 114, 1984.
[2] Hausmann J.T. et al., *Injury*, **38**: 763, 2007.
[3] Gruszka D.S. et al., *J Hand Surg Am*, **37-A**: 1142, 2012.

Figure 1: *Cannulated screws tested: Medartis, Acumed, Synthes (from left to right)*

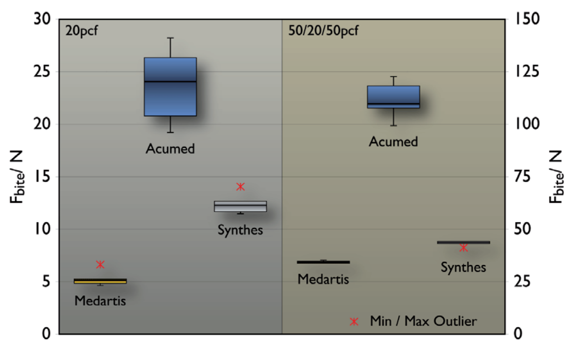

Figure 2: *Bite force of different screws in two substrates (Sawbones 20 pcf and 50/20/50 pcf); lower values are better*

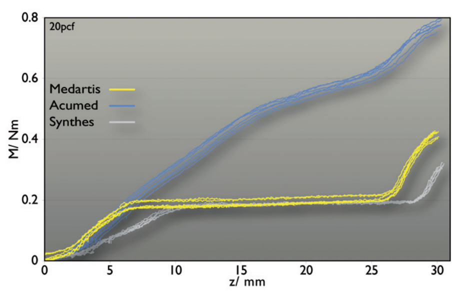

Figure 3: *Insertion behaviour of different screws in Sawbones 20 pcf substrate; lower values are better*

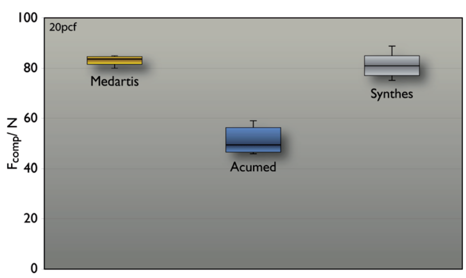

Figure 4: *Compression of different screws in sawbones 20 pcf substrate; higher values are better*

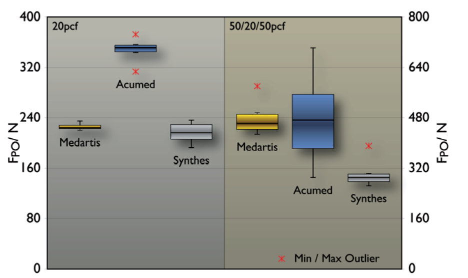

Figure 5: *Pull-out force of different screws in two substrates (Sawbones 20 pcf and 50/20/50 pcf); higher values are better*