*For full peer-reviewed manuscript, please reference:
Dayton P, Hatch DJ, Santrock RD, Smith B. J Foot Ankle Surg. 2018.*

Biplanar™ Plating with the Plantar Python® Anatomic Tension-Side Plate: Improved Biomechanical Properties*

Introduction

Lapidus fusion is becoming an increasingly utilized procedure for hallux abducto valgus (HAV) correction due to its versatility to treat any severity of HAV, as well as correct all three anatomic planes of the deformity (including frontal-plane metatarsal rotation). Lapidus fusion has traditionally required an extended period of post-operative immobilization to allow for primary bone healing when using rigid fixation approaches. However, recent AO research indicates that relative stability fixation can allow for controlled micromotion that stimulates a more biological healing process[1]– theoretically supporting earlier weight-bearing. One such relative stability construct is Biplanar™ Plating **| Figures 1A and 2A,** utilizing two small, low-profile locking plates at 90° to each other, which was previously shown to have superior mechanical properties to a traditional Lapidus plate and interfragmentary screw construct under cyclic loading.[2]

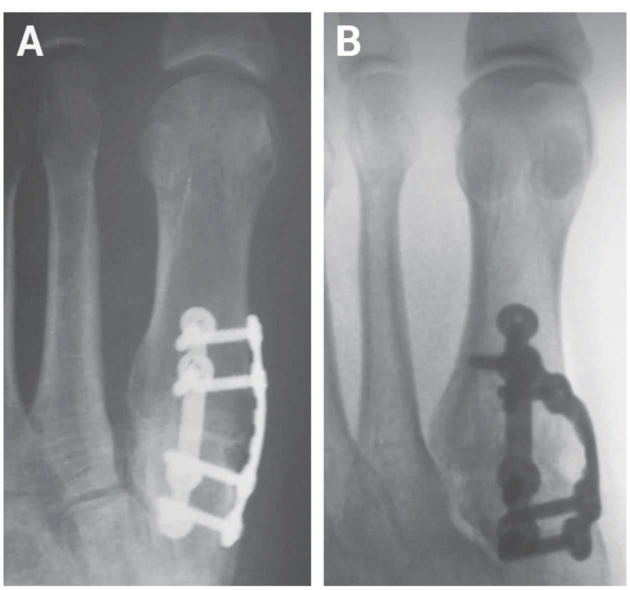

Figure 1 | AP radiographic appearance of the **(A)** Biplanar™ Plate construct and **(B)** Biplanar™ Plate with Plantar Python® tension-side fixation.

Fixation on the tension (plantar) side of the Lapidus arthrodesis site is another approach for improved stability, acting as a tension-band to naturally counteract the bending moment produced during ambulation. However, traditional attempts at plantar plating have not been widely adopted due to the required plantar exposure.
To address these limitations, a two-plate construct was designed **| Figures 1B and 2B** to provide the advantages of tension-side fixation and relative stability healing, while allowing application through a conventional incision. The purpose of this study is to compare the mechanical properties of Biplanar™ Plating with the Plantar Python® Anatomic Tension-Side Plate to the previously-tested Biplanar™ Plate construct under cyclic cantilever loading.

Methods

Mechanical testing was performed using two different Lapidus fixation constructs from Treace Medical Concepts, Inc. The Biplanar™ Plate construct consisted of two straight low-profile titanium four-hole locking plates; one was placed on the dorsal surface and the other was placed on the medial surface, 90° to each other **| Figures 1A and 2A.** The second construct consisted of one straight Biplanar™ Plate placed dorsally and an anatomic Plantar Python® Plate (machined from a solid block of titanium for optimal strength) designed to wrap from the medial surface of the cuneiform to the plantar surface of the 1st metatarsal **| Figures 1B and 2B.** Both constructs were fixated with 2.5mm unicortical locking screws with no additional inter-fragmentary screw. Test specimens were constructed using standardized surrogate fourth-generation anatomic Sawbones® models **| Figure 2** and tested on MTS material testing machines.

All loading was performed in plantar cantilever bending to simulate functional 1st TMT joint loading. Three pairs of constructs were tested in static ultimate failure loading to

Figure 2 | (A) Biplanar™ Plate construct (dorsal and medial straight plates) and **(B)** Biplanar™ Plate with Plantar Python® tension-side fixation (dorsal straight plate and medial-to-plantar anatomic plate).

set the parameters for the cyclic tests. Ten pairs of constructs were then tested in cyclic testing, using a starting load of 120N (3.6N·m bending moment) applied for the first 50,000 cycles and then increased by 25N each successive 50,000 cycles until failure or 250,000 cycles were reached. Statistical analysis was performed via unpaired t-tests to determine differences in mechanical performance between the two constructs.

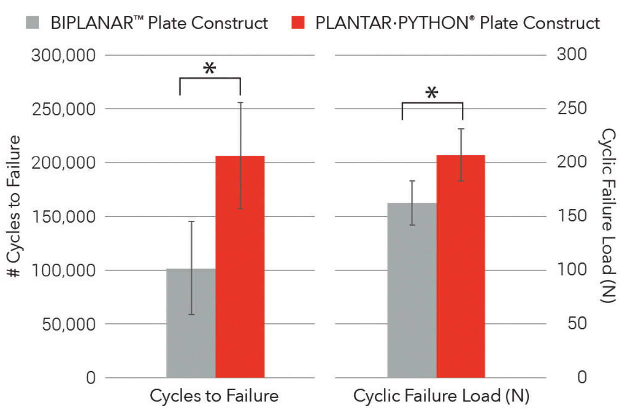

Figure 3 | Number of cycles to failure and cyclic failure load for the two constructs. The Plantar Python® Plate construct was significantly superior in both cyclic loading variables (*p<0.001).

Results

For the static ultimate failure test in plantar cantilever bending, the Biplanar™ Plate with Plantar Python® tension-side fixation failed at a 17% greater ultimate failure load than the straight Biplanar™ Plate construct (247.3±18.4N vs 210.9±10.4N; p=0.04).

For cyclic failure testing in plantar cantilever bending, the Biplanar™ Plate with Plantar Python® tension-side fixation failed at 103% greater number of cycles (206,738±49,103 vs 101,780±43,273; p<0.001) and 35% greater cyclic failure load (207.5±24.3N vs 162.5±20.6N; p<0.001) than the straight Biplanar™ Plate construct **| Figure 3.**

Discussion and Conclusion

The results of the current study demonstrate that the Biplanar™ Plate with Plantar Python® tension-side fixation significantly improves the biomechanical performance of Biplanar™ Plating under both static and dynamic cyclic loading conditions simulating Lapidus fusion. Applied through a conventional dorsal incision, these biomechanical results demonstrate that the Plantar Python® Plate offers the benefits of both multiplanar relative stability principles and tension-side fixation, while avoiding the extensive plantar dissection associated with conventional plantar plating. Taken together, this robust construct shows promise for clinical application as a more practical approach to tension-side fixation and may enable early return to weightbearing following Lapidus fusion.

References

1. Perren SM. Evolution of the internal fixation of long bone fractures. *J Bone Joint Surg Br*, 84: 1093-1110, 2002.
2. Dayton P, Ferguson J, Hatch D, Santrock R, Scanlan S, Smith B., Comparison of the mechanical characteristics of a universal small biplane plating technique without compression screw and single anatomic plate with compression screw. *J Foot Ankle Surg*. 55:567-71, 2016.

TREACE
Medical Concepts, Inc.
www.treace.com