

Biomechanical Comparison of a Biplanar™ Plate Construct to an Anatomic Plate with Compression Screw*

Introduction

Conventional internal fixation approaches for foot and ankle surgery have historically relied on achieving rigid compression fixation and absolute stability for primary bone healing. This technique often requires a large, stiff plate and interfragmentary compression screw to achieve absolute stability under multiplanar, weightbearing loads. This may be particularly problematic in cases when the plate is applied to the compression side of the bone, i.e. Lapidus fusion, where the need for excessively large and stiff constructs may lead to suboptimal load distribution, stress shielding, and inhibited healing.

Recent research has indicated that fixation with relative stability can provide interfragmentary movement of the bone surfaces to stimulate a more biological repair by callus formation.¹ One means of achieving uniform, relative stability in multiple planes without excessively rigid plates is to use two plates of smaller dimension along the axis of the bone (biplanar plating) without an interfragmentary compression screw. Initial studies of the mechanical characteristics of biplanar plating have shown improved stability relative to a single large plate.²

Objective

To compare the mechanical properties of a Biplanar™ Plate construct to a commonly-used Lapidus anatomic plate with compression screw under multiplanar cyclic loading.

Methods

Mechanical testing was performed using two distinct Lapidus fixation constructs. The Treace Medical Concepts Biplanar™ Plate construct consisted of two low profile titanium straight locking plates fixated unicortically with 2.5x14mm locking screws to produce a biplanar construct with no interfragmentary screw | **Figure 1**. The second construct consisted of a single anatomic Lapidus locking plate with four 3.5mm bicortical locking screws (Wright

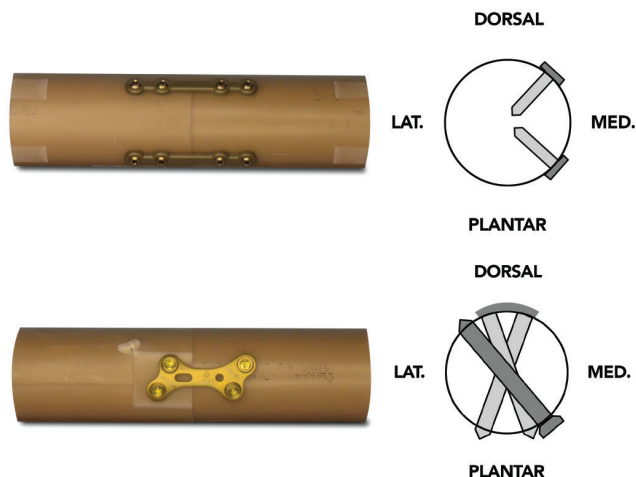


Figure 1 | Image of a test specimen and schematic of the cross section of the BIPLANAR™ Plate construct (top) and the Wright anatomic plate and compression screw construct (bottom).

Medical DARCO™ LPS Plate 0-Step) and a 4.0mm bicortical interfragmentary screw (Wright Medical DART-FIRE™ headed screw) | **Figure 1**. Test specimens were constructed using standardized surrogate Sawbones® models on MTS material testing machines. The plating constructs were placed according to the associated manufacturer's surgical technique guides.

A static cantilever failure test was first performed (n=2, both groups) in plantar bending to set the loading parameters for the cyclic tests. For the cyclic testing, an initial cantilever load was 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. Two sets of cyclic testing were performed at different starting load magnitudes. The first set of cyclic testing had an initial starting load of 180N (5.4N.m bending moment) in the plantar loading direction (n=4, both groups). The second set of cyclic testing was performed with a starting load of 120N (3.6N.m bending moment) in the plantar loading direction (n=5, both groups) as well as at a 90 degree offset from the

plantar load direction (n=5, both groups). A t-test was used to determine differences in mechanical performance between the two constructs.

Results³

For the static ultimate failure test in plantar bending, the BIPLANAR™ Plate construct failed at 130% greater load than the anatomic plate and compression screw construct (556N vs 242N) (p<0.05).

For cyclic failure testing in plantar bending at 180N starting load, the Biplanar™ Plate construct failed at 1,054% greater number of cycles and 35% greater load than the anatomic plate and compression screw construct (p<0.05) | **Figures 2 and 3**. For cyclic failure testing in plantar bending at 120N starting load, the Biplanar™ Plate construct failed at 30% greater number of cycles and 10% greater load (p>0.05) | **Figures 2 and 3**. For the cyclic testing with 90 degree offset loading (i.e. medial to lateral bending) at 120N starting load, all five Biplanar™ Plate constructs and two of the five anatomic plate and compression screw constructs achieved 250,000 cycles without failure | **Figures 2 and 3**.

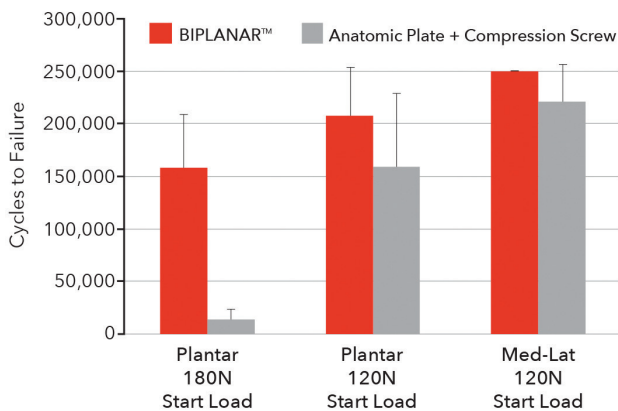


Figure 2 | Number of cycles to failure for the two fixation constructs.

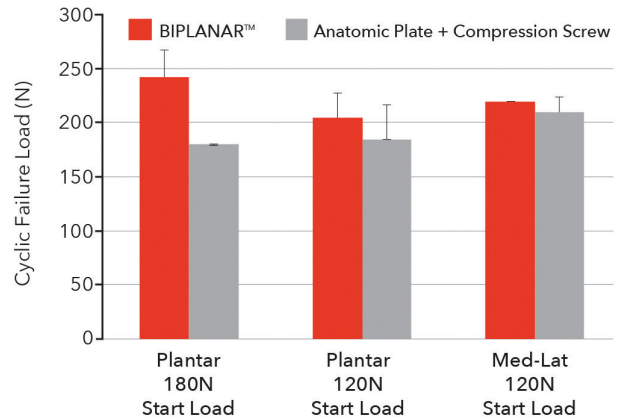


Figure 3 | Cyclic failure load for the two fixation constructs.

Conclusion

The results of the current study demonstrate that the small, flexible Biplanar™ Plate construct without compression screw has superior mechanical properties to a single anatomic plate with interfragmentary compression screw under both static and dynamic fatigue conditions simulating the loading environment experienced with Lapidus fusion in the foot. These findings indicate that the low-profile, titanium Biplanar™ Plate construct with unicortical screws can provide a versatile fixation platform that achieves robust, multiplanar relative stability, potentially eliminating the drawbacks associated with compression screws and absolute stability techniques.

References

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3. Smith B, Santrock R, Hatch D, Dayton P. Comparison Of The Mechanical Characteristics Of A Universal Small Biplanar Plating Technique Without Compression Screw To Single Anatomic Plate With Compression Screw. *J Foot Ankle Surg*. 2016. In Press.

