Biplanar Plating with an Anatomic Tension-Side Plate for Lapidus Fusion: Improved Biomechanical Properties

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Introduction/Purpose: Fixation with relative stability has been shown to provide a rapid, more biological osseous incorporation than primary bone healing,1 theoretically supporting earlier weight bearing following osteotomy and or fusion. One such relative stability construct is 90-90 biplanar locked plating, which previously demonstrated superior biomechanical properties compared to a traditional Lapidus plate and interfragmentary-screw construct.2 Plantar, tension-side fixation is another approach for improved stability with Lapidus fusion, though the required plantar exposure has limited widespread adoption. Thus, a two-plate construct was designed to provide tension-side fixation and relative stability healing, while allowing application through a conventional incision. We tested the hypothesis that biplanar plating with tension-side fixation (low-profile straight dorsal plate and anatomic medial-plantar plate), would demonstrate improved mechanical stability versus the previously-tested biplanar construct.2

Methods: The straight biplanar plate construct consisted of two straight low-profile locking plates, one placed dorsally and the other medially, 90° to each other. The biplanar plate construct with tension-side fixation consisted of a straight locking plate dorsally and an anatomic tension-side plate wrapping from the medial surface of the cuneiform to the plantar surface of the metatarsal. Both constructs were fixed with 2.5mm unicortical locking screws with no interfragmentary screw. Standardized surrogate fourth-generation anatomic Sawbones models (Vashon Island, WA) were used; loading was performed in cantilever bending on a Materials Testing Machine (Minneapolis, MN). Constructs were tested in static ultimate failure and ten pairs were tested in cyclic loading, applying a 120N starting load for the ?rst 50,000 cycles and then increasing by 25N each successive 50,000 cycles until failure or 250,000 cycles was reached. T-tests were used to determine differences in mechanical performance between the two constructs (see figure).

Results: For the three pairs of constructs tested to static ultimate failure in plantar cantilever bending, the biplanar plate construct with 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 the ten pairs of constructs tested in cyclic fatigue failure in plantar cantilever bending, the biplanar plate construct with 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.

Conclusion: The results of the current study demonstrate that biplanar plate construct with tension-side fixation significantly improves the biomechanical properties of straight biplanar plating under both static and cyclic loading conditions simulating Lapidus post-operative weight bearing. Designed for application through a dorsal incision, this tension-side construct offers the mechanical advantages of tension-band fixation and biological benefits of relative stability healing, while avoiding the extensive plantar dissection associated with conventional plantar plating. Taken together, this novel construct shows promise for clinical application as a more practical approach to tension-side fixation and early return to weight bearing following Lapidus fusion.

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