

Hallux Valgus Correction: A Comparison of IM Angle and 1st MTC Joint Pressure before and after Correction

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Objective

The objective of this study was to quantify and compare the contact pressure at the first metatarsal cuneiform joint as a result of hallux valgus correction. In addition, the intermetatarsal angle was quantified and compared amongst the groups.

Methods and Materials

Six lower extremities (three pairs, ages: 77, 80, and 95) with hallux valgus deformities were used for testing. Seven groups were tested in each lower extremity, and testing was performed in the following order: 1) intact (served as control); 2) immediately after placement of the Mini TightRope (TR); 3) Mini TightRope (TRC) after 2000 load cycles; 4) immediately after placement of the proximal TightRope (PTR); 5) proximal TightRope after 2000 load cycles (PTRC); 6) immediately after a standard distal Chevron osteotomy (CHEV); and 7) chevron osteotomy after 2000 load cycles (CHEVC). The Mini TightRope bunion procedure and proximal TightRope bunion procedure were conducted according to the manufacturer's guidelines. The three repair types can be seen in Figure 1, Figure 2, and Figure 3.

Figure 1: Distal Mini TightRope repair



Figure 2: Proximal TightRope repair with TightRope FT



Figure 3: Chevron osteotomy repair fixated with 2 metal K-wires



The lower extremities were amputated 31 cm proximal to the inferior aspect of the calcaneus. Proximal soft tissues were stripped leaving the Achilles, flexor hallucis longus, and flexor digitorum longus tendons intact for attachment to pneumatic actuators. A dorsal incision was made above the 1st MTC joint to allow insertion of a pressure sensor (Tekscan #4201 pressure sensor).

Specimens were mounted in an MTS Mini Bionix load frame with the above tendons attached to pneumatic actuators. Constant tendon loads were applied as follows: 400 N on the Achilles, 100 N each on the FHL, and FDL tendons. The specimens were cyclically loaded from 72 to 720 N at a rate of 0.5 Hz while pressure data was acquired continuously for 30 cycles. After 30 cycles, the pressure sensor was removed and an additional 2000 cycles at 3 Hz was conducted using the same load values. After the completion of 2000 cycles, the pressure sensor was re-inserted, and post-cycling pressure was measured in the same method as described for pre-cycling.

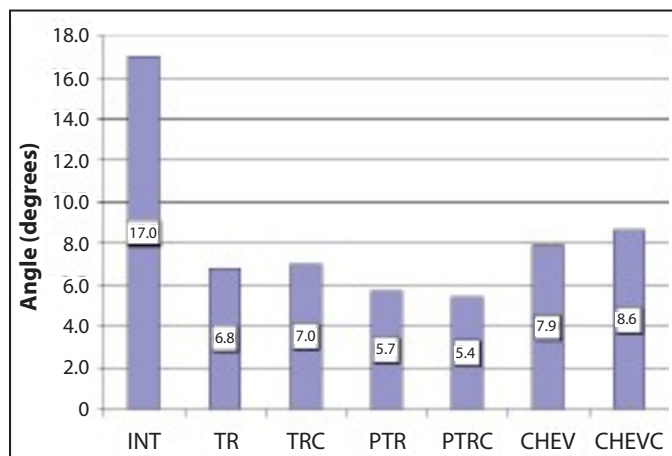
Fluoroscopic images were obtained for the intact foot and all experimental conditions immediately after the correction was performed and again after 2000 load cycles. Adobe Photoshop was used to measure the IM angles for the various conditions.

The pressure maps were split into quadrants for analysis as follows: inferomedial, inferolateral, superolateral, and superomedial. A one-way repeated measures ANOVA was used to determine if any observed differences were significant.

Results

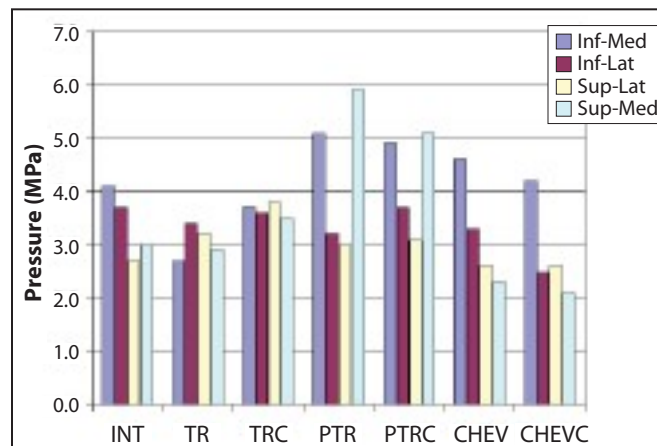
The results for the IM angle measurements are shown in Figure 4 below. As compared to the intact state, the lesser IM angle after correction (both before and post-cycling) was significantly different for all repairs ($p < 0.0017$ for all comparisons). No significant difference in IM angle was observed between the immediate postoperative correction and the post-cycling correction for any of the corrective techniques ($p > 0.55$ for all comparisons). Similarly, no significant difference in IM angle correction was observed between any of the corrective procedures, before or post-cycling ($p > .160$ for all comparisons).

Figure 4: IM angle data



The results for the pressure measurements are shown in Figure 5. The greater pressure of the PTR group in the superior-medial quadrant was statistically different from that of the INT, CHEV, CHEV C, and TR ($p < .003$ for all comparisons). In this quadrant, the greater pressure of the PTRC group was statistically different from that of the CHEV and CHEV C groups ($p < .003$ for both comparisons). No other significant differences were observed in the pressure measurements.

Figure 5: 1st MTC joint pressure



Conclusion

The distal Mini TightRope correction for hallux valgus corrected the IM angle without significant increases at the first metatarsal cuneiform joint pressure. Repetitive loadings to 720 N for 2000 cycles did not significantly change the IM angle from that of the immediate postoperative position. Nor did the repetitive loadings significantly alter the peak joint pressures from those of the immediate postoperative pressures.

The proximal TightRope resulted in significant correction of the IM angle, but also resulted in a statistically significant increase in pressure in the superomedial aspect of the first metatarsal cuneiform joint. The clinical relevance of this pressure difference is not known.