The Effect of Two Distal Interlocking Screw Configuration and Orientation on Intramedullary Nail Stability: A Biomechanical Study

INTRODUCTION: Long bone diaphyseal fractures are a very common injury encountered in orthopedic practice. This type of fracture is often treated using an intramedullary (IM) nail. In this day and age there are many options in regards to the orientation of the distal interlocking screws. The goal of this study was to determine if the distance between two distal locking screws affects the stability of the IM nail, and to determine which screw configuration is the most biomechanically stable for IM nailing of such fractures.

METHODS: Eighteen modified tibial IM nails with six different interlocking screw configurations were tested in torsion (sinusoidal cycled of 0.5 Hz at +7.0 Nm for 10 cycles tested with 5 N of compression), compression (range: +15 N to -700 N at a rate of 70 N/sec), and bending (anterior-posterior and medial-lateral, sinusoidal cycled of 0.05 Hz at +15 N for 10 cycles) using simulated long bones consisting of Delron pipe (Figure 1). Screw orientations tested were: (I) two medial-to-lateral, (II) one medial-to-lateral and one anterior-to-posterior, and (III) one medial-to-lateral and one oblique (30 degrees). Each screw orientation was tested with two different screw gap distances (24mm and 9mm) (Figure 2).

RESULTS: There were small differences that were statistically significant detected between all six configurations when comparing the four test conditions combined. When breaking down the test conditions individually, some of the statistical significance was lost. The small differences were not statistically significant in the analysis of the stability under compressive loading and rotation torque from the post hoc analysis. The average deflections for all configurations were less than 0.5 mm for compression and approximately 10.9° for rotation. Statistically significant difference was detected between the two screw gap distances for all test modes except for the oblique screw orientation. The two medial-to-lateral screw configuration (ML-L) was statistically found to be more stable when compared to the other five configurations and the screw orientation with one medial-to-lateral and one oblique (OB-L) was found to be the most unstable compared to the other screw orientations. Although the literature is inconclusive in regards to the optimum rigidity for an IM nail, all configurations deflected less than 6° with the applied load.

DISCUSSION: The results of this study show that the two medial-to-lateral screw configuration (ML-L) was more biomechanically stable for the IM nailing of simulated long bones when compared to the other five configurations. Our results also showed that the oblique interlocking option (OB-L) did provide less construct stability for the fixation of the nail when compared to the other two interlocking screw options.

SIGNIFICANCE: This study may be indicated a better option for operative treatment of long bone diaphyseal fractures utilizing IM nail fixation with optional distal interlocking screw placement, where preservation of soft tissue and rigid stabilization are needed.

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KEYWORDS: Biomechanics; Fracture; Intramedullary nailing; Interlocking screw configuration; Screw orientation