Preventing Iatrogenic Fibula Fractures using the Push-Pull Technique: A Biomechanical Comparison of Unicortical vs Bicortical Post Screws

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Introduction/Purpose: In displaced diaphyseal fractures fixed with a plate, reduction is often achieved using the direct reduction method known as the Push-Pull Technique. In this method, the plate is attached to the distal fragment of the fracture while a post screw is placed on the proximal fragment. A bone spreader is then placed between the plate and the post screw to achieve length by distracting the fracture for reduction. After fixation, the post screw is removed. This screw is placed either bicortically or unicortically based upon surgeon preference. Anecdotally, the force imparted onto the unicortical screw may cause iatrogenic fracture of the bone. This study evaluates the relative risk of causing iatrogenic fibula fracture with either a unicortical or bicortical post screw during the push-pull technique.

Methods: Four matched pairs of fresh-frozen human cadaveric lower limbs were used. A 2 cm oblique osteotomy was performed on the distal diaphysis of the fibula to simulate a displaced, oblique fracture. A 6-hole tubular locking plate was attached distally. For the post screw, a 12 mm unicortical screw or 20 mm bicortical screw was placed 1 cm proximal to the proximal end of the plate. For all constructs, the only difference was the type of post screw used. Each leg was secured to a wooden jig in the neutral position, and the jig was mounted to the platform of an MTS 858 Mini-Bionix testing system which provided compressive load as well as data measurements. The tip of the spreader was wedged between the plate and post screw to simulate the 'push' phase of the 'push-pull' distraction technique. Force applied, displacement, and number of ratchet clicks were recorded for each specimen.

Results: All unicortical screws failed at under 15 clicks of the lamina spreader. There was no significant difference between applied load, energy absorbed, or stiffness at the greatest common displacement prior to any failure (22.64 mm, or 10 'clicks') between unicortical and bicortical post screw placement. At maximum applied spreader load, there were statistically significant differences in displacement (p=0.002) and energy absorbed (p=0.023). Post-hoc power analysis shows 99% power achieved for displacement and 90% power achieved for energy. The failure mode for all unicortical screws was through screw toggle and bone cut-out, while all bicortical screws failed through bending of the screws with no visible damage to the bone at the screw site.

Conclusion: Clinically speaking, if a distal fibula fracture requires minimal distraction to achieve proper reduction (less than approximately 10 spreader 'clicks'), then it may be appropriate to use a unicortical post screw in order to minimize residual cortical bone damage post-surgery at the post screw location. When performing extensive reductions that require longer distractions, a bicortical post screw should be used to prevent screw toggle and potential bone chipping or fracture at the expense of residual diaphyseal bicortical screw holes.

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|               | Displacement (mm) | Load (N)     | Energy (Nmm) | Stiffness (N/mm) |
|---------------|-------------------|--------------|--------------|------------------|
| **Bicortical**| 22.65 ± 0.01      | 240.84 ± 54.77 | 2269.32 ± 579.09 | 11.56 ± 2.09     |
| **Unicortical**| 22.89 ± 0.49      | 236.71 ± 75.97 | 2468.56 ± 1196.14 | 11.45 ± 2.71     |

|               | Displacement (mm) | Load (N)     | Energy (Nmm) | Stiffness (N/mm) |
|---------------|-------------------|--------------|--------------|------------------|
| **Bicortical**| 52.35 ± 2.40      | 466.26 ± 148.28 | 14047.15 ± 4284.89 | 11.56 ± 2.09     |
| **Unicortical**| 30.74 ± 4.40      | 310.89 ± 74.05 | 4583.83 ± 1643.34 | 11.45 ± 2.71     |

* Unicortical significantly lower than Bicortical (p=0.002)

b Unicortical significantly lower than Bicortical (p=0.023)