Fracture Reduction Following Flexible Intramedullary Nailing of Simulated Pediatric Radial Shaft Fractures: A Cadaveric Comparison of Radial Styloid vs. Lister’s Tubercle Entry Points

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INTRODUCTION: Pediatric forearm fractures are among the most common fractures in children, with operative management typically reserved for cases where closed reduction and casting are insufficient. The goal of operative treatment is to achieve anatomic reduction while minimizing complications. Flexible intramedullary nailing, using elastic stable intramedullary nails or titanium elastic nails, has become a widely adopted technique for managing these injuries. Despite its popularity, limited research has addressed how the nail entry point affects radius fracture reduction quality. The two most used entry points, radial styloid and Lister's tubercle, have been utilized with little comparative data. This study aimed to evaluate whether the entry point influences fracture reduction quality in pediatric forearm fractures by comparing outcomes between radial styloid and Lister's tubercle approaches across different fracture locations (proximal, midshaft, and distal) and nail sizes (2.0 mm, 2.5 mm, and 3.0 mm).

METHODS:

This cadaveric biomechanical study utilized 36 fresh-frozen adult cadaveric forearms, randomized into two groups based on nail entry point. Standardized fractures were created at proximal, midshaft, or distal locations along the radial shaft, and reduction was performed under continuous fluoroscopic guidance. Postoperative alignment was assessed through radiographic measurement of radial bow location, coronal displacement, and sagittal displacement.

RESULTS:

For nail size 2.0 mm in proximal fractures no statistically significant differences were observed between techniques. In midshaft fractures, Lister's tubercle entry demonstrated a significantly higher postoperative coronal displacement compared to the radial styloid approach ($p = 0.012$, 95% CI: -12.4527, -2.31777). In distal fractures, no statistically significant differences were observed with post-op coronal or sagittal displacement. Although there was more coronal and sagittal displacement in the radial styloid group.

For nail size 2.5 mm in proximal fractures, no significant differences were identified. In midshaft fractures, the radial styloid technique resulted in significantly greater postoperative coronal displacement ($p = 0.045$, 95% CI: 6.9681, 2.7585). In distal fractures, the radial styloid approach resulted in significantly higher coronal displacement ($p = 0.001$, 95% CI: 19.1256, 27.4012), while the Lister's tubercle approach demonstrated significantly greater sagittal displacement ($p = 0.023$, 95% CI: -36.2386, -3.8982).

In the 3.0 mm nail group, proximal fractures treated with the radial styloid technique showed significantly higher coronal displacement ($p = 0.008$, 95% CI: 3.2524, 32.9914). No statistically significant differences were observed in midshaft fractures. In distal fractures, the radial styloid entry was associated with significantly higher coronal displacement ($p = 0.009$, 95% CI: 4.7412, 22.3338).

Furthermore, there is no significant difference between preoperative bow and postoperative bow when using any size nail at either location for either technique.

DISCUSSION AND CONCLUSION:

This cadaveric biomechanical study aimed to assess whether the entry point for flexible intramedullary nailing in pediatric forearm fractures, Lister's tubercle versus the radial styloid, impacts the quality of fracture reduction across proximal, midshaft, and distal radius fractures. Our hypothesis proposed that radial styloid entry would result in greater fracture displacement due to the increased curvature and angulation required to access the medullary canal. However, our results do not fully support this hypothesis and instead highlight a more nuanced, nail-size and fracture-location-dependent relationship between entry point and reduction quality.

In general, no consistent significant difference was observed in the location of radial bow postoperatively across techniques or nail sizes, indicating that both entry points preserve the natural radial curvature adequately. However, fracture alignment measured by coronal and sagittal translation, did vary with both technique and nail size. For instance, with 2.0 mm nails, the Lister's tubercle approach resulted in higher coronal displacement in midshaft fractures, contrary to our original assumption. Conversely, with 2.5 mm and 3.0 mm nails, the radial styloid entry demonstrated significantly greater coronal displacement in both midshaft and distal fractures. These findings suggest that the radial styloid approach may be more prone to malreduction in the coronal plane, particularly with increasing nail diameter and more distal fracture locations.

Interestingly, in the 2.5 mm nail group, sagittal displacement was significantly greater using the Lister's tubercle approach in distal fractures, which may reflect the challenge of aligning a flexible nail introduced dorsally with a more volarly located

fracture plane. These variations indicate that neither entry point is uniformly superior; rather, the optimal choice may depend on specific anatomical and technical considerations such as fracture location and nail size.

This study highlights the nuanced relationship between nail entry point, fracture location, and nail diameter in achieving optimal fracture reduction. While both entry points preserve overall radial bow, they produce different patterns of localized angular deformity depending on fracture location. The findings challenge the assumption that one entry point universally offers better outcomes. Instead, they support a tailored approach to optimize alignment and stability. Based on radiographic measurements and biomechanical results, we recommend using Lister's tubercle entry point for distal third radius shaft fractures due to the increased angular deformity associated with the radial styloid approach. Further clinical studies are warranted to determine whether these radiographic differences translate into meaningful functional outcomes in pediatric patients.