

Effect of Trimmable Fixation Nail on Acromion Stress Fractures– A Biomechanical Model

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INTRODUCTION: Acromion fracture following reverse total shoulder arthroplasty (rTSA) has been recognized as a challenging complication, with incidence rates reported as high as 10%. In patients with multiple risk factors, including female sex, osteoporosis, and a diagnosis of rotator cuff arthropathy, this rate can nearly double. Management options range from nonoperative symptom maintenance to open reduction and internal fixation (ORIF) – neither yielding consistently encouraging patient outcomes. Recently, a prophylactic intervention to mitigate Levy 2 zone fractures was proposed, offering a bio-integrative, trimmable fixation nail (OfN) inserted at the posterolateral acromion edge and drilled lengthwise into the scapular spine along the coronal plane. For this reason, the primary objective of this study was to evaluate the displacement, stiffness, and ultimate load to failure of the acromion after fixation with the OfN in a biomechanical model simulating osteoporotic bone.

METHODS: A total of 12 sawbone osteoporotic scapulas separated into two groups. The control group (defect) acromions were drilled with a 2.0 k-wire in the posterolateral acromion directed down the scapular spine followed by a 4.0 cannulated tap over the guidewire to a depth of 40mm, which was then removed yielding a bony defect to simulate osteoporosis. Additionally, a small stress riser was introduced as either a 2.0 k-wire defect introduced on the superior acromion surface directed through the 40mm defect and exiting the inferior acromion surface, or a 2.0 k-wire defect in the posterior acromion directed anteriorly until penetrating the original 40mm defect (Figure 1). The experimental group replicated the same defects, however, the OSSIOfiber® nail, a trimmable fixation nail (OfN), was instrumented to a depth of 40 mm. All scapulas were then embedded in a rectangular high-strength resin mold up to the mid-scapula and rigidly mounted to the biomechanical testing frame. The loading platform was fixed to a universal joint attached to a 5kN load cell. To simulate the biomechanics of a post-RSA acromion, the scapulas were oriented such that the load frame's vertical axis coincided with the loading vector (Figure 2). Cantilever bending was performed on the lateral acromion in a stepwise fashion, beginning with 3 rounds of precondition loading (50 N at a rate of 1 mm/s) and proceeding to a staircase protocol applying a valley load of 50 N and peak load of 100 N for 100 cycles at 0.5 Hz. Loading was increased by 100N after each step, where each step was 100 cycles, until failure. Motion was tracked using a 3D camera system. Stiffness measurements were derived from the force vs. displacement curves and defined as the linear portion of the curve. Displacement (mm), failure load (N), and stiffness (N/mm) were compared with a 1-way ANOVA. Data are presented as mean ± standard deviation.

RESULTS: No statistical differences were noted for stiffness, except at LS3 where samples with OfN significantly higher stiffness at 33.5 N/mm had compared to the defect group at 28.3 N/mm (p=.049). Similarly, the amount of displacement at LS1 and LS2 were not significantly different. At LS3, it was observed that the defect group had a significant increase in displacement compared to the OfN (13 mm vs. 7.3 mm; p=.017). All of the defect group failed at the end of LS2 transitioning to LS3 and did not reach 300 N, whereas those with OfN failed later in LS3, where one sample achieved LS4. On average, the defect group failed at 296 N and the OfN failed at 298 N. It was also observed that in samples with defects; the fractures were at Zone 3 or Zone 3/2 junction. Adding the OfN, the fractures were at Zone 2 or Zone 1 (Figure 3).

DISCUSSION: In this osteoporotic biomechanical model, it was shown that introducing a trimmable nail into the acromion does not significantly change the biomechanical properties such as stiffness at lower loads, but did improve the stiffness at higher load steps. Similar behavior was noted for displacement, which suggest the OfN may provide some support to the acromion. While no significant difference was observed in the ultimate failure load, it was noted that the fracture patterns shift from Zone III to Zone II/Zone I region, which may provide a more manageable outcome.

SIGNIFICANCE/CLINICAL RELEVANCE: Biomechanical testing demonstrated improved stiffness and reduced displacement at higher loads, with a shift in fracture location to more favorable zones. These findings suggest the OfN may help mitigate difficult to treat Levy-2 fractures.

IMAGES AND TABLES:

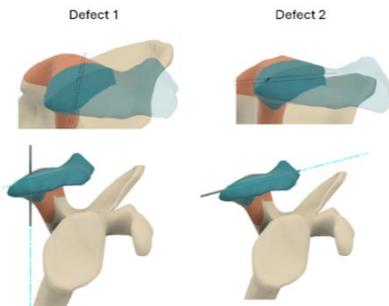


Figure 1. Illustration of defect creation and trajectory of k-wire



Figure 2. Biomechanical Testing set-up ORS 2026 Annual Meeting PaperNo.1464

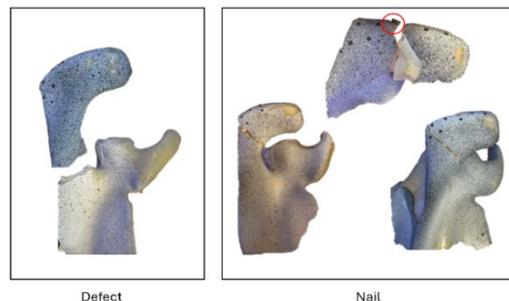


Figure 3. Representative images of failure modes