Fracture-Plane Position and Device Type Govern Interfragmentary Compression: A Bench-Top Comparison of Sustained Dynamic Compression, Cannulated Lag, and Variable-Pitch Fully-Threaded Compression Screws

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INTRODUCTION: Interfragmentary compression must be generated at fixation and sustained as the bony interface remodels. Surgeons often use *insertion torque* as a tacit proxy for "purchase," yet torque may not correlate with the compression that actually stabilizes the fracture. Device design and the fracture-plane location along the implant are therefore clinically relevant. We evaluated how device type and fracture-plane location—near insertion (toward the head), centered (midspan), or far from insertion (toward the tip/threaded region)—affect (i) initial compression, (ii) compression after a standardized 1-mm gap loss, and (iii) insertion torque. We anticipated that a sustained dynamic compression (SDC) implant would outperform conventional screws, especially after resorption, that fully threaded compression screws would be sensitive to fracture-plane location, and that partially threaded lag screws would be comparatively less sensitive to plane position.

METHODS: Two polyurethane foam blocks (Sawbones®) were apposed to form a planar "fracture plane" and fixed with one of three devices: SDC device, partially threaded headless lag screw, or variable-pitch fully-threaded screw. The plane was placed near insertion (25% of device away from insertion), centered (50% of device length away), or far from insertion (75% of device length away, Fig. 1A). Interfragmentary force was recorded immediately after fixation and again after a controlled 1-mm reduction in interface distance. Insertion torque was recorded at final seating. Each device×location condition targeted n=5 constructs (total compression dataset n=45; torque dataset n=45). Two-way ANOVA (GraphPad Prism, $\alpha=0.05$) with factors Device and Fracture Location was applied to initial compression, compression after 1mm resorption, and to insertion torque.

RESULTS: Initial compression depended on device and fracture-plane location with a significant interaction (Device: $F_{(2,36)}=63$, $p<0.001$; Location: $F_{(2,36)}=5.3$, $p=0.009$; Interaction: $F_{(4,36)}=6.1$, $p<0.001$). The SDC construct produced the highest initial compression overall, performing similarly in near and centered positions with a modest (non-significant) reduction in far position; the partially threaded headless lag screw showed comparatively small location-dependence; and the fully threaded screw was highly location-sensitive, with negligible compression when the plane was far (75% away from insertion). After 1-mm simulated resorption, the SDC construct maintained non-zero interfragmentary force across positions and remained substantially higher than both conventional screws, which declined toward low or near-zero loads. For insertion torque, two-way ANOVA identified a significant Location effect and a device×location interaction, but no Device main effect (Device: $F_{(2,35)}=1.57$, $p=0.221$; Location: $F_{(2,35)}=4.03$, $p=0.026$; Interaction: $F_{(4,35)}=5.33$, $p=0.002$). Notably, the fully threaded screw exhibited equal or higher torque when the fracture plane was far away, precisely where the construct delivered almost no compression, indicating that "harder to screw in" did **not** translate to effective interfragmentary loading. In contrast, the SDC device combined high compression with insertion torque that did not depend critically on plane location.

DISCUSSION: Device design was the dominant determinant of initial compression, and fracture-plane location mattered in a device-specific manner. The SDC mechanism sustained meaningful compression after a simulated gap loss across locations. The fully threaded screw's performance hinged on plane location; when the plane intersected the threaded region (far from insertion), compression collapsed despite equal or higher insertion torque – explaining why these screws may *feel* like they are purchasing well while providing little stabilizing load. The partially threaded headless lag screw behaved as expected from lag mechanics and was less sensitive to plane location than the fully threaded design, yet it still lost most compression after resorption. These data caution against using insertion torque as a surrogate for fixation quality and support deliberate control/reporting of fracture-plane location, particularly with fully threaded constructs.

SIGNIFICANCE/CLINICAL RELEVANCE: High insertion torque should not be equated with effective interfragmentary compression. Fracture-plane location is critical for fully threaded compression screws but less influential for partially threaded screws. An SDC implant provided the highest initial compression in most positions and (most importantly) preserved compression after a standardized 1-mm gap loss, supporting its use when durable interfragmentary loading is desired and bone resorption/settling is likely.
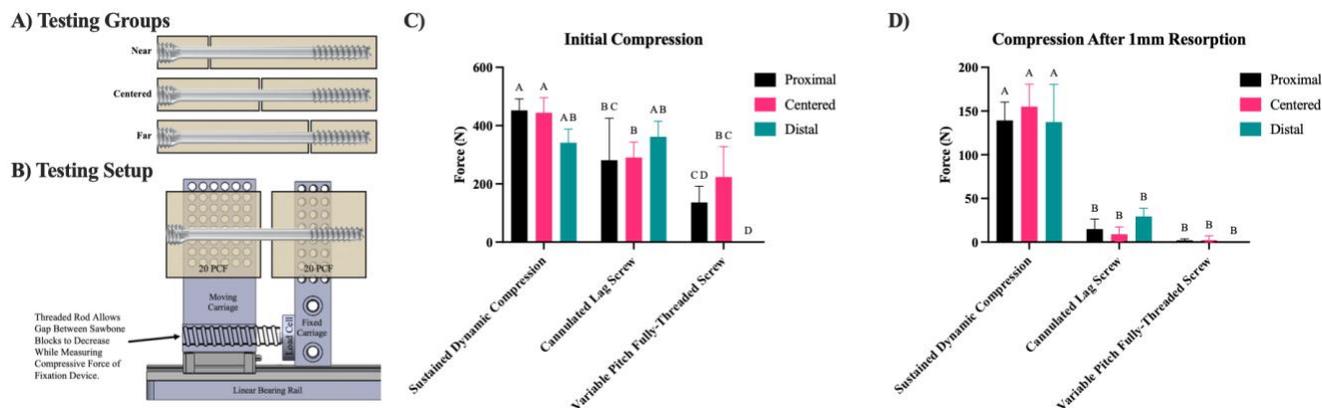
IMAGES AND TABLES:

Figure 1. Experimental setup and interfragmentary compression by device and fracture-plane position. (A) Representative constructs with the fracture plane positioned near, centered, or far locations. (B) Mechanical test fixturing for force measurement. (C) Initial interfragmentary compression (means±SD; n=5 per device×position). (D) Compression after 1-mm simulated resorption, illustrating higher residual compression for the SDC device.