The use of Perimeter Screws to Reduce Cup Micromotion and Increase Fixation Strength in the Presence of an Acetabular Defect?

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INTRODUCTION: Stability and initial fixation are crucial for the success of cementless implants, micromotion exceeding 150 µm has been shown to hinder bone ingrowth at the bone/implant interface often resulting in fibrous tissue growth(1). Prior studies have demonstrated that enhanced stability can be achieved utilizing screws in acetabular cups. However, locating quality bone within the traditional "safe zones" can be challenging with bone defects, especially in revision case(2). Research suggests that adequate bone quality may be found in the inferior region, an area often underutilized in primary surgeries, but has shown to be effective in the reduction of re-revision cases(3). It is hypothesized that extra fixation may be achieved utilizing novel designs that allow for screw placements in these regions(4, 5). The hypothesis for this study was that the use of perimeter screws can meaningfully improve fixation in acetabular revision surgery in the presence of defects by utilizing screw locations in the cup that give surgeons access to the pubis and ischial regions, **Figure 1**.

METHODS: Eighteen cadaveric hemi-pelves, each with a Paprosky Type 2B superior acetabulum defect of the anterior column(6) created by the surgeon, were implanted with the novel cup design by an experienced orthopedic surgeon. These were comprised of nine matching left-right pairs. In one hemi-pelvis of each pair, three dome screws were implanted, while additional perimeter screws were placed in the ischium and pubis of the corresponding side. Specimens were grouped according to shell size, with three size 52 mm pairs, three size 56 mm pairs, and three size 60 mm pairs. A +5 mm offset polyethylene liner was impacted into each cup and the constructs were dynamically loaded in a laboratory setting using an Instron test frame with progressively increasing forces scaled by body weight (BW), 1xBW = 736 N, 1.33xBW = 978 N and a single 1500 N load point(7, 8). The micromotion between the shell and bone was measured using a digital image correlation (GOM, DIC) system.

Tracking markers (0.8 mm) were placed on the superior pubic ramus (SPR), ischium, anterior inferior iliac spine (AIIS) bone points, and corresponding locations on the cup rim. Maximum micromotion was analyzed at each bone point, with a rigid body transformation applied before summarization, **Figure 2a**. Fixation strength was assessed after the micromotion load application by levering the cups out of the pelvis using a loading arm fixed in the implant apical hole with measured applied load from the test frame, **Figure 2b**.

RESULTS SECTION: One outlier was identified and excluded using the Grubbs test ($p < 0.05$). The addition of perimeter screws resulted in a non-statistically significant decrease in micromotion ($p > 0.05$). The mean micromotion values for all load values remained below the 150 µm threshold, established in the literature, when perimeter screws were used ($p < 0.05$). The average retention strength with perimeter screws significantly increased by 41% ± 23% ($p = 0.028$).

DISCUSSION: This study employed prototype cups capable of accommodating perimeter screws in the upper rim. The increase in fixation strength was more pronounced in the smaller size shells, **Figure 3.** Variability in cadaveric specimens, such as differing acetabular sizes and bone quality, likely influenced the results and contributed to variability.

SIGNIFICANCE/CLINICAL RELEVANCE: During acetabular revision surgeries, it is essential to provide surgeons with multiple fixation options. While press-fit acetabular shells have demonstrated excellent long-term outcomes(9), revision cases often present challenging fixation conditions, particularly when significant defects exist. Strategic use of perimeter screws in acetabular revision surgery can improve fixation.

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Figure 1: Perimeter Screw Insertion

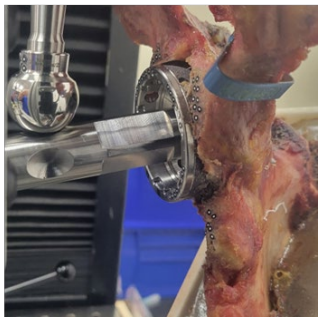

Figure 2a. Example Micromotion / **Figure 2b.** Fixation Strength

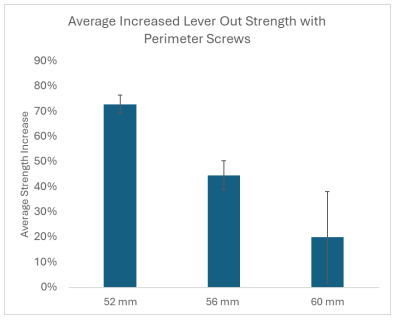

Figure 3: Increased Fixation Strength