Introduction: Smith-Peterson osteotomies provide a means to create a curve when treating the “flatback” or scoliotic spine. Previous studies have shown that each osteotomized level yields approximately 10° of lordotic restoration and are usually multi-level procedures, as compared to pedicle subtraction osteotomies, which create more acute sagittal adjustments at a single level of 30-40°. [1, 2] The addition of intervertebral fusion devices theoretically provide an anterior fulcrum, creating a greater leverage point and allowing for increased angulation. To extend this theory further, an expandable cage may allow for even greater adjustment in Cobb angle than a static cage. Therefore, the purpose of this cadaveric study was to examine the additional sagittal correction in multi-level Smith-Peterson osteotomy cases with the addition of an expandable titanium TLIF device.

Methods: Seven T10-S1 fresh-frozen cadaveric specimens were potted at T10 and S1. All discs and ligaments were left intact. Bilateral pedicle screws were placed from T11 to L5. Smith-Peterson Osteotomies (SPO construct) were created by a complete facet and posterior element resection of L2 through L4. After performing a TLIF approach discectomy at L2-3, L3-4, L4-5, titanium expandable interbody implants were inserted tightly into each of the prepared disc spaces (Contracted construct). The interbody device was sized for the disc space such that it simulated a static interbody device. Next, the device was expanded to give an additional 3mm height (Semi-Expanded). This provided an intermediate phase for the range, and may simulate an oversized static spacer in this application. Lastly, each implant was expanded vertically until a 2.0Nm torque limit was reached, which correlated to the full 7.0mm vertical expansion (Expanded construct). Closure of the osteotomy was performed by the same investigators for each specimen and between each construct in an attempt to maintain surgical consistency. Lateral fluoroscopic images (Figure 1) were taken after each construct to measure Cobb angles between the superior endplates of L2 and L5. The specimen was also placed on a 6 degree of freedom spine motion simulator for each construct tested to ensure that the addition of the interbody spacer did not affect range of motion. Pure bending moments (applied at 1°/sec until ±7.5Nm) created flexion-extension (FE), lateral bending (LB), and axial rotation (AR). Motion capture software was used to track the specimen’s movements. A one-way ANOVA with Tukey’s post hoc analysis was used to determine significant differences between constructs (p<0.05).

Results: Overall, an average of 5.4° of lordotic correction per vertebral body was observed with only an SPO (Figure 2). An additional 10.5° was seen between L2-L5 with interbody spacers, the intermediate height expansion yielded an additional 3.2°, while the full expansion had an additional 4.8° of lordosis. The average change in Cobb angle from L2-L5 was significantly greater once the interbody spacer was placed in the disc space, yet the differences were not significant between the different interbody expansion states. All instrumented constructs were equivalent in every mode of motion once rigid instrumentation was implemented, regardless of interbody expansion state (Figure 3).
Discussion: Interbody fusion devices did significantly improve the lordotic correction achievable for multi-level Smith-Peterson osteotomies, similar to other static interbody studies [3]. However, unlike the fixed amount of lordotic correction achieved with placement of a static spacer, the expandable aspect of this device did have an effect on the overall lordotic correction. With each additional millimeter in interbody height expansion, approximately another 1° in correction was achieved, and a slight decrease in the flexural mobility of the spine was observed with the expansion of the device, probably due to the increased load uptake by the “over-sized” device. Secondly, when utilizing a cage for lordotic correction, sizing, interspace placement, and maintenance of the endplates are key to ideal correction and can be difficult with static cages. The ability to place an initially smaller interbody, without endplate compromise, and then carefully expand it appears to allow for more ideal and consistent correction. In summary, even minimal expansion allows for intraoperative adjustments with respect to sagittal correction, even if these adjustments may not be significant from one another.

Significance: This study adds knowledge about the lordotic correction and effect on spine biomechanics when using an expandable interbody device in conjunction with Smith-Peterson osteotomies as compared to previous cadaveric, static interbody studies.

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