Segmental Lordosis and Stability Following Lateral Hyperlordotic Cage Placement, SPO, and ALL Release

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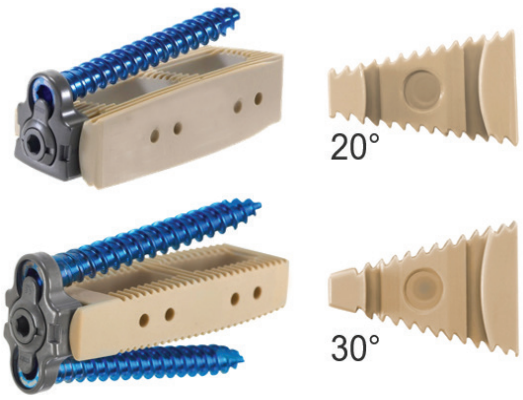
Summary

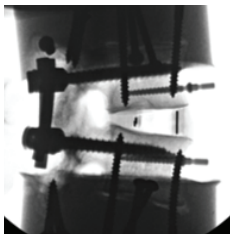
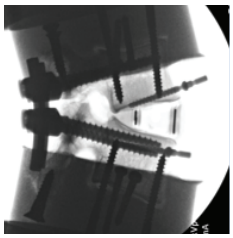
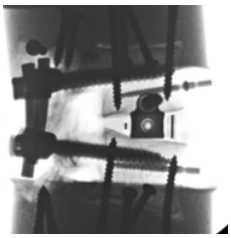
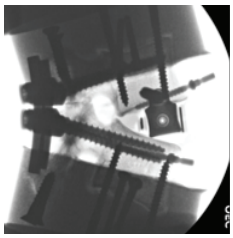
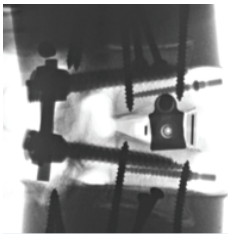
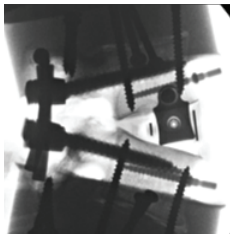
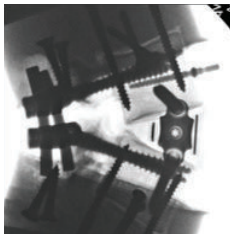
A biomechanical cadaver study finds single-site lordosis ≥20° possible via a hyperlordotic cage, bilateral facetectomy/SPO and ALL release. Though all interventions reduce range of motion from the native state, one may consider weighing the implications of desired focal correction with biomechanical stability; removing anatomy creates more segmental range of motion compared to anatomy left intact. Cantilever SPO with a hyperlordotic cage achieves substantial correction without compromising stability.

Background

Pedicle subtraction osteotomy (PSO) achieves ~30° of focal lordosis, but with high complication rates. Can less invasive methods such as Smith-Petersen Osteotomy (SPO) and anterior longitudinal ligament (ALL) release combined with a lateral hyperlordotic cage achieve comparable single-site lordotic correction? This biomechanical cadaver study assessed achieved focal lordosis and resulting biomechanical stability for multiple surgical interventions that included combinations of cantilever SPO and ALL release with the Timberline® MPF Lateral Fixation System.

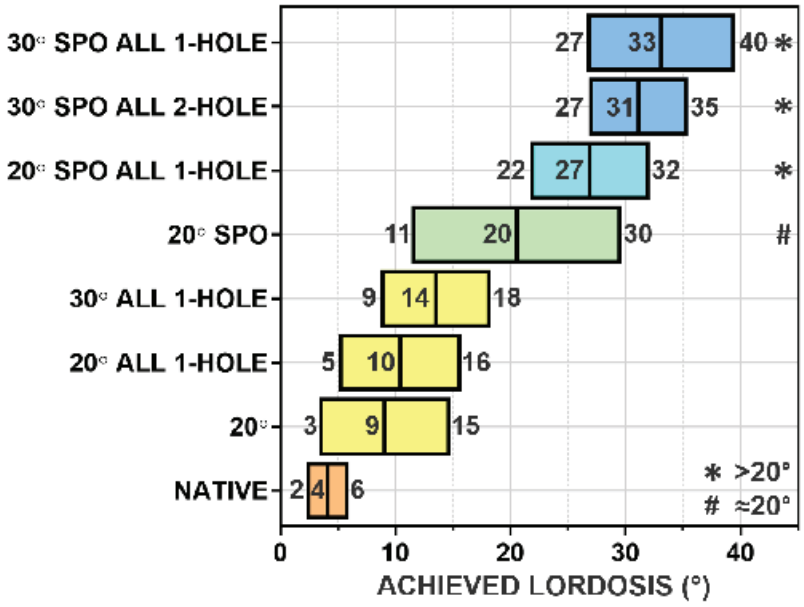


Study Design

Lordotic Interbody	Posterior Spinal Fixation	Smith-Petersen Osteotomy	ALL Release 1-Hole Plate	SPO ALL Release 1-Hole Plate	SPO ALL Release 2-Hole Plate
20°					Condition Not Possible
30°	Condition Not Possible	Condition Not Possible			

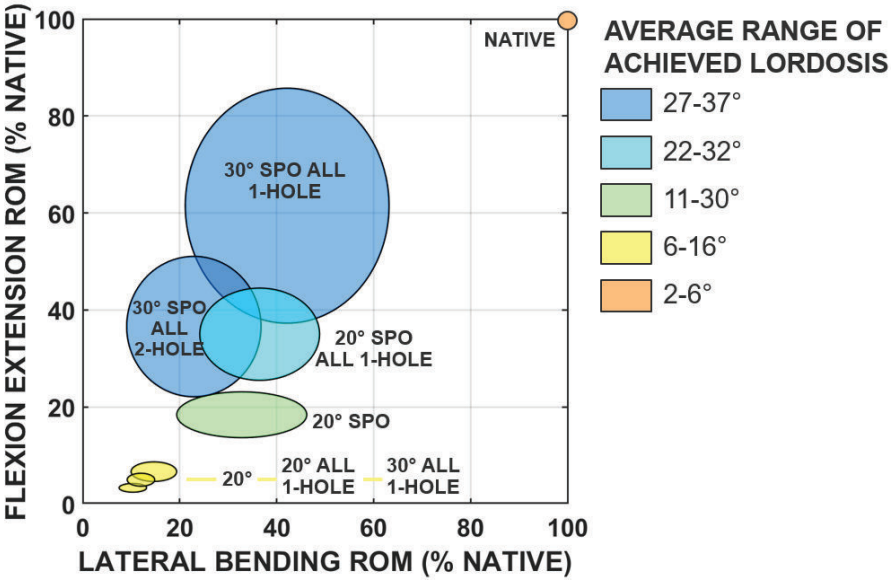
Key Findings

Average/Range of Total Segmental Lordosis Achieved by Each Intervention



- Cantilever SPO is necessary for segmental correction
- Achieved lordosis ≥20° is possible via
  - Hyperlordotic cage + cantilever SPO
  - Hyperlordotic cage + cantilever SPO+ ALL release
- ALL release alone does not significantly contribute to achieved lordosis
- Addition of a two-hole plate does not compromise achieved lordosis

Range of Motion vs. Achieved Lordosis



- Cantilever SPO alone does not compromise stability
- ALL release with cantilever SPO increases ROM
- A two-hole plate decreases ROM from that of a one-hole plate

Methods

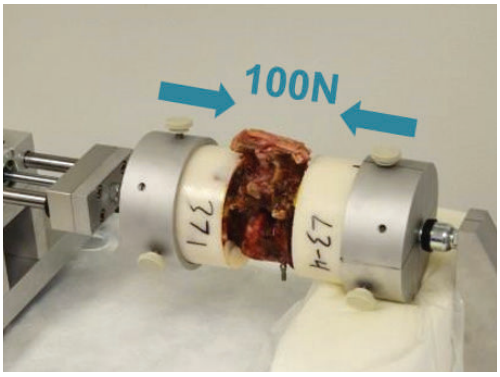
Six L1-L2 and L3-L4 cadaveric motion segments were isolated from cadaveric spines, all posterior musculature removed, and each vertebral body was potted in plaster with the pedicles exposed. Motion segments were randomly distributed into two groups to facilitate sequential surgical intervention. Instrumentation was performed by an experienced spine surgeon under 100N of compressive load, which is the average compressive load on the spinal column in the lateral decubitus position. Timberline MPF hyperlordotic cages (20° and 30°), plates and screws were sized accordingly for each level. With ALL release, a one-hole plate fixed to the cranial vertebra anchored the interbody cage. With SPO, a cantilever method was applied to the rod and pedicle screws. A two-hole plate replaced the one-hole plate in the final intervention. Rods and polyaxial pedicle screws from the Vital™ Spinal Fixation System backed up each level. Lateral fluoroscopic images were captured of the native segment and after each intervention for measurement of achieved lordosis. Additionally, range of motion (ROM) of the native segment and of each intervention was assessed using a six degree of freedom spine simulator. An optical motion capture system recorded the continuous angular displacement of markers fixed to each vertebra as the spine simulator applied pure 7.5 Nm moments for three cycles of flexion-extension (FE), then three cycles of lateral bending (LB) and three cycles of axial rotation (AR).

Data Analysis

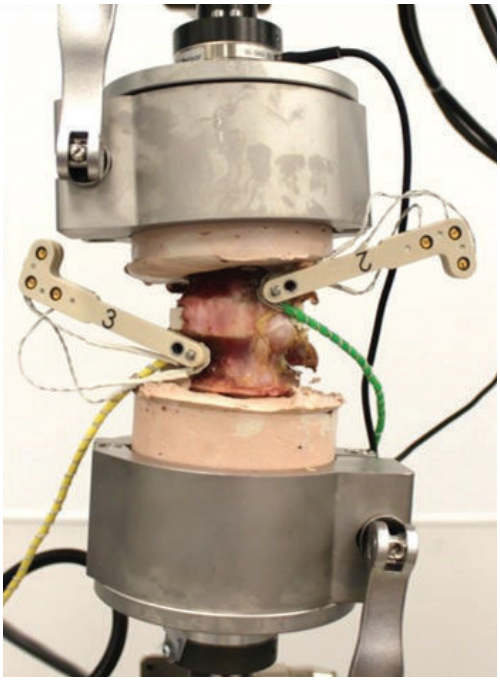
Achieved lordosis was determined via the lateral fluoroscopic images by measuring the angle of the vertebral endplates. Bar plots display the average achieved lordosis for each intervention bounded by one standard deviation. Peak range of motion was extracted from the third FE, LB and AR cycles and normalized to the ROM of the native motion segment. The ranges of FE and LB ROM are plotted here as one standard deviation from the average.

Statistical Analysis

A Shapiro-Wilk test determined that native segment lordosis and achieved lordosis for each intervention followed a normal distribution ($p<0.05$), therefore right-tailed t-tests against 20° determined which interventions achieved lordosis greater than 20°. Further, two-tailed t-tests against 20° that did not meet significance determined which interventions achieved lordosis equivalent to 20°. Significance set to $\alpha=0.05$.



Motion segments instrumented under 100N (~22lbs) of compressive load.



ROM in FE, LB, AR of each segment after each intervention was measured using optional motion capture while a six degree of freedom spine simulator applied pure moments in each plane.

CONCLUSIONS

- A hyperlordotic cage and cantilever SPO yield substantial correction without compromising stability
- Achieved lordosis ≥20˚ is possible via a hyperlordotic cage, SPO and ALL release + cantilever SPO
- A two-hole plate is recommended with ALL release to reduce ROM

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