ABSTRACT INTRODUCTION:
Conventional wisdom dictates that fusion rates increase with increasing construct stiffness. Traditional pedicle screw systems generally rely upon stiff components and rigid interconnections. For ease of insertion, some "semi-rigid" systems include polyaxial connections. A favorable bio logical outcome (fusion) is only weakly related to instrumentation type and it is increasingly recognized that even semi-rigid instrumentation may be too stiff [1]. Dynesys (Dynamic Neutralization System for the Spine, Centerpulse Spine-Tech, Inc., Minneapolis, MN) has non-rigid interconnections, non-rigid polymer spacers, and pedicle screw anchorage. The biomechanics of more traditional polyaxial pedicle screw/rigid rod fixation (Silhouette) compared to this non-rigid system are unknown. It was hypothesized that spines fixed with the non-rigid stabilization system will exhibit greater ranges of motion (ROM) than spines fixed with the all-metal semi-rigid pedicle screw system.

METHODS:
Twelve fresh-frozen calf lumbar spines were used. Soft tissues were removed but the discs and ligaments were left intact. Structures above L1 and below L5 were removed. Spines were kept moist and were maintained at 35-41 °C (body temperature) throughout testing.

Intact spines were tested in flexion, extension, left/right lateral bending, and left/right axial rotation. Instrumentation was applied at L3/L4 using the manufacturers’ recommended techniques and instruments. For non-rigid (Dynesys) stabilization, the facet joints were cut open. For semi-rigid (Silhouette) fixation, the facet joints were decorticated with a high speed burr and rongeurs. (This variation was necessary to accommodate geometric differences between the instrumentation types.) Spines were destabilized at the reconstructed level by creating a window in the annulus and by cutting the supraspinous, interspinous, and posterior longitudinal ligaments, and the ligamentum flavum. Six spines received non-rigid stabilization and six spines received semi-rigid fixation. Instrumented spines were retested in flexion, extension, left/right lateral bending, and left/right axial rotation.

A biaxial load frame was configured with two rotary actuators with integral rotary potentiometers mounted onto glide tables. This configuration created a six degree-of-freedom spine testing machine: the rotary actuators coincided with flexion/extension and lateral bending, the glide tables coincided with anterior/posterior and medial/lateral translations, and the biaxial actuator coincided with axial rotation and axial translation of the spine. Flexion—extension, axial rotation, and lateral bending moments were applied in 1.5Nm intervals up to +/-6Nm in each direction with no axial pre-load. Position data were recorded upon a third loading cycle after two preconditioning cycles. Relative intervertebral motions were recorded by a optoelectronic position measurement system (Optotrak 3020, Northern Digital Inc., Waterloo, Ontario, Canada). Ranges of motion were derived from the moment-angular displacement curves. For instrumented spines, ROM’s were normalized to intact and reported. In general, groups were compared by a t-test. A significance level of p<0.05 was chosen.

RESULTS SECTION:
In axial rotation, flexion/extension and lateral bending, spines with non-rigid stabilization were not significantly different from spines with semi-rigid fixation. In axial rotation, neither was significantly different from intact. However, in flexion/extension and lateral bending, both were significantly different from intact.

Table: Range of Motion (Percent of Intact, mean ± 1 s.d.)

<table>
<thead>
<tr>
<th></th>
<th>L/R Axial Rotation</th>
<th>Flexion/Extension</th>
<th>L/R Lateral Bending</th>
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</thead>
<tbody>
<tr>
<td>Non-Rigid Fixation</td>
<td>125 ± 50</td>
<td>54 ± 12</td>
<td>10 ± 4</td>
</tr>
<tr>
<td>Semi-Rigid Fixation</td>
<td>125 ± 47</td>
<td>40 ± 29</td>
<td>13 ± 7</td>
</tr>
</tbody>
</table>

DISCUSSION:
Both constructs substantially reduced flexion/extension and lateral bending motion but the constructs were not different from each other.

Consequently, neither fixation system was superior in terms of reducing flexion/extension and lateral bending. In axial rotation, neither Dynesys nor Silhouette was different from its intact condition and the constructs were not different from each other. Neither construct substantially affected axial rotation motion.

Our findings are limited to single-level, bilateral constructs; no differences between non-rigid stabilization (Dynesys) and semi-rigid fixation (Silhouette) were notable. Multi-level or unilateral constructs may likewise exhibit no differences between instrumentation types, but these variables were not included in this study. Another limitation is that calf lumbar spines were tested in this study. Wilke has found that calf and human spines are biomechanically similar and that the calf spine is an appropriate model for the human spine in vivo test s [2]. Our tests were further limited in that the spines were fresh-frozen and the spines were normal without obvious anatomic defects or disease. These limitations are accepted for all in vitro tests. No axial preload was applied though axial preload has been shown to have an important effect when examining natural spine kinematics [3]. The best axial preload for in-vitro comparisons of posterior fixation systems remains to be demonstrated. It has been recommended by other investigators than care be taken to guarantee that any preload be consistently applied throughout testing [4]; our methodology ensured this. The constructs model fixation only immediately post-operatively and without bone graft. The effects of time of implantation may be important in several ways. First, ranges of motion and stiffness may be affected by repeated loading in situ; in this study, a nominal number of load cycles were applied. Second, the material properties of the bone or of the implants may change with time in situ; these changes could not be modeled. Third, successful fixation should lead to the development of a fusion mass in situ; the biomechanical consequences of the presence of a fusion mass were not studied.

Contrary to the hypothesis, non-rigid stabilization and semirigid fixation presented equivalent ranges of motion in axial rotation, flexion/extension, and lateral bending. Both the non-rigid stabilization system and the semi-rigid fixation system provided acute stability.

REFERENCES:
2. Wilke HJ, Krischak ST, Wengen KH, Claes LE: Load-displacement properties of the thoracolumbar calf spine: experimental results and comparison to known human data. Eur Spine J 1997;6(2):129-37