The limitation of lateral mass screws as compared to pedicle screws for cervical fixation: a biomechanical study.

Zenya Ito MD*, Kosaku Higashino MD*, Satoshi Kato MD*, Sung Soo Kim MD*, Eugene Wong MD*, Katsuhito Yoshioka MD*, William C. Hutton DSc#*
# Emory Spine Center, Atlanta, GA * VA Medical Center, Atlanta, GA z.itou@nifty.com

Introduction
Biomechanical studies focusing on pedicle and lateral mass screws inserted into the cervical spine are limited in number. Todd et al. reported that cervical pedicle screw fixation provides a significantly lower rate of loosening at the bone–screw interface, as well as higher pullout strength after fatigue testing (in flexion/extension only) for only 200 cycles at a maximum load of 44.5 N. However, Jones et al. reported that pullout strength of lateral mass screws inserted in the upper-middle cervical spine (C3 to C5) was greater than those inserted into lower levels (C6 and C7). Therefore, it is somewhat controversial as to whether lateral mass screw fixation in the upper-middle cervical spine (C3 to C6) can offer any biomechanical security as compared to pedicle screw fixation. The purpose of this study was to compare pullout strengths of pedicle screws and lateral mass screws inserted into cervical vertebrae (C3 to C6) after a period of cyclic loading (in two planes) in order to determine the limitation of lateral mass screws for cervical fixation at C3 though to C6.

Materials & Methods
Thirty-two (32) vertebrae (C3 to C6) were harvested from eight spines; eight each of C3, C4, C5 and C6. All screws were 3.5-mm diameter titanium cortical screws (Medtronic, Memphis, TN). All pedicle screws were 25 mm in length and had unicortical purchase. All lateral mass screws (16 mm in length) had bicortical purchase (Figure 1). For each vertebra, one side was randomly chosen to receive a pedicle screw and the other side a lateral mass screw. Each vertebra thus served as its own internal control.

The pedicle or lateral mass screws inserted into the first 16 vertebrae (four each of C3, C4, C5, and C6) were cyclically loaded (using an MTS 858 Mini-Bionix) to simulate flexion/extension (ie axial rotation) of the spine. The pedicle or lateral mass screws inserted into the remaining 16 vertebrae were cyclically loaded to simulate flexion/extension of the spine. Before cyclic loading commenced, a laminectomy was performed in order to prevent load applied to the screw on one side being transmitted to the pedicle or lateral mass on the other side. Then all screws were cyclically loaded: ±75 N at 1 Hz for 500 cycles. At the end of the cyclic loading each pedicle and lateral mass screw was pulled out along its long axis (at a displacement rate of 12.5 cm/minute), and the pullout force was recorded.

Results
The results are shown in the Table. Overall, and for both flexion/extension and torsion the mean pullout strengths of the pedicle screws as compared to the lateral mass screws favored the pedicle screws.

For each vertebra separately (C3, C4, C5 and C6) the difference in the mean pullout strength between pedicle screws and the lateral mass screws favored the pedicle screws in every case (Figure 2).

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<tr>
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<th>Lateral mass screws</th>
<th>Pedicle screws</th>
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<tr>
<td>Overall</td>
<td>206±118</td>
<td>64±2±50</td>
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<tr>
<td>Flexion/Extension</td>
<td>280±72</td>
<td>571±233</td>
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<tr>
<td>Torsion</td>
<td>191±81</td>
<td>762±171</td>
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Table 1: The mean pullout strength (N) for the lateral mass screws and for the pedicle screws.

Discussion
The main results to come from this experiment are: 1) Overall the mean pullout strength of the pedicle screws was higher than the mean pullout strength of the lateral mass screws (cf 643 N with 206 N); 2) Similarly the mean pullout strengths for pedicle screws in the flexion/extension group and the torsion group were higher than the mean pullout strength of the lateral mass screws in the flexion/extension group and the torsion group (cf 571 N with 280 N for flex/ex; and 762 N with 191 N for torsion). The oval shaped pedicle clearly influenced the resistance of the pedicle screw to forces in the axial direction (cf 762 N with 571 N); 3) Looking at the individual vertebral levels C3, C4, C5, and C6 and combining the results for flexion/extension and torsion, the mean pullout strength of the pedicle screws was significantly higher than the mean pullout strength of the lateral mass screws in every case (see Figure 2).

Lateral mass screws are commonly used in especially upper-middle cervical spine (C3-5) as a safer alternative to pedicle screws, despite their lower pullout strength. This study demonstrates that pedicle screws have a clear advantage in terms of strength (resistance to a combination of fatigue and pullout) at every level from C3 to C6 (see Figure 2).

Jones reported on the difference in mean pullout strength between pedicle screws and lateral mass screws for each vertebra as follows: C3, 217 N; C4, 236 N; C5, 464 N; C6, 402 N. However in our study the differences were greater: C3, 440 N; C4, 376 N; C5, 487 N; C6, 497 N. Clearly, by carrying out cyclic loading before pulling the screws out, we have accentuated the difference in strength between pedicle screws and lateral mass screws.

Conclusion
Not forgetting the potential risks of inserting pedicle screws in cervical vertebrae, pedicle screws are a better biomechanical choice than lateral mass screws for cervical fixation at the levels C3 through to C6.

References