Modified K Line in MRI is a Powerful Tool to Predict Clinical Outcomes in Patients with Non-Lordotic Alignment after Laminoplasty for a Treatment of Cervical Spondylotic Myelopathy

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Introduction: We have previously reported the modified K-line (mK-line), which was defined as a line connecting the midpoints of the spinal cord at C2 and C7 on T1 weighted sagittal MRI, can predict postoperative insufficient decompression in patients with cervical spondylotic myelopathy (CSM) who underwent laminoplasty. Although it is very important for spine surgeons to predict postoperative clinical outcomes, particularly in patients with cervical malalignment such as kyphotic or sigmoid alignment, before selecting a surgical procedure for the treatment of CSM, few studies thus far has assessed a relationship between postoperative outcomes and anticipated spinal cord shifting quantified on MRI. The purpose of this study is to investigate whether mK-line can be a powerful tool to predict postoperative clinical outcomes in patients with non-lordotic alignment.

Methods: Sixty-one consecutive patients who underwent laminoplasty for the treatment of CSM between 2000 and 2011 at our hospital were retrospectively reviewed. Cervical sagittal alignment, as classified by Kamata and Matsumoto et al., was assessed based on lateral neutral X-ray, and then 23 patients whose cervical alignment was not lordosis were enrolled. An interval between the preoperative mK-line and anterior structure of the spinal canal at each segment of C3 to C6 levels (INTn; n=3-6, Figure 1) was measured on sagittal T1-weighted MRI. The sum of the INTn (INTsum=INT3+INT4+INT5+INT6) was then calculated as anticipated degree of posterior cord shifting. In addition, we defined INTmin as the minimum interval among INTn in each patient (Figure 1). The Japanese Orthopedic Association (JOA) scoring system and recovery rate of the JOA score for cervical myelopathy was evaluated as clinical outcomes.

Results: The mean age was 62.5 (± 9.1) years. The mean JOA score was 9.2 (± 3.0) points before surgery and 12.5 (± 2.8) points at final visit, respectively, yielding that mean recovery rate of JOA score was 42.1 (± 23.5) %. The number of patients with non-lordotic alignment was 8 for sigmoid, 7 for straight, 5 for kyphosis, and 3 patients for reversed-sigmoid alignment, respectively. Cervical alignment on MRI was closely associated with that on lateral neutral X-ray in each patient. A linear regression model demonstrated a significant correlation between INTmin and recovery rate of JOA score in these patients (y= 6.347x+22.36, y=the JOA score recovery rate, x=INTmin, r2=0. 25, p=0.018, Figure 2), whereas INTsum was not associated with recovery rate. From this analysis, recovery rate greater than 50% requires INTmin of > 4.35mm preoperatively.

Conclusion: The current study revealed that the preoperative mK-line can predict clinical outcomes in patients with non-lordotic alignment following laminoplasty by the measurement of INTmin, rather than that of INTsum. These results indicate that it might be important to recognize the apex of the kyphosis or anterior compression in presence of malalignment as a risk factor for lack of posterior cord shifting after laminoplasty, and that anterior decompression with fixation or posterior decompression with fusion should be applied to such cases.
Modified K-line in MRI is a powerful tool to predict clinical outcomes in patients with non-lordotic alignment after laminoplasty for a treatment of cervical spondylotic myelopathy

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Background

Laminoplasty for treatment of myelopathy has been shown to be...

- Relatively low-cost
- Minimally invasive
- Safe
- A method that preserves stability and mobility on the cervical spine

Many authors had reported the procedure can achieve good outcomes in most myelopathic patients.
Risk factors of poor outcome...

- Age (Tanaka et al. *Spine* 1999)
- Preoperative severe paralysis (Lee et al. *J. Neurosurg.* 1997)
- Cervical kyphotic alignment (Suda et al. *Spine* 2003)
- Anterior impingement of spinal cord (Hirai et al. *Spine* 2012)

- Modified K-line (mK-line) on magnetic resonance imaging was developed to evaluate both cervical global alignment and anterior compression of the spinal cord.

- This index has been shown to predict the incidence of residual anterior compression after laminoplasty.

  (Taniyama et al. *Spine* 2013)

**Most important thing** for spine surgeons is to predict postoperative clinical outcomes particularly in patients with kyphotic or sigmoid misalignment before selecting a surgical procedure.
Objective

• To investigate whether a preoperative index based on mK-line predicts clinical outcome in patients with cervical mis-alignment after laminoplasty for cervical spondylotic myelopathy (CSM).
Methods

- Sixty-one consecutive patients who received Kirita and Miyazaki method laminoplasty for CSM between 2000 and 2011 at our hospital were reviewed.
- According to Kamata’s classification (Matsumoto et al. *Injury* 1998), 23 patients where cervical alignment was categorized as non-lordotic were enrolled into this study.

The Japanese Orthopedic Association (JOA) scoring system and recovery rate of the JOA score for cervical myelopathy were evaluated as clinical outcomes.
Definitions of the mK-line, $\text{INT}_{\text{sum}}$ and $\text{INT}_{\text{min}}$

The mK-line: A line connects between the midpoints of the spinal cord at the C2 and C7 levels on T1 weighted image.

$\text{INT}_{\text{sum}}$: $(\text{INT}_3 + \text{INT}_4 + \text{INT}_5 + \text{INT}_6)$ The sum of $\text{INT}_n$ which is an interval between the preoperative mK-line and anterior structure of the spinal canal at each segment of C3 to C6 levels.

$\text{INT}_{\text{min}}$: The minimum interval of the $\text{INT}_n$ in each patient
## Demographic data

<table>
<thead>
<tr>
<th></th>
<th>Non-lordotic patients (n=23)</th>
</tr>
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<tbody>
<tr>
<td>Age (y-o)</td>
<td>62.5 ± 9.1</td>
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<tr>
<td>Male (%)</td>
<td>82.6%</td>
</tr>
<tr>
<td>Preoperative JOA score</td>
<td>9.2 ± 3.0</td>
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<tr>
<td>Postoperative JOA score</td>
<td>12.5 ± 2.9</td>
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<tr>
<td>Recovery rate of the JOA score</td>
<td>42.1 ± 23.5</td>
</tr>
<tr>
<td>Preoperative C2-7 lordotic angle (degrees)</td>
<td>5.2 ± 8.0</td>
</tr>
<tr>
<td>INT$_{\text{sum}}$</td>
<td>20.8 ± 8.1</td>
</tr>
<tr>
<td>INT$_{\text{min}}$</td>
<td>3.38 ± 2.1</td>
</tr>
</tbody>
</table>
Results

✓ A significant correlation between $\text{INT}_{\text{min}}$ and recovery rate of JOA score in these patients was seen ($y = 6.347x + 22.36$, $r^2 = 0.25$, $p = 0.018$), whereas $\text{INT}_{\text{sum}}$ was not associated with recovery rate.
Discussion

- It has been documented that laminoplasty is sometimes ineffective for patients with non-lordotic alignment. (Suda et al. *Spine* 2003, Uchida et al. *J. Neurosurg.* 2009)

- Some authors had reported that neurological improvement is influenced by not only global kyphosis but also anterior compression of the spinal cord, which appears to lead to a lack of decompression at the ventral aspect of the spinal cord. (Hirai et al. *Spine* 2011, Baba et al. 1996)

- The results of the current study suggest that neurological improvement in patients with misalignment might require a sufficient posterior cord shift at only the most compressed segment rather than throughout the entire spinal cord.
Limitations of this study

- retrospective nature.
- relatively small cohort sized.
- should categorize a larger patient pool into five different alignments to determine the relationship between our new index and clinical outcomes in each alignment type in future.

Conclusions

- $\text{INT}_{\text{sum}}$ was not associated with clinical outcome in non-lordosis groups.
- $\text{INT}_{\text{min}}$ was a significant predictive factor for postoperative clinical outcome in patients with non-lordotic alignment.
- $\text{INT}_{\text{min}}$ can help spine surgeons to decide whether LAMP should be performed in patients with non-lordotic alignment.