Biomechanical analysis of posterior decompression with and without fixation on the cervical ossification of posterior longitudinal ligament.

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INTRODUCTION: Cervical ossification of the posterior longitudinal ligament (C-OPLL) causes myelopathy [1]. Though posterior decompression for C-OPLL showed positive results, poor outcomes were seen in patients with a kyphotic alignment. Especially, posterior decompression for C-OPLL had poor outcomes in patients with K-line (-) [2]. Posterior decompression with fusion (PDF) tends to show better results compared to posterior decompression. The aim of this study is to evaluate the effects of the posterior procedures for C-OPLL.

METHODS: Based on 3D finite element C2-C7 spine created from medical images. The facet joints, the posterior longitudinal ligament, and ligamentum flavum were added to the model. Spinal cord models were modeled using the mean transverse and anterior-posterior diameter at each spinal cord segment of the report [3]. The following compression models were created: the intact model, K-line 0mm model, and K-line 2mm model. These models were used to analyze the effects of posterior decompression with varied lengths of fixation. The stress of the spinal cord was calculated for intact, K-line 0mm, and K-line 2mm as preoperative models, and laminectomy (LN)-K-line 0mm, PDF (C4-C5)-K-line 0mm, PDF (C3-C6)-K-line 0mm, LN-K-line 2mm, PDF (C4-C5)-K-line 2mm, and PDF (C3-C6)-K-line 2mm model as operative models in a neutral, flexion, and extension. A pure moment of 1.5 Nm was applied to the C2 odontoid process, cervical spine, and dura matter to simulate flexion/extension. The inferior endplate of the C7 vertebra was fixed. The model was subjected to the compressive follower load of 100N to represent the weight of the head/cranium and cervical muscle contractions

RESULTS: In the neutral posture, flexion, and extension, as the compression increased, stress on the spinal cord increased compared to intact model. *K-line 0mm model:* In the neutral posture, the stress on spinal cord for LN-K-line 0mm, PDF (C4-C5)-K-line 0mm, and PDF (C4-C6)-K-line 0mm models decreased by 82% respectively compared to the K-line 0mm model. In flexion, the stress on the spinal cord for LN-K-line 0mm, PDF (C4-C5)-K-line 0mm, and PDF (C4-C6)-K-line 0mm models decreased by 41%, 44%, and 77% respectively compared to the K-line 0mm model. In extension, the stress on the spinal cord for LN-K-line 0mm, PDF (C4-C5)-K-line 0mm, and PDF (C4-C6)-K-line 0mm models decreased by 74%, 74%, and 80% respectively compared to the K-line 0mm model. *K-line 2mm model:* In the neutral posture, the stress on the spinal cord for LN-K-line 2mm, PDF (C4-C5)-K-line 2mm, and PDF (C4-C6)-K-line 2mm models decreased by 52%, 52%, and 61% respectively compared to the K-line 2mm model. In flexion, the stress on the spinal cord for LN-K-line 2mm, PDF (C4-C5)-K-line 2mm, and PDF (C4-C6)-K-line 2mm models decreased by 49%, 49%, and 80% respectively compared to the K-line 2mm model. In extension, the stress on the spinal cord for LN-K-line 2mm, PDF (C4-C5)-K-line 2mm, and PDF (C4-C6)-K-line 2mm models decreased by 54%, 55%, and 82% respectively, compared to the K-line 2mm model.

DISCUSSION: Clinically, the posterior decompression for C-OPLL has been reported as a relatively easy surgical procedure and with positive results, although it is an indirect decompression technique. However, in patients with kyphotic cervical spine alignment or high spinal canal occupancy of ossification, posterior shift (indirect decompression) of the spinal cord is insufficient, resulting in poor clinical outcomes [4]. Although it is more invasive, the addition of posterior fixation has shown to have similar outcomes to an anterior decompression with fusion; though both procedures has shown to be better than the posterior decompression[1]. The posterior fixation prevents kyphosis deformity and provides stability to the cervical segment mobility. However, it is inconclusive whether a short or long length of fixation should be performed. A K-line (-) indicates high ossified occupancy and kyphotic alignment. Our results indicated that the K-line 2mm model had higher intraspinal stress. In addition, posterior decompression decreases the intraspinal stress in the neutral posture, K-line 0mm, and K-line 2mm. However, in LN and PDF (C4-C5), intraspinal stress increased, especially in flexion and extension and was more pronounced with K-line 2mm, which is consistent with previous reports [4]. Long-length fixation for C-OPLL can prevent an increase in the stress of the spinal cord.

CLINICAL RELEVANCE: K-line (-) and cervical kyphotic alignment increases intraspinal stress, and posterior decompression and short fixation has a poor decompression effect. In kyphotic cervical OPLL, it is essential to control spine mobility in the posterior approach.

REFERENCES:

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IMAGES & TABLES:

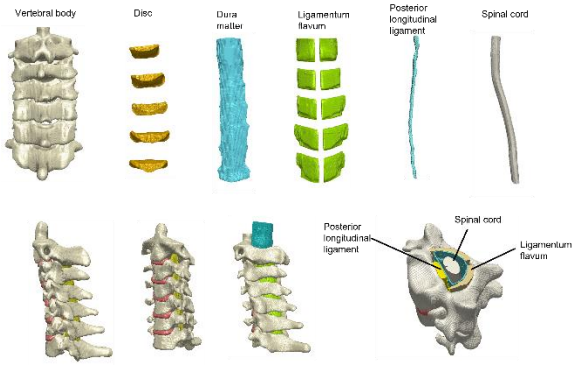

Figure 1: Spine and spinal cord model

Part	Young's modulus E [MPa]	Poisson ratio
Cortical bone (Normal)	12000	0.3
Cancellous bone (Normal)	1500	0.3
Annulus fibrosus	25	0.3
Nucleus pulposus	1	0.45
Anterior longitudinal ligament	68	0.3
Posterior longitudinal ligament	96	0.3
Ligamentum flavum	28.6	0.3
Spinal cord	0.222	0.3
Dura matter	63	0.3
Ti-6Al-4 V: rod and screw	127000	0.33

Figure 2: Material properties of the model.