The Spine Journal 15 (2015) 2216–2221

Clinical Study

Kinematic relationship between missed ligamentum flavum bulge and degenerative factors in the cervical spine

Guibin Zhong, MD[a,b], Zorica Buser, PhD[a,*], Lifeng Lao, MD[a,b], Ruofeng Yin, MD[a,c], Jeffrey C. Wang, MD[a]

[a]Department of Orthopaedic Surgery, Keck School of Medicine, University of Southern California, 1520 San Pablo St., Suite 2000 Los Angeles, CA 90033, USA

[b]Department of Orthopaedic Surgery, Renji Hospital, Jiaotong University School of Medicine, No. 160, Pujian Road, Pudong New Area, 200127 Shanghai, China

[c]Department of Orthopedic Surgery, China-Japan Union Hospital, Jilin University, 126 XianTai St, Changchun City, Jilin Province 130033, China

Received 6 November 2014; revised 14 May 2015; accepted 12 June 2015

Abstract

BACKGROUND CONTEXT: Bulging of ligamentum flavum can happen with the aging process and can lead to compression of the spinal cord and nerves. However, the distribution and the risk factors associated with a missed ligamentum flavum bulge (LFB) are unknown.

PURPOSE: The aim was to evaluate the distribution and risk factors associated with missed LFB in the cervical spine.

STUDY DESIGN: This was a retrospective analysis of kinematic magnetic resonance images (kMRI).

PATIENT SAMPLE: Patients diagnosed with symptomatic neck pain or radiculopathy between March 2011 and October 2012 were included.

OUTCOME MEASURES: The outcome measures were missed LFB and degenerative factors.

METHODS: A total of 200 patients (1,000 cervical segments) underwent upright kMRI in neutral, flexion, and extension postures. The LFB, sagittal cervical angles, disc herniation, disc degeneration, disc height, angular motion, translational motion, age, and gender were recorded. After excluding segments with LFB in neutral and flexion position, Pearson and Spearman correlation coefficients were used to evaluate the relation between the risk factors and missed LFB in the extension position.

RESULTS: The average depth of LFB was 0.24±0.71 mm at C2–C3, 1.02±1.42 mm at C3–C4, 1.65±1.48 mm at C4–C5, 2.13±1.37 mm at C5–C6, and 1.05±1.54 mm at C6–C7. The distribution of LFB was the most frequent at C5–C6 level (76.58%) followed by C4–C5 (63.06%). Disc herniation, disc degeneration, angular variation, and translational motion were significantly correlated with missed LFB at C4–C5 andC5–C6. Disc degeneration was the only factor significantly correlated with missed LFB at all cervical segments.

FDA device/drug status: Not applicable.

Author disclosures: ***GZ:*** Nothing to disclose. ***ZB:*** Nothing to disclose. ***LL:*** Nothing to disclose. ***RY:*** Nothing to disclose. ***JCW:*** Royalties: Stryker (B), Osprey (B), Aesculap (B), Biomet (F), Amedica (D), Seaspine (D), Synthes (C); Stock Ownership: Fziomed (less than 1%), Alphatech (less than 1%); Private Investments: Promethean Spine (less than 1% of entity), Paradigm spine (less than 1% of entity), Benevenue (less than 1% of entity), NexGen (less than 1% of entity), Pioneer (less than 1% of entity), Amedica (less than 1% of entity), Vertiflex (less than 1% of entity), electrocore (less than 1% of entity), surgitech (less than 1% of entity), Axiomed (less than 1% of entity), VG Innovations (less than 1% of entity), corespine (less than 1% of entity), expanding orthopaedics (less than 1% of entity), syndicom (less than 1% of entity), osprey (less than 1% of entity), amedica (less than 1% of entity), bone biologics (less than 1% of entity), curative biosciences (less than 1% of entity), pearldiver (less than 1% of entity); Board of Directors: North American Spine Society (Nonfinancial), Cervical Spine Research Society (Nonfinancial, non-financial, reimbursement for travel for board meetings), AO Spine/AO Foundation (Honoraria and travel reimbursement, F), Collaborative Spine Research Foundation (Nonfinancial); Fellowship Support: AO Foundation (E, spine fellowship funding, Paid directly to institution/employer); Other: non US CME course expenses (Financial, B reported by DepuySynthes for teaching at a non US CME course sponsored by AO Foundation).

The disclosure key can be found on the Table of Contents and at www.TheSpineJournalOnline.com.

The study was funded by departmental funds. The authors declare that they have no conflicts of interest.

* Corresponding author. Department of Orthopaedic Surgery, Keck School of Medicine, University of Southern California, Hoffman Medical Research Center, HMR 710, 2011 Zonal Ave, Los Angeles, CA 90033, USA. Tel.: (323) 442-0206.

E-mail address: zbuser@usc.edu (Z. Buser)

http://dx.doi.org/10.1016/j.spinee.2015.06.048

CONCLUSIONS: Occurrence and depth of missed LFB was the highest at C4–C5 and C5–C6 compared with other cervical levels. Disc degeneration, disc herniation, angular variation, and translational motion could play a role in the development of LFB at C4–C5 andC5–C6.

Keywords: Ligamentum flavum bulge (LFB); Cervical spine; Kinematic; Magnetic resonance imaging; Spinal cord compression; Disc degeneration

Introduction

Cervical spinal stenosis is caused by anterior and posterior element compression and leads to direct damage or secondary ischemic changes of spinal cord and nerve roots [1–3]. The ligamentum flavum (LF) plays an important role among posterior compression factors by bulging into the canal and causing spinal stenosis [4,5]. Chen et al. [6] reported that ligamentum flavum bulge (LFB) can contribute significantly to the canal encroachment in the extension position. In a study done by Breig et al. [7], the cervical canal was narrowed in the overstretched position, which was mainly due to the dynamic changes within the LF and the intervertebral disc.

Magnetic resonance imaging (MRI) is the most sensitive noninvasive diagnostic method for detecting pathologic changes of soft tissue, including LF. However, it can only obtain nonweight bearing, static images. The LFB occurs most frequently during the cervical spine extension and can be missed in the neutral posture with the conventional MRI. A possible solution to this limitation is the utilization of kinematic magnetic resonance imaging (kMRI), which allows imaging of patients in flexion-extension and neutral positions. Several previous studies have used MRI to measure the thickness and dynamic changes of the LF in the spine [8–10]. However, to our knowledge, there is no study that evaluated the distribution and depth of LFB, as well as the predisposing risk factors associated with LFB in the cervical spine.

The purpose of our study was to assess the frequency of missed LFB and the correlation between disc degeneration, radiographic factors, and the development of LFB in the cervical spine using kMRI.

Materials and methods

Patients

Two hundred (88 males and 112 females) patients diagnosed with neck pain or radiculopathy between March 2011 and October 2012 were included in our study. The mean age was 49.36±10.4 (range 19–68) years. The inclusion criteria were defined as patients who had neck pain with or without neurologic symptoms (radiculopathy or myelopathy). The exclusion criteria were trauma, rheumatoid arthritis, spinal tumors, and history of cervical spine surgery. The study was approved by the institutional review board.

Magnetic resonance imaging positioning and protocol

All patients underwent cervical kMRI scanning in upright weight-bearing neutral, flexion and extension positions (0.6-T MRI scanner; Fonar Corp., New York, NY, USA). Initially, each patient was seated on a bench between the two poles of the MRI magnet in a neutral position (0°), head facing straight ahead. Next, the patients were positioned with their chin angled toward their chest (40° flexion position) and lastly with their chins angled toward the ceiling (−20° extension position). For each position, a flexible cervical coil was placed around the participant's neck, and a padded support bar and headrest were used.

Magnetic resonance imaging measurement

All measurements were made using the midsagittal slices of kMRI. The missed LFB was only present in the extension position. The depth of the LFB was measured by the perpendicular distance between the two parallel lines. One line connected the two adjacent laminae representing the posterior border of the LF. The second line was drawn from the highest point of the LF protrusion, parallel to the first line, representing the anterior border of the LF. The distance between those two lines represented the depth of the LFB (Fig. 1).

Disc degeneration was graded using a previously reported system [11]. Miyazaki et al. [11] developed a comprehensive grading system that included nucleus signal intensity, structure, disc height, and distinction of nucleus and annulus. Disc herniation was measured from the line connecting the posterior cranial and caudal edges of two adjacent vertebral bodies to the point of greatest disc protrusion in the neutral position. The translational motion was measured from C2–C3 to C6–C7 by determining the anterior-posterior motion of one vertebra relative to the other in flexion and extension positions. The intervertebral angular motion was measured on the same five levels and was defined as the difference of the angular movement between two vertebrae from flexion to extension. The posterior disc height was measured between the posterior-superior and posterior-inferior points of adjacent vertebral bodies, excluding osteophytes. The sagittal cervical angle was measured by two line intersecting angle in the neutral