Medical Hypotheses 76 (2011) 73–76

Contents lists available at ScienceDirect

Medical Hypotheses

journal homepage: www.elsevier.com/locate/mehy

Rotational stress: Role in development of ossification of posterior longitudinal ligament and ligamentum flavum

Chen Jian, Wang Xinwei, Wang Ce, Yuan Wen *

Department of Orthopedics, Second Military Medical University affiliated Changzheng Hosipital, 415# Fengyang Road, Shanghai, PR China

ARTICLE INFO

Article history:
Received 27 April 2010
Accepted 7 August 2010

SUMMARY

Ossification of the posterior longitudinal ligament (OPLL) and ossification of ligamentum flavum (OLF) are characterized by progressive ectopic bone formation in the spinal ligaments. OPLL and OLF involved multiple etiological factors, and mechanical stress plays an important role. However, the details that what kind of mechanical stress promotes ligament ossification are still unknown. In this paper, we try to make a hypothesis that rotational mechanical stress might play a key role in OPLL and OLF development. It was supported by the conclusions that drawn from literature review: (1) Lumbar spine had the lowest prevalence of OPLL and OLF. (2) Lumbar spine was most rigid in axial rotation. (3) Atlanto-axial fusion might cause the development of sub-axial cervical OPLL. (4) Incidence of OLF was related to the range of rotation of the vertebrae.

Introduction

Ossification of the posterior longitudinal ligament (OPLL) and ossification of ligamentum flavum (OLF) are characterized by progressive ectopic bone formation in the spinal ligaments. The ossified plaques may cause the compression of the spinal cord and the nerve roots, leading to various degrees of neurologic impairment. It is known today that multiple etiological factors, including genetic factors, metabolic abnormalities, dietary habits and biomechanical factors [1] are involved in the pathogenesis of OPLL and OLF. It has been supported by clinical evidence that mechanical stress played an important role in OPLL and OLF progression [2]. Several *in vitro* studies have also [3–5] confirmed that OPLL cells had a higher sensitivity to mechanical stress than non-OPLL cells.

However, the details on what kind of mechanical stress promoted ligament ossification in OPLL and OLF are not clear yet. This paper focused on this subject and tried to establish a novel hypothesis on role of mechanical stress in OPLL and OLF development.

The hypothesis

We assumed a new theory that rotational stress might play a more important role than lateral bending or extension-flexion stress in the development of ligament ossified diseases, such as OPLL and OLF.

* Corresponding author. Tel.: +86 1500218 873.
E-mail address: aspirin_cj@yahoo.com.cn (W. Yuan).

0306-9877/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.mehy.2010.08.034

Evidence of the hypothesis

The epidemiology of OPLL and OLF

The prevalence of OPLL has been reported up to be 1.9–4.3% among individuals older than 30 years of age [6] in Japan. In other East Asian countries or regions, it was similar. It was 0.6% in Korea [7] among those older than 16 and 2.8% in Chinese Taiwan [8]. As to the prevalence of OPLL in different spinal regions, radiologic population studies [9–11] indicated that it was 3.2% in cervical spine, 0.6–0.8% in thoracic spine and 2.9% in lumbar spine. Meanwhile, the study of Nose et al. [12], which included 74 cases totally, reported 73 cases in cervical spine, two in thoracic and four in lumbar.

However, it was known that in plain film merely, lumbar OPLL was difficult to be distinguished from a dislocation of the posterior vertebral angle, a spur on the posterior margin of vertebral body, or a calcification of the intervertebral disc [13]. This might be the cause that previous studies [11] have reported a relatively high incidence of lumbar OPLL. Moreover, literature on lumbar OPLL was much fewer than that on cervical or thoracic. The number of reports on lumber OPLL on PubMed was fewer than 10 since 1970s [11–16]. Meanwhile, Tamura et al. [13] reported that there were only 22 reports in Japanese literature, most of which were small-sample case reports. Comparatively, thoracic OPLL was much more documented, and most of them [17–23] included more than 10 cases, some of which [18,22,23] was more than 30 cases. Besides, according to Tamura et al. [13], all patients with lumbar OPLL also had cervical OPLL and systemic ossification concurrently. All the factors involved above made it possible that the prevalence of lumbar OPLL was much lower statistically than that of cervical and thoracic, despite of lack of solid epidemiological evidence.

Similarly, epidemiological data of OLF was yet insufficient. There were several studies [24–26] indicated the OLF prevalence ranged from 4.5% to 35.4% in different regions of the world. However, almost all these studies were limited due to their corresponding sample size, region of the spine imaged, or the method of diagnosis. A recent large sample study [27] in China has suggested that the overall prevalence within the southern Chinese population was 3.8%. In that study, there were 52.2% OLF locating in T9–T12, 26.1% in T1–T4, 16.3% in T5–T8, 4.3% in cervical spine and only 1.1% in lumbar spine.

As a summary, we could conclude that the most common region for OPLL was the cervical spine, followed by the thoracic spine and then the lumbar spine. However, the most common region for OLF was the thoracic spine, followed by the cervical spine, and then the lumbar spine as well. *It is inconsistent to our common sense that lumbar spine was much more flexible than thoracic spine and was similar to cervical spine.*

Table 1
A review of normal spine kinematics.

Spine level		One side axial rotation	Flexion/ extension	One side lateral bending
Cervical spine [28–32]	C1-2	28.4°–36.3°		1.6°
	C2-3	1.6°–3.0°	9°–12°	3.7°
	C3-4	2.6°–6.5°	14°–15°	3.5°
	C4-5	2.1°–6.8°	16°–23°	3.3°
	C5-6	2.6°–7.0°	15°–28°	4.3°
	C6-7	1.5°–5.4°	11°–19°	5.7°
	C7-T1	1.5°–2.2°		4.1°
Thoracic spine [33,34]	T1-T4	11.8°–15.9°	16.6°–16.8°	5.6°–6.2°
	T4-T8	21.5°–25.3°	19.3°–19.9°	7.7°–8.5°
	T8-T12	7.9°–11.8°	20.3°–22.5°	11.9°–13.2°
	T12-L1	1.0°–2.0°	7°–12°	5°–8°
Lumbar spine [35–37]	L1-2	0.6°–2.3°	8.6°–12°	5.6°–6°
	L2-3	1.0°–2.7°		
	L3-4	1.0°–3.6°	8.8°	8.7°
	L4-5	1.0°–3.4°	7.8°	7.4°
	L5-S1	1.0°–1.7°		
	T12-S1	17°–18°*	70°–115°	23°–47°**

* Combined two sides axial rotation.
** Combined two sides lateral bending.

The kinematics of spine

The spine displays complex motions comprising flexion–extension, lateral bending, axial rotation, and even translation, known as coupled motions. There were plenty of literature [28–37] on spine biomechanics and kinematics; however, the results were conflicting due to the difference of methods. A summary review of these papers was listed in Table 1. Although the results varied, there was one conclusion that was a consensus. *It was that lumbar spine was flexible in flexion–extension and lateral bending, but not in axial rotation, while thoracic spine was rigid in flexion–extension and lateral bending, but relatively flexible in axial rotation*. It was in accordance with White and Panjabi (Shown in Fig. 1) [38].

Other evidence

The occurrence and development of OPLL were understandable after lower cervical spine operation [39], because surgical interventions, such as laminoectomy, would destruct the posterior structure and thus cause instability and increasing stress. However, it was interesting that people who underwent atlanto-axial fusion had the sub-axial cervical OPLL years after surgery [40]. Fur-

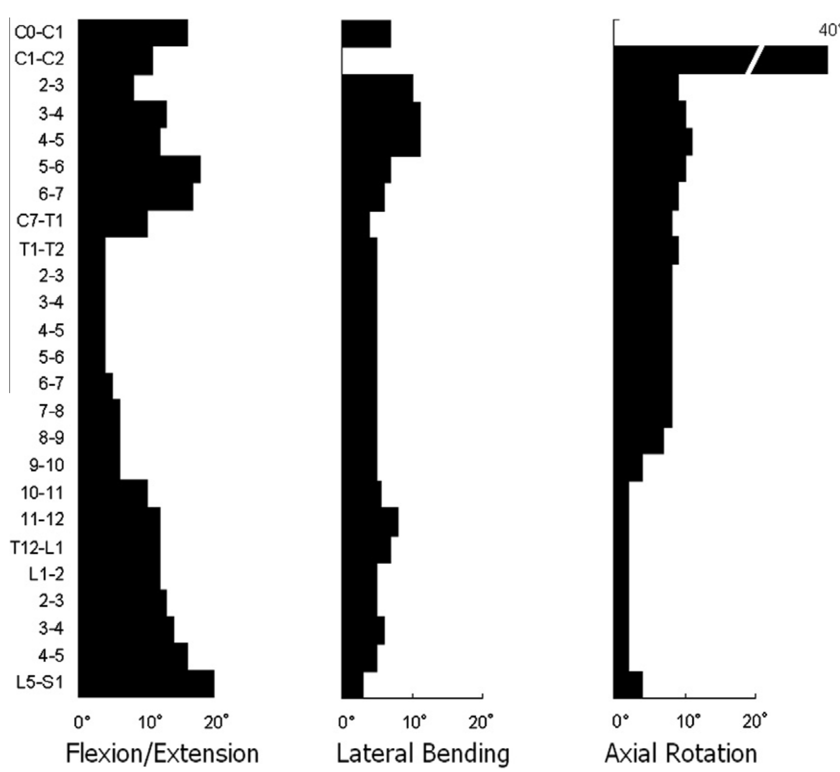

Fig. 1. Range of motion (ROM) of human spine. This figure is adapted from White and Panjabi [38].