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Ossification of Ligamentum Flavum: A Morphological Study In Dried Vertebrae

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Abstract: *AIM: To find out the prevalence, segmental distribution and morphological characteristics of ossification of ligamentum flavum in thoracic spine. MATERIALS AND METHOD: We examined 1786 numbers of dried thoracic vertebrae preserved in the osteology sections of our institutes for the presence of ossification of ligamentum flavum along the upper margin and inner surface of their laminae. We found out vertebral segments commonly affected by this pathology and compared with that of other studies. We also classified them into different morphological types according to Sato classification and found out the frequency of occurrence of each type. OBSERVATION: Out of 1786 thoracic vertebrae examined 261 number of vertebrae (14.6%) showed ossification of ligamentum flavum. A lower thoracic vertebra (T9-T12) was most frequently affected and was highest in T11. CONCLUSION: Ossification of ligamentum flavum is one of the most important contributing factor for acquired thoracic spinal stenosis leading to thoracic myelopathy and radiculopathy. It has been suggested by various authors that hypermobility of the thoracic spine could be responsible for this. As it develops more frequently in East Asians, most of the researches were done on populations of China, Japan and Korea. All the earlier studies are based on CT or MRI scans. Our study is an anatomical study in dried vertebrae. The prevalence and distribution of ossification was found to be consistent with most of the reports from other studies.*

Key words*: Ligamentum flavum, Ossification, Spinal stenosis, Thoracic vertebrae.*

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I. Introduction

The ligamentum flavum anatomically exists in the interlaminar space connecting the laminae of adjacent vertebrae. Thus it forms part of the posterior wall of the spinal canal. Their attachments extend from facet joint capsules to the point where laminae fuse to form spines. The lateral part of the ligament is described as capsular part and the medial portion is known as the interlaminar part. Their predominant tissue is yellow elastic tissue, whose fibres descend from lower anterior surface of one lamina to the upper margin of lamina below. As it forms part of the posterior wall of spinal canal, its ossification causes spinal stenosis leading to myelopathy. The disease begins with thickening of ligamentum flavum and then ossification occurs along the superficial layer of thickened ligamentum flavum. The ossified ligament usually compresses the spinal cord leading to myelopathy or radiculopathy[1]. Degenerative spinal stenosis is most commonly seen in thoracic spine which is under local mechanical stress due to repetitive motion.[2, 3, 4] Thickened and ossified ligamentum flavum leading to spinal stenosis is usually detected in CT and MRI in patients suffering from myelopathy. Ossification of ligamentum flavum is most common in East Asian population and most of the reports come from East Asian countries like Japan and Korea.[5, 6, 7, 8] However epidemiological studies in south Asian countries like India are not available. So we have conducted this morphological study in dried vertebrae to find out its frequency and distribution in our community.

II. Materials and method

We collected 1786 number of intact, adult thoracic vertebrae of unknown sex and age preserved in the osteology section of Anatomy department of S.C.B. Medical College, Cuttack and VIMSAR, Burla. We examined each vertebra individually along the line of attachment of ligamentum flavum at the upper margin and

inner surface of the lamina. Vertebrae showing ossification of ligamentum flavum were separated into three groups. T1 to T4 , T5 to T8 and T9 to T12 vertebrae were grouped under upper, middle and lower thoracic segments respectively. We calculated the number of upper, middle and lower thoracic vertebrae showing ossification of ligamentum flavum to find out the vertebral segments commonly affected by the disease. Vertebrae belonging to lower thoracic segments which were most frequently involved were studied individually from T9 to T12 and percentage was calculated for each of them. We followed Sato classification to study the severity and progress of ossification of ligamentum flavum.[9] Accordingly we categorised them into five groups as described below.

Lateral type: ossification of capsular portion of ligamentum flavum
Extended type: extension of ossification to interlaminar portion.
Enlarged type: anteromedial thickening and enlargement of ossification
Fused type: fusion of bilateral ossification of masses at the midline
Tuberous type: anterior growth of fused mass of ossification

III. Observation

Out of 1786 thoracic vertebrae examined 261 vertebrae (14.6%) vertebrae were found to be having ossification of ligamentum flavum . Lower thoracic vertebrae were most commonly involved (50.2%) and the incidence was highest at T11. The most common morphological variant was extended type (Fig.1,2, 3,4 and Table no. 1,2).

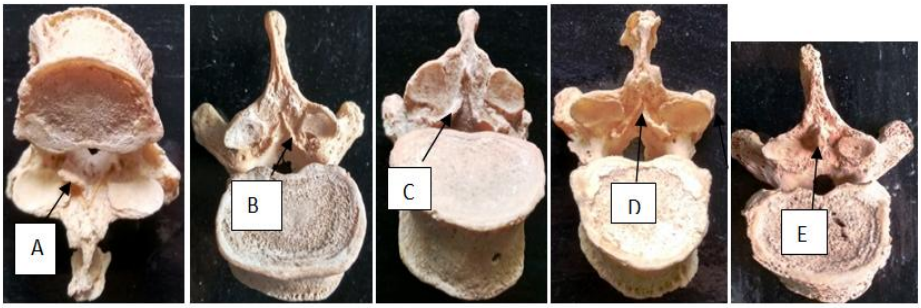

Figure-1: Upper attachment of ossified ligamentum flavum shown from below A- Lateral B- Extended C- Enlarged D-Fused E-Tuberous

Figure-2: Lower attachment of ossified ligamentum flavum in different stages of progression

Table-1 (segmental distribution of olf from total number of 261 thoracic vertebrae with OLF)

Vertebra	No. Of Vertebrae Showing Olf	Percentage
T1-T4 (Upper)	43	16.5
T5-T8 (Middle)	87	33.3
T9-T12(Lower)	131	50.2

Table-2 (Distribution Of Different Morphological Types Of OLF According To Sato Classification)

Vertebrae	Lateral	Extended	Enlarged	Fused	Tuberous	Total
T1-T4	11	14	4	5	9	43
T5-T8	18	26	6	13	24	87
T9	4	4	2	0	0	10
T10	15	12	0	0	0	27
T11	7	38	7	0	1	53
T12	6	35	0	0	0	41
Total	61	129	19	18	34	261

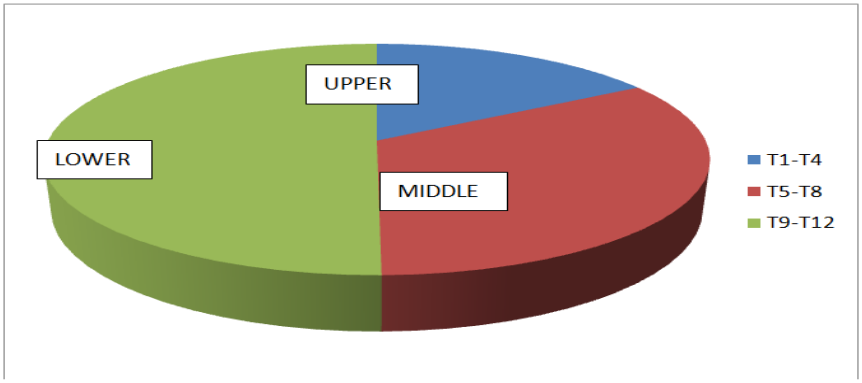

Figure-3: Segmental distribution of OLF

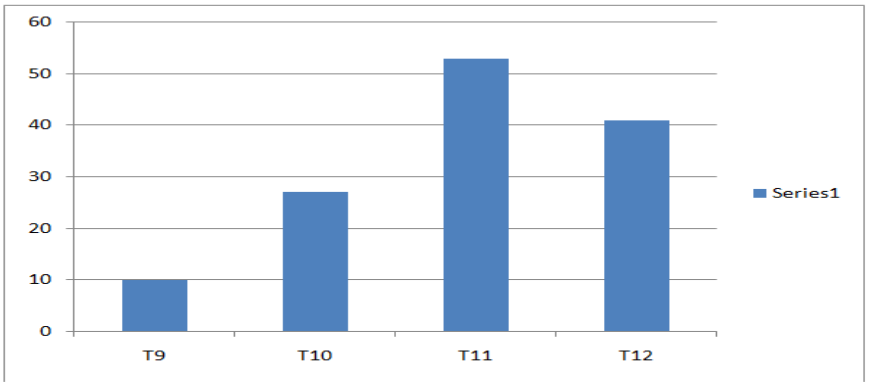

Figure-4: Distribution of ossification ligamentum flavum in lower thoracic vertebrae

IV. Discussion

It has been seen that hypertrophy, overgrowth and progression of ossification of ligamentum flavum leads to spinal canal stenosis, thus playing an important role in the pathological process of myelopathy. Although the exact etiology is not clear, its incidence is found to be higher in patients with diffuse idiopathic skeletal hyperostosis, diabetes mellitus, flurosis.[10,11]Both dynamic and static mechanical stresses act as local factors for the development of ossification of ligamentum flavum. In common form of spinal stenosis CT images usually demonstrate osteophytes, protruding intervertebral disc and a thickened ligamentum flavum contributing to the stenosis. Kurakami et al. and Yamazaki et al. described disc degeneration and vertebral wedging acting as local factors that increase the tension of ligamentum flavum.[12, 13] Otani et al. found ossification of ligamentum flavum in 58% of 29 adult patients with kyphosis.[14] In our earlier study on degenerative changes in spine we also observed high incidence of ossification of ligamentum flavum associated with other degenerative changes in vertebral bodies and facet joints.[15] It indicates that local mechanical stress on ligamentum flavum contributes to development of its ossification. Anatomically, the ligamentum flavum in thoracic region is subjected to static stress continuously and it is greater in lower thoracic spine. So the frequency of occurrence is found to be higher in this region.

Prevalence rate reported by different authors ranges from 3.8% to 63.9%.[5, 6, 7, 14, 15, 16] There exists a wide range of variations in different populations. Most of the studies were done on East Asian population with little report from South Asian countries like India. The present study shows that the incidence is also quite high in India contrary to the belief that Caucasians are less affected by ossification of ligamentum flavum. Lower thoracic vertebrae were found to be most frequently involved followed by middle. The upper thoracic vertebrae are least frequently involved. The highest incidence was in 11th thoracic vertebra. Most of the earlier studies had the same observations.[5, 6, 14, 15, 16, 17, 18] (Table no.3, 4, 5). In our study out of all the morphological types, extended variety was the most common and was most frequent in 11th and 12th thoracic vertebrae.

Table-3 (Prevalence of thoracic OLF)

AUTHOR	YEAR	POPULATION	STUDY BASED ON	PREVALENCE
Guo Jiong et al.	2010	Southeren Chinese	T2 weighted MRI	3.8%
Ning Lang et al.	2013	Beijing	CT imaging	63.9%
Mori K et al.	2013	Japanese	CT scan	36%

Bong ju Moon et al.	2015	Korean	MRI based	16.9%
Fujimori et al.	2016	Japanese	CT Scan	12%
Present study	2018	Indian	Dried vertebrae	14.6%

Table-4 (segmental distribution of OLF)

AUTHOR	YEAR	POPULATION	UPPER THORACIC	MIDDLE THORACIC	LOWER THORACIC
Fangcai li et al	2006	Chinese			77.4%
Guo Jiong et al.	2010	Southern Chinese			Most common
Kyung Chung Kang et al	2011	Korean			71%
Ning Lang et al.	2013	Beizing			T1O-11 44% T11-12 41.6%
Mori K et al.	2013	Japanese		T4-5- 2nd highest	T10-11 Highest
Mubarak Hussain et. al	2014	Pakistan	20%		80%
Bong ju Moon et al.	2015	Korean			T10-11 57.5%, T9-10 35%, T 11-12 26.7%
Fujimori et al.	2016	Japanese			Most common in T11
Present study	2018	Indian	16.5%	33.3%	50.2%

Table-5 (Morphological analysis of ossified ligamentum flavum according to Sato classification)

	LATERAL	EXTENDED	ENLARGED	FUSED	TUBEROUS
Ning Lang et al. 2013	45.4%	24.3%	45.4%		
Wang Y et al. 2016	16.6%	31.6%	40%	8.3%	3.3%
Present study. 2018	23.4%	49.4%	7.3%	6.9%	13%

V. Conclusion

The present study is a pioneer effort in dried vertebrae of South Asian population to study about ossification of ligamentum flavum as most of the earlier studies were based on CT and MRI scans in East Asian populations.

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