Localized osteophytic changes in the thoracic vertebra: an osteological and cadaveric study
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The authors have no conflicts of interest to declare.

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Data are available upon reasonable request to corresponding author.

Introduction
Osteophytes are the lumps that are formed on bones either in spine or around joint, developed by the degeneration of the bony surfaces and are also called as bone spurs or bone lumps. Osteoarthritis-induced joint damage is the primary cause of bone spurs further includes vertebral stenosis, degenerative disc changes [14]. Osteophytes are developed where excessive pressure is produced [4, 28]. Presence of osteophytes are mostly seen in places such as: Foot, especially the heel (calcaneal spurs) [1], Hand or finger [6], Hip & Knee [11], Shoulder [9], Neck, and Spine [2]. According to research, the occurrence of osteophytes increases with age [23] and are common along the right lateral side of thoracic vertebral levels T4-T10 [15, 25]. Vertebral osteophytes are thought to be a common finding in cadaveric anatomy and dry bones. However, they are also frequently reported as common radiological findings [17]. A large number of cases are neither cured nor identified. Clinical manifestations include pain (radiating pain), loss of function, stiffness, joint tenderness, movement restriction, nerve compression, bone crushing against the tissues.

An extensive review of literature on osteophytes has yielded limited findings. It was observed that there is a scarcity of cadaveric studies on osteophytes, and the...
majority of previous clinical investigations have primarily concentrated on the cervical [7, 8] and lumbar vertebrae [3]. We examined thoracic vertebrae in order to analyse osteophytes on both wet (cadaveric) and dry (osteological) specimens. Aim of the current study was to determine the frequency of occurrence and distribution of osteophytes along the thoracic vertebrae, as well as potential side effects affecting the surrounding structures of the posterior mediastinum.

The aim - to observe the incidence of osteophytes in the thoracic vertebrae and to document their frequency of distribution and prevalence.

Materials and methods
Protocol of the Ethics Commission
This study was approved by the Institutional ethics committee of MVJMC & RH (dated December 7, 2023). This study was based on the National Ethical guidelines for biomedical and health research complied by ICMR Bioethics unit, Bangalore, India. The study was conducted in Department of Anatomy of MVJ MC& RH, Bangalore. 25 cadaveric vertebral columns and 188 dry thoracic vertebrae were used to study the incidence of osteophytes.

Cadaveric analysis
Following the removal of lung and heart, posterior mediastinum structures were dissected and the posterior thoracic vertebral column was exposed. Osteophytes were studied for their position and vertebrate levels. Cadavers with all deformities such Kyphosis, Scoliosis were excluded.

Osteological analysis
188 dry thoracic vertebrae (T1-T12) of south Indian population of unknown age & sex from the Department of Anatomy, MVJ MC& RH were procured. The location (vertebral levels) and the position (anterior/lateral) of osteophytes were observed. Vertebrae with sign of trauma were excluded from the study.

Statistical analysis
The data observed from this morphometric study was entered and analyzed using Microsoft excel version 2019. Incidence was expressed in terms of frequency and percentage.

Results
Cadaveric Findings. In the present study, we found osteophytes in six thoracic vertebra (24 %) out of 25 Cadaveric vertebral columns analyzed. Osteophytes were identified at anterior and lateral aspect of vertebral column. It was noted that majority of the osteophytes occurred mostly on right side of vertebral bodies than on to the left. Also observed that osteophytes were most commonly seen in mid thoracic level (T4-T8), followed by T9, T10 and T2 (Fig. 1, 2). Table 1 shows the frequency of position of osteophytes with vertebral levels.

Osteological Findings. Out of 188 thoracic vertebrae studied, 33 (17.5 %) of them showed the presence of

Fig. 1. Position of osteophytes in different vertebral levels (marked with red circles).
Fig. 2. Position of osteophytes in different vertebral levels (marked with red circles).

Table 1. Distribution of osteophytes in the cadaveric thoracic vertebra.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Total no. of Osteophytes</th>
<th>Position</th>
<th>Vertebral level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>Left, Lateral side of the vertebral body, Right, Lateral side of the vertebral body</td>
<td>T2, T5</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Right, Lateral side of the vertebral body, Right, Lateral side of the vertebral body</td>
<td>T8, T9</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>Anterior side of the vertebral body, Anterior side of the vertebral body</td>
<td>T6, T7</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>Right, Lateral side of vertical body, Right, Lateral side of vertical body</td>
<td>T4-T8, T10</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>Right, Lateral side of vertical body, Right, Lateral side of vertical body</td>
<td>T6, T8</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>Right, Lateral side of vertical body</td>
<td>T4-T8</td>
</tr>
</tbody>
</table>

Fig. 3. Incidence of different position of osteophytes (marked with black circles and arrows). A-D: Anterior; E, F: Anterior Upper border; G, H: Anterior Lower border.
Osteophytes. Osteophytes were observed at anterior and lateral aspect of the thoracic vertebra. High incidence of osteophytes were observed along the upper border followed by lower border of vertebra, combination of anterior and right / left laterality osteophytes were also observed (Fig. 3, 4).

**Discussion**

Osteophytes are bone spurs formed due to degeneration of bone surfaces. Vertebral column is more prone for occurrence of osteophytes. In the current study, cadaveric vertebral columns were examined alongside dry bones to determine the frequency and prevalence of osteophytes in relation to position, whereas previous studies have used Magnetic resonance imaging (MRI), computerized tomography (CT) and X-rays to estimate the prevalence of osteophytes. Vertebral stenosis, degenerative disc changes, and arthritis are the etiological factors predisposing to the occurrence of osteophytes [24, 25]. Few studies indicate that increase in age is also a predisposing factor [23].

N. Kumar et al. [14] used 50 cadaveric vertebral columns and recorded the highest incidence of osteophytes in lower thoracic levels T10-T11. Z. Klaasen et al. [13], observed maximum osteophytes at T9-T10 level. H. Nathan [15] also quoted highest incidence around T10 in the right side and T11 & T12 on the left side. Anterior osteophytes were more commonly observed. He further proposed an anatomical classification to grade the osteophytes which can be used for all levels of vertebral column. Grade 0 signifies absence of osteophytes, Grade1-points of isolated hyperostosis, Grade 2-Horizontal protrusion of osteophytes from body of vertebra, Grade 3 end of osteophytes curving to intervertebral disc, grade 4 signifying real bony bridge between two vertebra. T. Valasek et al. [25] also observed commonest location of osteophytes at T7-9 segments. He also studied the correlation between the grade of osteophyte with age and BMI and observed no correlation between the two.

A study conducted by Kim D. K. et al. [12] on 87 Joseon skeletons involving cervical, thoracic and Lumbar

![Fig. 4. Incidence of different position of osteophytes (marked with black circles and arrows). A: Right Lateral Upper border; B: Right Lateral lower border; C: Left Lateral Lower border; D: Left Lateral Upper border; E: Anterior & Right Lateral; F: Anterior & Left Lateral.](image)
vertebras. They documented that the higher incidence of osteophytes were observed in the C5, T9, T10, and L4. They also added that mean osteophytic value was found significantly higher in thoracic vertebrae when compared to cervical and lumbar osteophytes. In present study, we found out the highest frequency at T4-T8 levels along the right lateral side of vertebral body.

S. R. Pye et al. [19] postulated that decreased disc space could be a causative factor resulting in formation of osteophyte. Degeneration of intervertebral disc or pressure on vertebral end plates can also lead to formation of osteophytes [19, 21]. Macnab’s theory indicates that osteophytes are formed as a result of instability between adjacent vertebral bodies [27]. Clinical features such as decreased flexibility of joint, stiffness and numbness, pain are usually associated with presence of osteophytes.

J. Jankowsky et al. [10] reported a case of 39 year old man presenting with history of chronic pain in the lower ribs on the right side initially, later involving thoracic spine and upper abdomen. CT scan revealed the presence of massive osteophyte on the anterolateral aspect of T8-9 vertebrae compressing the greater splanchnic nerve. Surgical removal of osteophyte was done to relieve symptoms.

A. A. Padur et al. [17] observed that osteophytes may compress the aorta or inferior vena cava causing ischemia or perforation. The current study found out the incidence of anterior and right lateral osteophytes in great numbers than posterior osteophytes. Anterior osteophytes can present as dysphagia [20], focal pulmonary fibrosis, and obstructive pneumonia due to pressure effects on bronchus [5, 18, 29]. Osteophyte-induced nerve root compression may present as back and leg pain [17]. It may co exist with abdominal aortic calcification. The least frequency of osteophyte presence was seen on left lateral and posterior aspect of thoracic vertebrae. Posterior lumbar osteophytes may present as lumbar stenosis.

N. Kumar et al. [14] studied the microscopic anatomy of osteophytes encountered in routine dissection and found a layer of hyaline cartilage capping the trabecular bone indicating endochondral ossification and concluded that osteophytes develop through the process of endochondral ossification.

The pathogenesis of osteophytes starts with degeneration of disc, nucleus pulposus. As the disc loses height there ’s redistribution of stress which increases stress to surrounding structures causing capsular synovitis and cartilage thinning. Further facet degeneration occurs eventually resulting in formation of osteophytes. Due to this there is less room for nerve, causing compression [16]. Synovial mesenchymal stem cells were considered as the cellular source of osteophyte precursors, developed osteophytes consists of fibroblasts, mesenchymal pre- chondrocytes, maturing chondrocytes, hypertrophic chondrocytes and osteoblasts. TGFβ and Fibroblast growth factor play a major role to initiate chondrogenesis in osteophytes [26].

Even a normal vertebrate may develop osteophytes by excessive pressure as in labor work or strenuous exercise. With respect to age, the intervertebral disc is intact in young age, able to distribute load uniformly along the vertebral end plates and absorbs shocks effectively. Therefore, osteophytes develop when degeneration of disc starts as age progress [15]. Vertebral osteophytes are formed as compensatory mechanism for lack of nucleus pulposus to maintain the stability and flexibility to bear the load [28]. The size and position of thoracic osteophytes varies from each other at each level. Occurrence of thoracic osteophytes increases along with the age [12, 23].

MR scan is used to find out any pathology associated which causes osteophyte formation, CT is used to diagnose any bone tumors, or muscle disorders. By presence of osteophyte on CT, size and location can be determined for further study. Simonovich et al. based on CT readings as observed the number of osteophytes on each side of the thoracic vertebrae [22].

Study of osteophyte is important to radiologists as they may be confused with anterior mediastinal mass in X Ray Anthropologists use them to estimate for age at death. The clinical importance must be known by the anatomist, radiologist, clinicians so as to cure with efficient treatment.

By and large further research needs to be carried out to explore the developmental basis and pathophysiology and molecular mechanisms involved in the formation of osteophytes.

Conclusion
1. In the present study, the highest frequency and prevalence were observed at thoracic vertebrae T4-T8 levels which was 24 % of cadaveric findings and 17.6 % of osteological findings irrespective of age and sex. Therefore, occurrence of osteophytes is due to degenerative disc changes of vertebral column.

2. Clinical features depend on the site where osteophytes are located.

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References


Було проведено та опубліковано декілька поперечних та проспективних досліджень щодо шийного та поперекового часу дослідження трупного матеріалу та скелетованих залишків. Особливості часу дослідження трупного матеріалу та скелетованих залишків обмеження рухів. Клінічні прояви включають біль і його вплив на функціональні можливості і скутість болючість у суглобах, частоту і редкість, що вони можуть викликати проблеми з диханням, а також з вагітністю, після вагітності. Остеофіти хребта часто спостерігаються під час дослідження трупного матеріалу та скелетованих залишків. Багато випадків даної патології не виявляється або не виявляється відчутно. Часто іррадіюючий біль часто супроводжується зниженням функціональних можливостей, але може змінюватись з часом.

Локалізовані остеофіти стовбурових відростків, що мають механічну роль у інфільтрації трупного матеріалу та скелетованих залишків.
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Sangeeta M. - writing of the original draft, critical review, final approval.
Varalakshmi K. L. - analysis and interpretation of data, final approval.
Anusha R. - data collection, analysis and interpretation of data, review writing and editing.
Jesima Preethi A. - data collection, analysis and interpretation of data.