REVIEW ARTICLE

Vertebral spinal osteophytes

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Abstract Osteoarthritis is a common complication in the elderly and is often associated with osteophyte growth on vertebral bodies. The clinical presentation of vertebral osteophytes is related to anatomical structures adjacent to the spinal column. For instance, cervical osteophytes potentially involve the pharynx and esophagus, leading to dysphagic symptoms that may be accompanied by food aspiration, vocal fold paralysis and obstructive sleep apnea. In addition to anterior cervical osteophytes, posterior and uncinate process osteophytes may form, compressing the spinal cord and vertebral artery blood supply, respectively. Cervical osteophytes have also been shown to form an accessory median atlanto-occipital joint when the relationship between the atlas, dens and basiocciput is involved. In the thorax, the esophagus is often affected by osteophytes and may result in dysphagia. Traumatic and non-traumatic thoracic aorta pseudoaneurysm formation has been attributed to sharp osteophytes lacerating the aorta, a direct complication of the relationship between the aorta anterior vertebral column. Additionally, aspiration pneumonia was reported in patients with compression of a main stem bronchus, due to mechanical compression by thoracic osteophytes. In the lumbar spinal region, the two major structures in close proximity to the spine are the inferior vena cava and abdominal aorta, both of which have been reported to be affected by osteophytes. Treatment of osteophytes is initially conservative with anti-inflammatory medications, followed by surgical removal. Increasing obesity and geriatric populations will continue to result in an array of osteoarthritic degenerative changes such as osteophyte formation.

Keywords Spinal column · Pathology · Bone · Ageing

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Background Information

Osteoarthritis is complicated by many types of degenerative changes including osteophyte formation on spinal vertebral bodies. Osteophytes (osteo-osteo = bone and phyte-futon = plant) are defined as abnormal bony growths or bone spurs that are bony projections formed along joints. While osteophytes may form on any degenerating joint, such as the hip, knee and distal interphalangeal joints (Heberden's nodes), vertebral osteophytes present with clinical symptoms unique to affected adjacent structures. Interestingly, vertebral osteophytes are a common finding in the gross anatomy laboratory, and their clinical significance is rarely discussed in anatomy and embryology books. More importantly, vertebral osteophytes are a common radiological finding affecting 20–30% of the elderly population (Brown and Neumann 2004). The aim of this review therefore is to provide a comprehensive picture on the possible etiologies, presentation and treatment of this common condition in relationship to the gross anatomy and imaging.

A number of etiological factors result in vertebral osteophyte formation; however, the main factor is obesity, which is often accompanied by non-insulin dependent diabetes mellitus. Extra body mass increases weight on the vertebral column, contributing to mechanical stress associated with degenerative changes of osteoarthritis. Additional etiological factors are hypervitaminosis A (Seawright et al. 1965; Yee et al. 1985) and secretion of bone morphogenetic factor for stimulation of bony tissue growth (Hanamura et al. 1980; von Ludinghausen et al. 2005; Urist et al. 1979; Yee et al. 1985). Recent studies suggest excessive mechanical stress, particularly at a young age, may predispose one to osteophyte formation later in life (O'Neill et al. 1999; Schmitt et al. 2004).

The pathogenesis of osteophytes begins with degeneration of the spinal column, specifically, the nucleus pulposus. As one ages, the nucleus pulposus loses water content and turgor, resulting in decreased height of the intervertebral disc and less resiliency to load-bearing weight. Concomitantly, the annulus fibrosus also begins to lose elasticity. In order to maintain maximal load-bearing potential, the margins of the zygapophyseal joint form bony projections to increase the surface area for weight distribution. This adaptation does not adequately relieve joint pressure and results in increased bony protrusion from the vertebral body.

The epidemiology of the osteophyte formation with regards to population difference, gender, occupation, subsistence and other causes that may effect osteophytes formation has been reported in several physical anthropology studies (Sofaer-Derevenski 2000; Bridges 1994; Knusel et al. 1997). Sofaer-Derevenski (2000) compared vertebral degenerative changes from the sixteenth to nineteenth century site of Ensay, the Outer Hebrides and the medieval site of Wharram Percy, the Yorkshire Wolds, noting gender-specific facet remodeling and osteophytic changes in Ensay females related to load-bearing using creels. Furthermore, Knusel et al. (1997) analyzed 81 skeletons from social-class-specific plots from the thirteenth to fourteenth century medieval priory cemetery of St. Andrew, Fishergate, York, reporting no significant difference between the groups in regards to vertebral column degenerative joint disease (DJD). The authors postulated that differences between individuals were produced as a response to erect posture during bipedal locomotion rather than differences in occupational stress (Knusel et al. 1997).

Isolated data regarding specific regions of the body, such as cervical, thoracic and lumbar, are reported in this review (Table 1). In addition, there are no specific data regarding the frequency of osteophyte formation and its age-related changes. We know that osteophytes are one of the main characteristics of osteoarthritis. Bearing this in mind, we can assume that osteophytes will have similar presentation

Table 1 Data regarding location and clinical presentation of osteophytes in vertebral column

Most common location	Clinical presentation
Cervical	
Atlas, dens and basiocciput	Physiotherapy and/or iatrogenic movement of the joints may lead to inadvertent fracture of the osteophyte, causing pain and crepitation in the region
	Osteoarthritic degeneration of these two joints may cause immobility and stiffness of the cervical spine, as well as headaches secondary to occipital and cervical involvement
	Osteophytes derived from vertebral uncinate processes may interfere with the transverse foramen, leading to compression of the vertebral artery (anteriorly or posteriorly)
C5–C7	Large osteophytes may mechanically cause blockage of the esophagus, causing dysphagia
	Small osteophytes may cause obstruction by compressing the esophageal segment attached to the cricoid cartilage, most commonly at C5–C6
	Esophagus-compressing osteophytes coexisting with decreased closure of the larynx may additively increase dysphagia
	Osteophytes at C3–C4 may impair tilting of the epiglottis over the laryngeal inlet
	Inflammation around the osteophyte may lead to esophagitis or pharyngitis, ultimately worsening dysphagia. Through their analysis of 55 patients with dysphagia, aspiration problems were present in 75% of patients with osteophytes larger than 10 mm and in 34% of patients with osteophytes smaller than 10 mm
Thoracic	
T9 and T10	Dysphagia
	The sympathetic trunk and the descending thoracic aorta may also be affected
	At the level of T8–T10 the sympathetic trunk and deviating splanchnic nerves, the right greater splanchnic nerve is compressed most frequently at this position. Compression of sympathetic structures in 655 specimens, noting that the sympathetic trunk is only affected by osteophytes at lower thoracic levels
Lumbar	
L4–L5	Lumbar osteophytes associated with abdominal aortic calcification and with inferior vena cava obstruction
	Osteophyte-induced nerve root compression L5

as osteoarthritis. By the age of 40 years, 90% of all persons have some degenerative changes in their weight-bearing joints, even though clinical symptoms are generally absent. In one study 85% of the patients aged 55–64 years had some degree of osteoarthritis in one or more joints (Brown
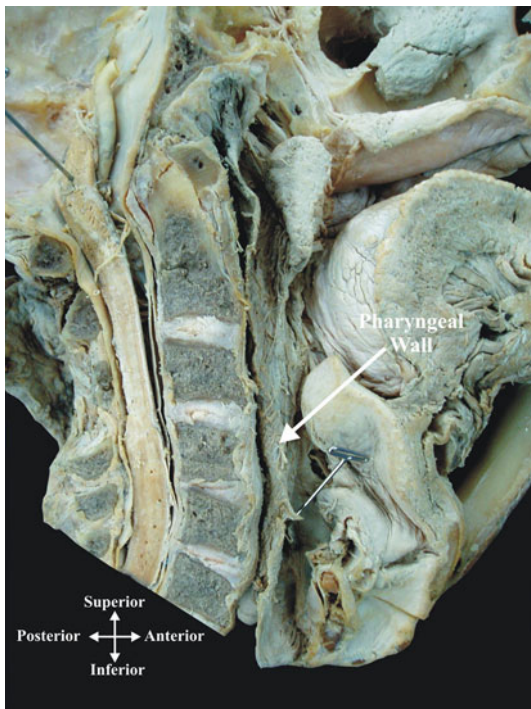
Fig. 1 A normal specimen without osteophytes with normal pharyngeal wall

Fig. 2 A normal specimen without osteophytes with normal pharyngeal wall with approximately 1 mm thickness

Fig. 3 Several cervical osteophytes protruding towards the pharyngeal wall. Notice the thickness of the pharyngeal wall musculature

and Neumann 2004). We can only hypothesize that osteophytes follow the same pattern of presentation.

Cervical osteophytes

The sequela of cervical osteophytes is well documented, with cases implicating all vertebrae in circumstances related to their anatomic location. The anatomical relationship of the atlas, dens and basiocciput is affected by cervical osteophyte formation, as is C2–C3 with involvement of the posterior pharynx. Additionally, the relationship of C4–C7 to the larynx and esophagus is also important, as cervical osteophytes diminish the retropharyngeal space and compress these structures (Figs. 1, 2, 3, 4).

Even though osteophytes may form on all of the cervical vertebrae, there is a predilection for the lower vertebrae. Cervical vertebrae C5–C6 and C6–C7 have the greatest frequency of osteophyte formation, attributed to their mobility and load-bearing nature (Schmidek 1986; Yee et al. 1985; Yoskovitch and Kantor 2001). Also, these three vertebrae are at greatest risk for lordosis, adding to the likelihood of vertebral degeneration and subsequent osteophyte formation (Yoskovitch and Kantor 2001). With the esophagus resting on the anterior border of the cervical vertebrae from C4–C7, anterior osteophytes may hinder peristalsis of food through this segment of the esophagus (Fig. 5).
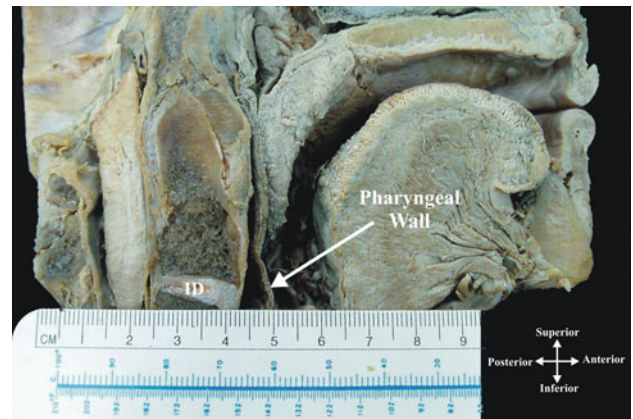
Dysphagia is a common complication in the elderly population and is often underreported. The underlying causes of dysphagia are numerous, including esophagitis and esophageal cancer, with cervical osteophyte compression of the esophagus being a less common but important etiological factor. Historically, dysphagia due to cervical osteophytes has been well reported in the literature (Aronowitz and Cobarrubias 2003; Di Vito 1998; Fuerderer et al. 2004; Goel et al. 1999; Kanbay and Selcuk 2006; Kodama et al. 1995; Ng et al. 2005; Rosen 1985; Stancampiano et al. 2002; Strasser et al. 2000; Stuart 1989; Srinivas and George 1999; Yee et al. 1985;
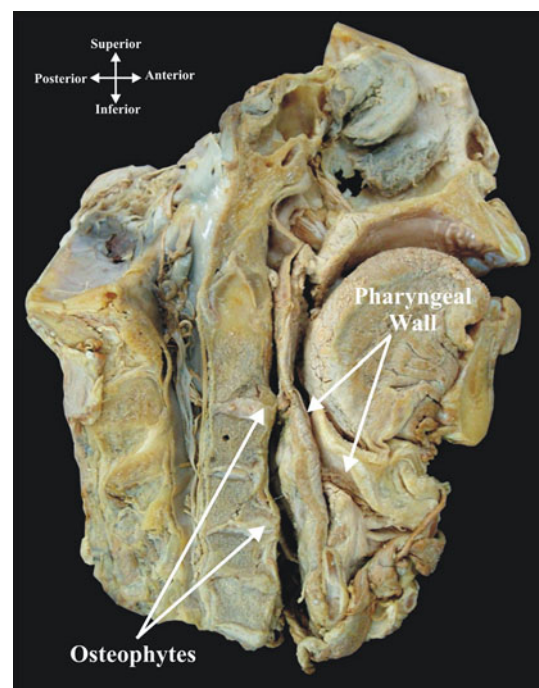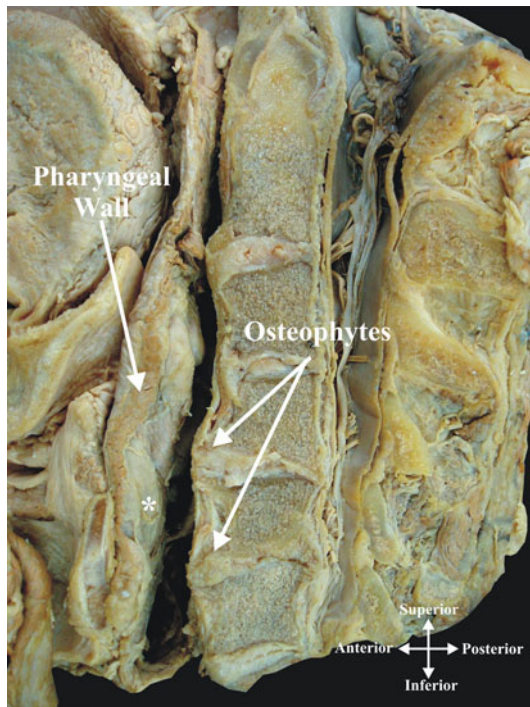
Fig. 4 Several cervical osteophytes protruding towards the pharyngeal wall. Notice the thickness of the pharyngeal wall musculature. Interestingly, at the points at which no osteophytes are compressing the pharyngeal wall, the pharyngeal musculature retains its normal musculature thickness (*asterisk*)

Yutan et al. 2001), dating back to 1905 when Zahn (1905) reported the first case (Idem 1906). This was followed in 1926 by Mosher (1926) who reported two cases and in 1938 by Iglauer (1938) who performed the first surgical excision of cervical osteophytes in an attempt to relieve dysphagia. Additionally, Hilding and Tachdjian (1960) found 36 cases in a 1960 review of the literature, followed in 1973 by Meeks and Renshaw (1973), who studied 60 cases of dysphagia in which 10 were surgically repaired.

In general, there are five characteristics of osteophyte-induced dysphagia that are found in the majority of cases reported: (1) large osteophytes may mechanically cause blockage of the esophagus (Lambert et al. 1981; Resnick et al. 1978; Sobol and Rigual 1984; Strasser et al. 2000), (2) small osteophytes may cause obstruction by compressing the esophageal segment attached to the cricoid cartilage, most commonly at C5–C6 (Crowther and Ardran 1985; Davies et al. 1989; Strasser et al. 2000), (3) esophagus-compressing osteophytes coexisting with decreased closure of the larynx may additively increase dysphagia (Di Vito 1998), (4) osteophytes at C3–C4 may impair tilting of the epiglottis over the laryngeal inlet (Crowther and Ardran 1985; Strasser et al. 2000) and (5) inflammation around the osteophyte may lead to esophagitis or pharyngitis,
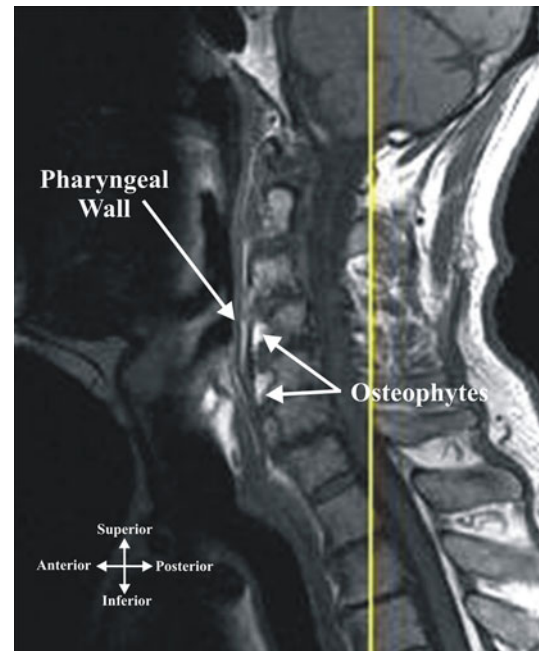

Fig. 5 An MRI picture of a patient suffering from osteophytes and dysphagia

ultimately worsening dysphagia (Deutsch et al. 1985; Di Vito 1998).

There are several unique and important cervical osteophyte-induced dysphagia cases. A case by Di Vito (1998) reported dysphagia due to a stroke complicated by a pre-existing osteophyte complex bridging C3–C5. The stroke had reduced laryngeal elevation and epiglottic tilt, and this coupled with the osteophytic bridge indented the cricopharyngeal opening to deflect food boluses into the open larynx (Di Vito 1998). A similar osteophyte bridging mechanism was reported by Yoskovitch and Kantor (2001), with massive osteophytes on C3–C6 that displaced the esophagus and resulted in dysphagia and compression of the left tracheoesophageal groove. This compression of the tracheoesophageal groove compressed the recurrent laryngeal nerve and thus paralyzed the vocal fold. The concept of an osteophytic shelf was first introduced by Davies et al. (1989), but the hypothesis of the shelf acting as a deflection mechanism or being involved in vocal paralysis was not mentioned.

Complimenting the case introduced by Di Vito (1998) was a study by Strasser et al. (2000) who explored the concept of cervical osteophytes causing dysphagia and concomitant aspiration. Through their analysis of 55 patients with dysphagia, aspiration problems were present in 75% of patients with osteophytes larger than 10 mm and in 34% of patients with osteophytes smaller than 10 mm (Strasser et al. 2000). These results suggest that size of the osteophyte may correlate with the degree of compression and subsequent likelihood of difficulty with aspiration.

Obstructive sleep apnea may also accompany osteophyte-induced dysphagia. In a case series of five patients suffering from dysphagia, Fuerderer et al. (2004) noted that two patients also suffered from obstructive sleep apnea. Additionally, in one of these patients, a multi-level connection of osteophytes from C3–T1 perforated the pharynx, resulting in an emergency tracheostomy. Fuerderer et al. (2004) proposed that the retropharyngeal osteophytes compressed the airway in the supine position, explaining the apneic symptoms.

Whereas dysphagia is a result of anterior cervical osteophytes, there are situations in which osteophytes occur at other positions on the vertebral body. Posterior osteophytes are thought to form when mechanical stresses increase tension on Sharpey's fibers inserting into vertebral bodies adjacent to degenerating intervertebral discs (Pate et al. 1988; Schmorl and Junghanns 1971). Osteophyte projections on the posterior region of the vertebral body directly implicate the spinal cord. At one point, it was hypothesized that correction of anterior bony protuberances would lead to resorption of posterior osteophytes (Cloward 1987; Robinson et al. 1962). This notion was refuted by Stevens et al. (1993) when they found that in 26 postoperative cases no posterior osteophytes showed resorption for up to 12 years following anterior osteophyte correction.

Two independent studies by von Ludinghausen et al. (2005, 2006) have shown important osteophytic relationships between the basiocciput, atlas and dens. In 2005, they noted osteophytes on the articular surfaces of the median atlanto-axial joint, coupled with large osteophytes of the anterior arch of the atlas contacting the basiocciput (von Ludinghausen et al. 2005). These additional contact points between the osteophyte and basiocciput were histologically confirmed to be real joints, designated accessory median atlanto-occipital joints (von Ludinghausen et al. 2005). Recently, von Ludinghausen et al. (2006) investigated 100 cadavers, of which 42 showed osteophytes of the articular surfaces of the median atlantoaxial joint. In five cases, a large osteophyte on the anterior arch of the atlas made contact with the basiocciput in a similar manner as described in their 2005 study (von Ludinghausen et al. 2005).

Osteophytes of the atlanto-occipital and atlanto-axial joints have important clinical manifestations. Physiotherapy and/or iatrogenic movement of the joints may lead to inadvertent fracture of the osteophyte, potentially causing pain and crepitation in the region (von Ludinghausen et al. 2006). Additionally, osteoarthritic degeneration of these two joints may cause immobility and stiffness of the cervical spine, as well as headaches secondary to occipital and cervical involvement (Aufdermauer 1979; Bovim et al. 1994; Chouret 1967; Edmeads 1978; Fournier and Rathelot

1959; Jackson 1967; Kamieth 1959; von Ludinghausen et al. 2006).

Osteophytes derived from vertebral uncinate processes may interfere with the transverse foramen, leading to compression of the vertebral artery. This mechanism was first recognized in 1924 when Barre (1924) noted that cervical deformities may compress the vasculature leading to the medulla, resulting in motor dysfunction. In 1940, Krogdahl and Torgersen (1940) studied 12 cadavers with uncovertebral arthritis, and concluded that vertebral deformities compressed both the vertebral artery and the sympathetic nerve plexus. Recently, Cagnie et al. (2005) observed 60% ($n = 111$) of dry vertebrae had osteophytes on the uncinate process of C5 and C6. Half of these osteophytes partially effaced the transverse foramen, forcing the vertebral artery to course around these projections, potentially compressing or dissecting the artery. Vertebral artery compression from osteophytes may occur anteriorly from the uncinate process or posteriorly from the superior or inferior articular facets (Cagnie et al. 2005; Ebraheim et al. 1997; Sheehan et al. 1960). In most cases, compression is likely to occur from the uncinate process rather than the articular facets, as osteophytes are present in 48 and 30% of cases, respectively (Cagnie et al. 2005).

Compression of the vertebral artery leads to a myriad of clinical symptoms, especially if blood supply to the brain stem is compromised. Impairment of blood flow may result in headaches and loss of strength in the legs (Dutton and Riley 1969) or in serious syncopal attacks (Schmidek 1986). Even with the presence of uncinate and articular facet osteophytes, vascular compression is not common. In most cases, the neck must be in a certain position to inflict compression, particularly hyperextension, flexion or head rotation (Dutton and Riley 1969; Schmidek 1986).

Thoracic osteophytes

Anatomically, the spatial relationship of structures in the thorax in relation to the spinal column is important when analyzing morbidity associated with osteophytes of thoracic vertebrae. Most structures located in close proximity to the spinal column (esophagus, descending thoracic aorta and lungs) may be implicated in damage caused by osteophytes projecting into the thorax. Of note, the tracheal bifurcation at T4–T5 and the esophagus piercing the diaphragm at T10 are important anatomical landmarks for thoracic osteophyte morbidity. Similar to the cervical vertebrae, the majority of symptomatic cases in the literature deal with osteophytes present on lower vertebral bodies. As reported by O'Neill et al. (1999), 681 women and 499 men over 50 years of age have thoracic osteophytes most frequently on T9 and T10. Additionally,

O'Neill et al. (1999) postulated that heavy physical activity particularly in young adult life is important in osteophyte development on thoracic vertebrae.

Osteophytes on the ninth and tenth thoracic vertebra have been associated with cases of dysphagia (Fig. 6). Cai et al. (2003) reported a 73-year-old man with dysphagia in the supine position, leading to osteophytes extrinsically compressing the esophagus. Anatomically, this may be explained by easier compressibility of the esophagus as it passes through the diaphragm at T10, as well as the weight of organs in the thorax fixating the esophagus onto osteophytes in the supine position. Esophageal compression leading to dysphagia in the thoracic region is not entirely restricted to T9–T10, as osteophyte compression as high as T4 has been reported (Cai et al. 2003; Willing and El Gammal 1983).

The sympathetic trunk and the descending thoracic aorta may also be affected by thoracic osteophytes. At the level of T8–T10, the sympathetic trunk and deviating splanchnic nerves may be involved, as Nathan (1987) reported that the right greater splanchnic nerve is compressed most frequently at this position. Additionally, in his study of 1,000 cadavers, Nathan (1987) observed compression of sympathetic structures in 655 specimens, noting that the sympathetic trunk is only affected by osteophytes at lower thoracic levels. Presumably, the sympathetic fibers on the left side of the vertebral column were less involved as a

Fig. 6 A specimen in which several thoracic osteophytes are evident (*asterisk*)

result of the descending thoracic aorta shielding the sympathetic trunk from potential osteophyte damage.

Chtata et al. (2005) reported a case of osteophytes causing trauma to the descending thoracic aorta. In their study, the tip of an osteophyte on T11–T12 pierced the aorta of a 50-year-old man following a head on car collision. They speculated that the osteophyte was not irritating the aorta until the impact of the car collision compressed the point of the osteophyte into the vessel wall, leading to the pseudoaneurysm. Recently, Dregelid et al. (2007) reported the first non-traumatic osteophyte-induced pseudoaneurysm occurring at the level of L1. The pseudoaneurysm occurred adjacent to the root of the superior mesenteric artery, due to perforation from a needle-sharp osteophyte.

Thoracic vertebrae osteophytes have also implicated the respiratory system. A case was reported in which an anterior thoracic osteophyte on T6–T7 obstructed the right main stem bronchus, resulting in chronic obstructive pneumonia (Leon et al. 2000). The patient, with a 120-pack-year history of cigarette smoking, had been coughing up purulent sputum for 3 years. Following removal of the osteophyte and antibiotic treatment, the obstruction diminished and the pneumonia dissipated. In another case, Otake et al. (2002) reported focal pulmonary interstitial opacities adjacent to thoracic spinal osteophytes. A CT scan displayed the opacities in the subpleural region of the lower lobe of the right lung, suggesting that mechanical compression of the osteophyte on the adjacent pulmonary tissue leads to a fibrotic reaction (Otake et al. 2002). In concordance with the observation that sympathetic trunk fibers were more frequently implicated on the right side, the descending thoracic aorta may protect adjacent structures from being affected by osteophytes, as the left lung was not fibrotic in this case (Nathan 1987).

Lumbar and sacral osteophytes

The spinal column's decent into the lumbar region to form vertebral bodies L1–L5 is linked to a similar course followed by the inferior vena cava and abdominal aorta. The abdominal aorta emerges into the abdominal cavity at T12 through the aortic hiatus, borders the left anterior portion of the vertebral body until L4, at which time it bifurcates into the common iliac arteries. Furthermore, following the formation of the inferior vena cava at approximately L5, this vessel demonstrates a similar course as the abdominal aorta on the right side of the spinal column. A result of these structures occupying the anterior border of the lumbar vertebral bodies is the likelihood of complications due to anteriorly projecting osteophytes.

While the size and strength of the lumbar vertebra are important in load bearing, their functional requirements

subject them to degenerative changes. In a study looking at the vertebral osteophytes in the elderly population, Cvijetic et al. (2000) found that 21.3% of men ($n = 263$) and 23.9% of women ($n = 280$) over 45 years of age had osteophytes on the lumbar spine. The observations of Pye et al. (2007) depicted that when the mean age is 65 years of age, 73% of men ($n = 286$) and women ($n = 299$) had evidence of lumbar osteophytes. In addition, they noted that with increasing severity of osteophyte formation, there was concomitant vertebral disc space narrowing, suggesting a potential relationship between worsening osteoarthritic changes and degree of osteophyte severity (Pye et al. 2007).

Similar to the etiology of thoracic vertebral osteophytes, lumbar vertebral osteophytes are a result of mechanical factors and heavy physical activity even from a young age (O'Neill et al. 1999) (Fig. 7). An interesting study on former elite track and field athletes demonstrated these two criteria. In their study, Schmitt et al. (2004) analyzed the lumbar vertebrae of 159 athletes looking for degenerative changes, namely the presence of osteophytes. They concluded that athletes in throwing disciplines, such as shot put and discus, and high-jumpers had a greater propensity for developing osteophytes in comparison to running athletes (Brandenberg and Leibrock 1986). Arguably, the increased rotation and load on the lower spine during these activities predisposes one to osteophyte formation.

Fig. 7 A specimen in which several lumbar osteophytes are evident (*asterisk*)

Osteophyte formation occurs in conjunction with many other degenerative changes of the lumbar vertebrae. As mentioned (Pye et al. 2007), increasing osteophyte formation correlates with decreased disc space, which may also be associated with intervertebral disc calcification (Chanchairujira et al. 2004). Spinal stenosis is another degenerative change implicating the lumbar region, causing compression symptoms characteristic of the nerve root affected (Leon et al. 2000; Leroux et al. 1992). Thus, lumbar osteophytes may be seen as part of a general degenerative process accompanied by other degenerative changes occurring in the lumbar region.

A report from the Framingham Heart Study suggested that lumbar vertebral osteophytes may lead to complications involving the cardiovascular system. Karasik et al. (2006) analyzed lateral lumbar radiographs from 777 men and 1,241 women (age range 47–80 years old), comparing anterior lumbar osteophytes and abdominal aortic calcification. A correlation was found between these two variables, with a significant association in both men and women (Karasik et al. 2006). Additionally, lumbar osteophytes have been associated with inferior vena cava obstruction (Leon et al. 2000; Scapinelli 1997). The close proximity of the abdominal aorta and inferior vena cava to the spinal column is attributed to the pathological findings in such cases.

Osteophyte-induced nerve root compression is a common clinical scenario. The L5 nerve is occasionally compressed in the lumbosacral tunnel, consisting of the fifth lumbar vertebral body, the lumbosacral ligament and the sacral ala. In a 2002 study, Matsumoto et al. (2002) found 6 out of 7 cadavers with osteophytes on the vertebral bodies of L5 and S1, which entrapped the L5 nerve in the lumbosacral tunnel, compared to L5 compression in only 1 out of 22 cadavers without osteophytes. Interestingly, recent studies have shown a dual, bidirectional blood supply to the lumbar nerve roots (Gilchrist et al. 2002). This blood supply may allow provisional blood flow to a compressed nerve, particularly in the case of L5 compression in the lumbosacral tunnel. It is conceivable that cases of compressed L5 nerves are underreported as a result of the dual blood supply nourishing the nerve, with symptomatic cases being reported when blood supply is drastically diminished.

Treatment and conclusions

Vertebral osteophyte-induced complications of adjacent structures are a model for spatial anatomy. From the cervical to lumbar region, osteophytes growing from vertebral bodies directly influence the physiologic function of adjacent structures. Traditionally, the first line of treatment in symptom correction is a conservative approach, usually

involving a non-steroidal anti-inflammatory drug to minimize the inflammatory reaction accompanying osteophyte formation. If a conservative treatment is unsuccessful, a surgical approach may be taken to access the osteophyte from an anterior or anterolateral direction, complimenting the most common direction of osteophyte orientation. In the majority of diagnosed cases, removal of the offending osteophyte will lead to resolution of the overlying symptoms (Uppal and Wheatley 1999).

A number of studies have used the anterior approach (Brandenberg and Leibrock 1986; Calisaneller et al. 2005; Hasegawa et al. 1984; Snodgrass 2004; Stevens et al. 1993) by excising the osteophytes and using a high-speed drill to smooth the surface of the vertebral body (Calisaneller et al. 2005). When osteophytes encompass C1–C2, a peri-oral-transpharyngeal approach is taken to access the vertebrae (Snodgrass 2004). Particularly when the osteophyte is present on maximal load-bearing vertebrae (C5–C6 and L1–L5), interbody fusion of the vertebrae is performed in order to decrease the probability of osteophytes recurring.

Compounding these factors with the obesity epidemic has lead to osteophyte formation secondary to osteoarthritis occurring more frequently, producing unique complications. Given that males and females show remarkably similar patterns of age-related changes in osteophyte development (Snodgrass 2004), osteophytes may eventually be considered part of the natural physiological aging process.

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