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Review Article: Osteophytes

Siu Him Janus Wong, Kwong Yuen Chiu, Chun Hoi Yan
Department of Orthopaedics & Traumatology, The University of Hong Kong, Hong Kong

ABSTRACT

An osteophyte is a fibrocartilage-capped bony outgrowth that is one of the features of osteoarthritis. This study reviewed the types, risk factors, pathophysiology, clinical presentations, and medical and surgical treatment of osteophytes. Extraspinal osteophytes are classified as marginal, central, periosteal, or capsular, whereas vertebral osteophytes are classified as traction or claw. Risk factors for development of osteophytes include age, body mass index, physical activity, and other genetic and environmental factors. Transforming growth factor β plays a role in the pathophysiology of osteophyte formation. Osteophytes can cause pain, limit range of motion, affect quality of life, and cause multiple symptoms at the spine. Medical treatment involves the use of bisphosphonates and other non-steroidal anti-inflammatory agents. Surgical treatment in the form of cheilectomy for impingement syndromes during joint replacement is recommended.

Key words: *osteophyte; physiopathology; risk factors; treatment outcome*

INTRODUCTION

An osteophyte is one of the features of osteoarthritis.[1] This study reviewed the types, risk factors, pathophysiology, clinical presentations, and medical and surgical treatment of osteophytes.

CLASSIFICATION

Osteophytes can be classified as extraspinal or vertebral. According to their radiographic appearance and formation mechanism, there are 4 types of extraspinal osteophytes.[2] Marginal osteophytes arise from the periphery of joints and appear as a 'lip'. They are caused by endochondral ossification stimulated by vascularisation of subchondral bone marrow.[3] They are found in non-pressure segments and thus not usually associated with significant adjacent sclerosis or subchondral cysts. They usually predominate on one side of the joint (Fig. 1a).

Central osteophytes are projections to the interior joint space and have an irregular rough articular contour. They are caused by hypervascularity-stimulating endochondral ossification. The original calcified cartilage demarcating the bases of button-like excrescences is known as 'reduplication'. They are most commonly found in the hips and knees (Fig. 1b).

Periosteal and synovial osteophytes appear as thickened intra-articular cortices. They are caused by intramembranous ossification as a result of stimulation of the periosteal and synovial membrane with appositional bone growth. Femoral neck buttressing is one example.[4]

Capsular osteophytes develop as a result of capsular traction and form along the direction of capsular tension. Bony outgrowth in the silhouette of seagull wings ('seagull sign') at the interphalangeal joints is one example.

Vertebral osteophytes are classified as traction or claw.[5] Traction osteophytes are horizontal bone

Address correspondence and reprint requests to: Chun Hoi Yan, Department of Orthopaedics & Traumatology, The University of Hong Kong, Hong Kong. Email: yanchunhoi@gmail.com

extrusions from the attachment of the outermost annulus fibrosus fibres >2 mm from the distal edge of the vertebral body. They are a sign of instability and regress as stability improves (Fig. 2a). Claw osteophytes are curved toward the adjacent disc (Fig. 2b) and are more common. In 20 cadavers, no corresponding similar spur was noted at the adjacent vertebral rim of a traction osteophyte, as would be expected if its formation was due to instability of the intervening disc.6 Thus, both types of spinal osteophytes are considered to be secondary to the same degenerative process rather than 2 distinct pathologies.[6]

An alternative classification system categorises osteophytes into 3 types: the real osteochondrophyte (arising in the synovium overlying bone at the junctional zone), traction spur (at the enthesis), and inflammatory spur (e.g. syndesmophytes in ankylosing spondylitis).[7]

RISK FACTORS

Age is associated with higher osteophyte grade at the lumbar spine[8] and outward osteophyte size at the knee at the left medial tibia (r=0.329, p=0.002).[9] Spinal osteophytes have been reported in up to 60% of women and 80% of men aged 50 years.[10] Osteophytes had been used as a forensic estimator of age,[11] but the association is insufficient to yield a predictive power beyond a general estimate.[12] Increased body mass index (BMI) and obesity are associated with larger osteophytes at multiple joints. In 126 Japanese women aged >60 years with back pain, the mean lumbar osteophyte area correlated with weight (r=0.557) and BMI (r=0.486).[13] In a UK study, increasing BMI was associated with increasing frequency of osteophytes at the lumbar spine, particularly at the dorsal aspect.[8] BMI correlates with outward osteophyte size at the lateral left femur and right tibia (r=0.329, p=0.002).[9]

In 51 subjects with a mean age of 60 years who exercised regularly, painless weight-bearing activity did not accelerate osteophytosis in the knee.[14] Nonetheless, in a UK study of 499 men, heavy physical activity was associated with development of osteophytes.[8] In a Japanese cross-sectional study, occupational kneeling and squatting (defined as >1 hour per day) was associated with increased area of femoral and tibial osteophytes.[15]

In a study that compared 135 young athletes with 550 controls, athletes were at higher risk of tibiofemoral osteophytes (adjusted odds ratio [OR]=2.9, 95% confidence interval [CI]=1.6–5.4) and notch osteophytes (adjusted OR=2.3, 95% CI=1.1–4.7).[16] Prior anterior cruciate ligament surgery increased the risk of tibiofemoral osteophytes (adjusted OR=4.8, 95% CI=2.4–9.4).[16]

Dietary factors may play a role in osteophyte formation in Japanese women (but not in men).[17] The osteophyte area was associated with a low

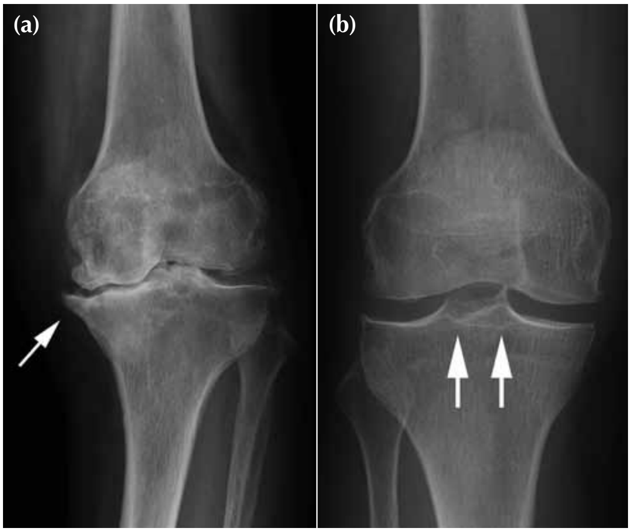

Figure 1 **(a)** Marginal osteophytes at the medial edge of the tibial plateau (arrow), and **(b)** central osteophytes at the tibial spines (arrows).

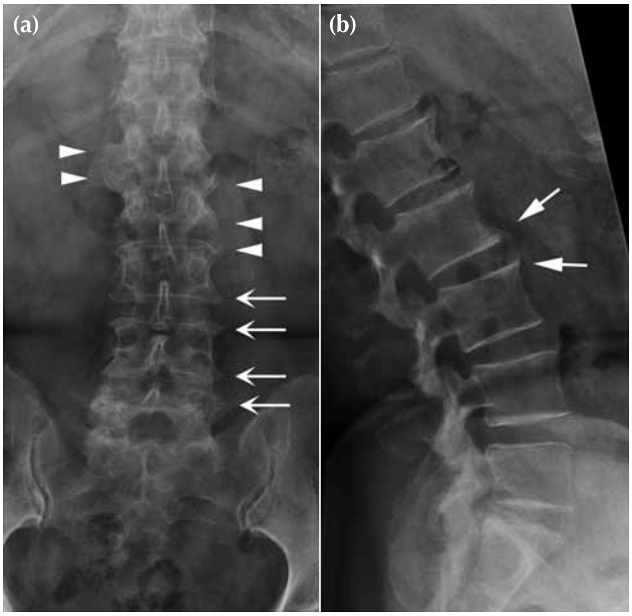

Figure 2 **(a)** Traction osteophytes at L5 and L4 and the inferior aspect of L3 (arrows) and claw osteophytes at the superior aspects of L3 and L2 and the inferior aspect of L1 (arrowheads), and **(b)** mixture of claw and traction osteophytes at the anterosuperior aspect of L3 and anteroinferior aspect of L2 (arrows).

level intake of vitamin E (regression coefficient= −0.15, 95% CI= −0.29 to −0.008, p=0.0383), vitamin K (regression coefficient= -0.10, 95% CI= −0.18 to −0.009, p=0.0302), vitamin B1 (regression coefficient= −0.35, 95% CI= −0.56 to −0.13, p=0.0020), vitamin B2 (regression coefficient= −0.22, 95% CI= −0.37 to −0.08, p=0.0025), Niacin (regression coefficient= −0.18, 95% CI= −0.33 to −0.03, p=0.0195), and vitamin B6 (regression coefficient= −0.25, 95% CI= −0.42 to −0.07, p=0.0053).[17] In a cross-sectional study of elderly people, low serum β-carotene level was a strong risk factor for lumbar osteophyte formation (OR=6.7, 95% CI=1.39–32.6, p=0.02).[18] In a US study of 791 older community-dwelling adults, a high serum level of dephosphorylated-uncarboxylated matrix-gla protein (indicative of low vitamin K status) was associated with higher risk of osteophyte formation (OR=1.7, 95% CI=1.1–2.5).[19]

The T^{29}→C polymorphism of the TGFβ1 gene at chromosome 19q13.1 has been shown to exhibit inverse patterns of association with genetic susceptibility to spinal osteophytosis.[20] Low birth weight was associated with development of osteophytes at the hip (OR=1.512, 95% CI=1.14–2.00, p=0.004).[21] A hostile uterine environment may play a role, with effects mediated through the vitamin D receptor gene.[21] Race may play a role in the prevalence and distribution of osteophytes as evidenced by differences in African and Caucasian populations.[22] Osteoarthritis of the hip is uncommon among Asians (compared to Caucasians).[23] Nonetheless, osteoarthritis of the knee is slightly more prevalent in the Beijing Osteoarthritis Study cohort than the Framingham Osteoarthritis Study cohort; the respective radiographic and symptomatic osteoarthritis prevalence ratios were 1.45 (95% CI=1.31–1.60) and 1.43 (95% CI=1.16–1.75) respectively.[24]

In a Croatian study of 543 subjects, vertebral deformities were associated with spinal osteophytes in those aged >45 years.[25] Osteophytes have been noted in young patients with adolescent idiopathic scoliosis.[26]

In a UK study that compared 1135 subjects with controls, high bone mineral density (Z-score) was associated with osteophytosis (OR=2.12, 95% CI=1.61–2.79, p<0.001).[27] Nonetheless, in a Japanese study of women scheduled to undergo total hip arthroplasty, end-stage osteoarthritis did not correlate with osteophyte formation.[28] Only osteoporosis was inversely associated with spondylosis, as measured by osteophyte formation and intervertebral disc narrowing.[29] Based on visual inspection of 337 adult skeletons, osteophytes positively correlated with enthesophytes (r=0.65, 95% CI=0.58–0.71).[30]

PATHOPHYSIOLOGY

Periosteal or synovial mesenchymal stem cells are thought to be the cellular source of osteophyte precursors, with developing osteophytes comprising fibroblasts, mesenchymal pre-chondrocytes, maturing chondrocytes, hypertrophic chondrocytes, and osteoblasts.[31] Periosteal cells in the bone-cartilage boundary are stimulated to proliferate, most likely by mechanical stimuli transcribed to biochemical factors or autonomous biochemical factors. TGFβ appears to be the most potent factor to initiate chondrogenesis in osteophytes,[32,33] whereas bone morphogenetic protein 2 plays an essential role in the terminal differentiation of chondrocytes and endochondral ossification of the osteophyte.[34] Cells inside the developing osteophyte undergo chondrogenesis and deposit aggrecan and other matrix molecules. Fibroblast-like cells in the covering layer proliferate and differentiate into chondrocytes, with specific stages of differentiation recognisable by expression of different types of collagen.[35] As the most central chondrocytes further differentiate and hypertrophy, they undergo endochondral ossification, deposit bone and form marrow cavities. A fully developed osteophyte is integrated with the original subchondral bone. Still showing an outer fibrous layer, it is covered by cartilage and expands the original joint cartilaginous surface. Nonetheless, the osteophyte cartilage is mechanically inferior to normal articular cartilage, possibly because of reduced loading, compared with normal articular cartilage.[36] In summary, neochondrogenesis in the periosteum at the bone-cartilage junction is the primary process of osteophyte formation, with synovial lining derived cells and intramembranous bone formation contributing to the definitive osteophyte.[31]

Vertebral osteophytes develop as a compensatory mechanism for the desiccation of the nucleus pulposus to increase stability and maintain resilience to load-bearing weight. Injury to Sharpey's fibres at the annular ligament insertion leads to osteophyte formation, either through ligament ossification or endochondral ossification of fibrocartilaginous repair tissue.[3,10]

The direction of osteophyte growth is predominantly upward in the medial femur, upper middle direction in the lateral femur, and outward in the medial and lateral tibia.[9] The direction of osteophytes varies according to the size and degree of local narrowing: from predominantly horizontal to vertical with increasing size at the medial tibia and medial and lateral femur.[37] In 42% of patients with anterior cruciate ligament–deficient knees undergoing total knee arthroplasty, posterolateral corner osteophytes at the medial tibial plateau were noted to prevent anterior translation.[38]

In a review of radiographs of 2850 patients, osteophyte growth was predominantly in the direction of the adjacent disc in the upper lumbar vertebrae (L1–L2 and L2–L3) and away from the adjacent disc in the middle or lower lumbar vertebrae (L3–L4, L4–L5, and L5–S1).[39] Differences in degenerative, anatomic, and biomechanical factors accounted for the differences in direction of spur formation in intervertebral spaces.[39]

In a UK study of 45 patients with hand osteoarthritis, the dominant hand had bigger and more osteophytes ($p<0.03$).[40] The third phalanx had the greatest number and area of osteophytes, corresponding to the largest forces exerted through the joints during power gripping.[41] The total number and size of osteophytes in the second and third phalanges was twice that of the fourth and fifth, probably owing to the tripod of finger action in precision grip.[42] The greatest hand-joint osteophyte is formed in the second distal interphalangeal joint, corresponding to the forces exerted through the joints in pulp pinch grip.[41] At the wrist, osteophytosis is greatest at the trapezium of the first carpometacarpal joint of the non-dominant hand; lesser finger strength in grasping objects during power gripping with the non-dominant hand results in higher forces across the trapezium and first metacarpal base.[41]

In a study of 10 ankles with anterior ankle impingement, the talar spur protruded medially at the medial talar neck, and the non-overlapping wider tibial spur peaked lateral to the midline.[43]

CLINICAL CORRELATES

Osteophytes correlate with joint space narrowing,[9,37] juxta-articular bone loss,[44] cartilage defects (correlation coefficient=0.22–0.41, $p<0.05$, positive predictive value=74–100%, specificity=59–100%),[45,46] end-plate sclerosis at the vertebrae (β coefficient=2.7, 95% CI=2.4–3.1),[47] and meniscal abnormalities at the knee (positive predictive value=71%, sensitivity=71%, specificity=68%).[48]

Osteophyte size at the knee and femur is associated with progression of osteoarthritis.[49,50] In patients with Kellgren and Lawrence grade-1 osteophytes, 62% developed osteoarthritis at 10-year follow-up, compared with 22% of controls.[51] The presence of hand osteophytes, especially at the first interphalangeal and carpometacarpal joints, is a sensitive biomarker for heritability of hand osteoarthritis.[52]

Joint pain can be partly caused by osteophytes, with vascularisation and subsequent invasion of perivascular and free nerve fibres into osteophytic marrow cavities.[53] It remains controversial whether increased osteophytosis is associated with increased pain. In >500 knees, the presence of osteophytes was the best radiological predictor of knee pain (OR=7.56, 95% CI=3.84–14.81 for skyline osteophytes; OR=5.00, 95% CI=2.40–10.43 for anteroposterior osteophytes).[54] Chronic knee pain correlated with presence of medial tibial condyle osteophytes.[55] Osteophyte at the inferior pole of the patella was associated ($p<0.05$) with knee pain.[48] Hand osteophytes were associated with pain in the finger joints among patients with hand osteoarthritis evaluated by ultrasonography (OR=4.8, 95% CI=3.1–7.5) and radiography (OR=4.1, 95% CI=2.4–7.1).[56] Nonetheless, in a magnetic resonance imaging study of 217 patients, the natural history of osteophytes showed no association with severity of pain.[57] The degree of patellar or trochlear osteophyte formation was not associated with anterior knee pain or any of the patellofemoral functional parameters.[45] In a meta-analysis, presence of osteophyte was not associated with low back pain; the pooled estimate of odds ratio between osteophytes and low back pain was 1.83 (95% CI=0.88–3.79, CLR=4.31) with significant heterogeneity (I^2=59.1%, $p=0.118$) in occupation-based populations, and 1.20 (95% CI=1.06–1.37, CLR=1.29) without significant heterogeneity (I^2=18.0%, $p=0.287$) in community-based populations.[58] Its high prevalence and natural occurrence with increasing age accounted for the weak association.[58]

In a Japanese population-based cohort, presence of osteophyte was a predictor of quality of life (as measured by the Western Ontario and McMaster Universities Osteoarthritis Index).[59] Osteophyte area was a predictor of physical functional disability within 3 years of follow-up.[59]

Osteophyte size of the knee was reported to be associated with active and passive flexion and extension.[9] Osteophyte size of the lateral femur and medial tibia was associated with the mechanical medial proximal tibial angle.[9] Medial osteophyte score was related to varus alignment ($r=0.46$, $p<0.0001$).[49] In logistic regression analysis of knee radiographs of 204 patients, osteophyte size was associated with local malalignment, bone attrition, and chondrocalcinosis at multiple sites.[37] In patients referred for magnetic resonance imaging of the knee, central knee osteophytes were noted in 15%; such patients were older (52 vs. 38 years, $p<0.0001$), heavier (92 vs. 78 kg, $p<0.0001$), sustained more full or near-full thickness articular cartilage defects (4.3 vs. 1.3, $p<0.0001$), had more marginal osteophytes

(3.9 vs. 1.1, p<0.0001), and were more likely to sustain a meniscal tear (p=0.004, Chi-square test).[60]

At the shoulder, the length of hooked osteophytes was greater in shoulders with full-thickness rotator cuff tears (2.7±2.2 mm) in an anatomic study of 86 cadavers.[61] Supraspinatus tendon rupture was associated with distally pointing osteophytes of the acromioclavicular joint.[62]

At the spine, osteophytes can be totally asymptomatic or cause a seemingly bizarre array of symptoms. Cervical osteophytes were most commonly found on C5, C6, and C7, with their mobility, weight-bearing nature, and risk for lordosis postulated as causes for the predisposition.[63] Cervical osteophytes can cause dysphagia.[64,65] There are 5 characteristics of osteophyte-induced dysphagia: mechanical obstruction by large osteophytes, strategic obstruction of the oesophageal segment attached to the cricoid by smaller osteophytes, osteophytes with coexisting decreased laryngeal closure, impaired tilting of the epiglottis over the laryngeal inlet by osteophytic compression, and peri-osteophytic inflammation inducing oesophagitis or pharyngitis.[66] In thoracic vertebrae, osteophytes can cause dysphagia,[67] compromised respiratory function,[68] compression injury to surrounding structures (such as the sympathetic trunk and greater splanchnic nerve),[69] and aorta injury.[70] Lumbar osteophytes can cause nerve root compression and low back pain, and occasionally inferior vena cava obstruction.[71] Anterior lumbar osteophyte was associated with abdominal aortic calcification.[72]

MEDICAL TREATMENT

Treatment with bisphosphonate alendronate may decrease osteophyte progression, compared with placebo (osteophyte score=3.2 vs. 4.7, p=0.04).[73] In an animal study, benoxaprofen, a non-steroidal anti-inflammatory drug, slowed osteophyte formation but at the possible expense of cartilage injury.[74] Other drugs that have shown success in animal models in reducing the size of osteophytes and cartilage lesions include the cytokine modulator tenidap,[75] non-steroidal anti-inflammatory carprofen,[76] and selective inhibitor of inducible nitric oxide synthase N-iminoethyl-L-lysine.[77] In a canine model, osteophyte size reduced after treatment with oral or intra-articular corticosteroids, but their clinical role and risk-benefit ratio remain to be elucidated.[78] Juxta-intervertebral osteophyte corticosteroid and local anaesthetic injection under fluoroscopic guidance can provide pain relief.[79] Although medical treatment for osteophytes per se may not be advisable in all joints, it plays a role in assessing the effect of therapeutic invention on joint destruction.[80]

SURGICAL TREATMENT

In patients with femoroactebular impingement, arthroscopic decompression of the acetabulum and proximal femur for pincer and cam type deformities improved the hip range of motion (Fig. 3).[81] Nonetheless, the lack of randomised controlled trials means that there is insufficient evidence to recommend any form of surgical intervention for femoroacetabular impingement.[82] Arthroscopic decompression of a central osteophyte is advocated to delay progression of arthritis, as the osteophyte lateralises the femoral head and thus is important to joint mechanics.[83] The osteophyte accelerates chondral damage to the femoral head by repetitive abrasion.[83]

Cheilectomy is an operation to remove impinging osteophytes to improve the range of motion of arthritic joints. In 42 osteoarthritic elbows followed up for >2 years, arthroscopic osteophyte resection and capsulectomy improved the range of motion, pain, and function as measured by the Mayo Elbow Performance Index.[84] In 5 professional boxers, arthroscopic debridement improved posterolateral elbow impingement and resulted in normal function and return to sport at one-year follow-up.[85] In 46 patients with anterior ankle impingement without osteoarthritis, arthroscopic removal of osteophytes improved the foot functional index up to 5 years.[86] Nonetheless, limited improvement in the range of ankle dorsiflexion was of little clinical significance and was accounted for by preoperative posterior tibiotalar capsular contraction.[86] Radiological anterior osteophytes have been reported to recur

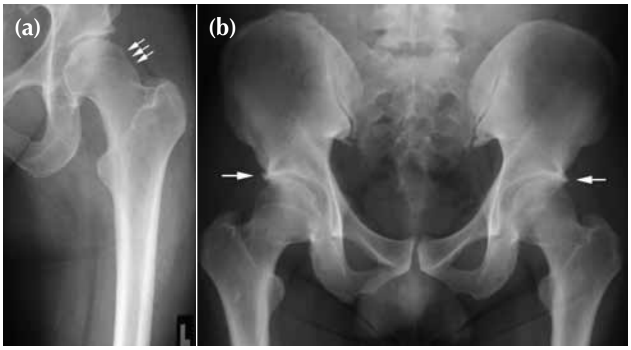

Figure 3 **(a)** The cam-type deformity of the left femur (arrows) and **(b)** the bilateral pincer-type deformity of the acetabula (arrows).

in 84% of patients and have minimal effect on pain and functional outcome.[87] Removal of osteophytes in posterior and medial ankle impingement has been successful.[88,89] Cheilectomy in hallux valgus has not been shown to accelerate cartilage destruction or increase symptoms.[90]

Osteophytes should be removed during total hip arthroplasty to avoid potential impingement.[91] The likely sites of impingement by acetabular osteophytes include the one and 2 o'clock positions that reduce the range of flexion and 90° of flexion with internal rotation, and the 7 and 8 o'clock positions that reduce the range of external rotation.[91] In a Hong Kong study of 92 patients, residual posterior femoral condyle osteophyte affected postoperative flexion, and routine removal was advocated to avoid impingement of the polyethylene insert on deep flexion.[92] In a study of unicompartmental knee osteoarthritis, surgical removal of osteophytes increased the postoperative varus-valgus range of motion.[93] Nonetheless, femoral trochlear osteophytes were not associated with anterior knee pain or patellofemoral function; patellofemoral symptoms and functional disabilities were attributed to patellofemoral joint osteophytes.[45]

Regression in the length of anterior vertebral osteophytes has been noted in fused segments after instrumented lumbar fusion for degenerative lumbar disorders.[94] Nonetheless, regression of posterior osteophytes was not noted 12 years after anterior interbody fusion; the osteophytes should have been removed at the time of initial surgery.[95,96] Osteophyte removal has been reported to reduce resistance to flexion by 49%, extension by 36%, left lateral bending by 36%, right lateral bending by 35%, and compression by 17%.[97]

DISCLOSURE

No conflicts of interest were declared by the authors.

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