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Original article

Tibial Osteophytes as Indicator of Osteoarthritis: Morphometry and Clinical Importance

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ABSTRACT

Background: An osteophyte is a bony outgrowth, covered with fibrocartilage,that is one of the hallmarks of osteoarthritis especially in the knee joint. Risk factors for development of osteophytes include age, physical activity, body mass index, and other genetic and environmental factors. **Aim:** To analyze the frequency and morphological features of osteophytes at the upper end of dry tibia bones and to define any relationship between the size of osteophytes and that of the intercondylar tibial spines. **Methods:** We evaluated 75 dry tibia bones for the degree of osteoarthritis at the upper end. Each plateau at the superior surface of the upper end was divided into four quadrants and the presence and size of bone outgrowths were recorded in each quadrant. The "medial/lateral tibial intercondylar spine index" for each specimen was calculated and relation with the osteophytes was observed. The measurements were meticulously recorded and the data were subjected to statistical analysis. **Results:** In the present study, osteophytes were found more frequently in the anterior quadrants of both the tibial plateaus than in the posterior quadrants. Grade 1 osteophytes were the most common type of osteophytes with predominance in anterior quadrants of both medial and lateral tibial plateaus. There was positive correlation between grades of osteophytes and spine index. **Conclusion:** This study would help clinicians to understand the morphological changes in the upper end of tibia in osteoarthritis which would help them in planning the management.

KEYWORDS: Intercondylar spine, Osteoarthritis, Osteophytes, Tibia.

INTRODUCTION

Osteoarthritis (OA) is the degenerative and typically a progressive disorder of the joints primarily involving the knee (tibiofemoral) joint, that may eventually lead to disability. Knee OA affects the 3 compartments of the knee joint (medial, lateral, and patellofemoral joint) and usually develops slowly over 10 to 15 years, interfering with daily life activities [1].Still the patho-physiology of the disease is not known clearly and is under investigation, it is accepted that knee OA is multifactorial in origin [2].Studies reports strong association of aging and OA and selectively targets certain joints like knee. Studies says that number of genetic, environmental and constitutional risk factors have been found responsible for OA [3]. The characteristic radiographic features of OA are focal cartilage loss, leading to "narrowing of joint", subchondral sclerosis of bone, bone cysts bony, contour remodelling, osteophyte formation and absence of bone atrophy [4].

Osteophyte

An osteophyte is a bony outgrowth of fibrocartilage and is one of the features of OA [5].Although exact mechanism of osteophyte formation and growth are still unknown, it is viewed as a remodelling and reparative feature of OA. According to some authors, in experimental joint damage,chondrocyte synthesis and osteophyte formation are influenced by growth factors [6]. Joint instability also might act as a biomechanical trigger to osteophyte formation, hence to better withstand loading forces, osteophyte and bone remodelling being viewed as an attempt to stabilize the compromised joint [7].

Rogers J et al suggested that abnormal stresses at the joint margins might be responsible for formation of osteophytes however, other factors such as genetic susceptibility and systemic predisposition may also contribute to their formation [8].Some authors believe that chondrocalcinosis due to calcium pyrophosphate crystals has been associated with a tendency to osteophyte formation and a “hypertrophic” form of OA [9].Some authors believed that osteophyte formation is related to enthesophyte formation [8],suggesting that the degree to which new bone forms is at least partially dependent on systemic factors and varies considerably from one person to another. Therefore, multiple factors might be responsible for osteophyte formation and contribute to the marked heterogeneity of OA with many distinct causal pathways, and the concept of OA as a single disease entity has been rejected by some, leading to the use of the phrase “osteoarthritic disorders” [10].

Pathophysiology

Pathophysiology of osteophyte formation is still not known exactly. 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 [11].According to Uchino M et al,Transforming Growth Factor β (TGFβ) appears to be the most potent factor to initiate chondrogenesis in osteophytes [12], whereas Bone morphogenetic protein 2 (BMP 2) plays an essential role in the terminal differentiation of chondrocytes and endochondral ossification of the osteophytes [5].Conventional radiography is still the most widely accepted modality,for detection of OA especially for epidemiological purposes [13].

Kellgren and Lawrence in 1957 introduced classification system that grades the severity of OA under radiographic study, and this grading system emphasizes the presence and size of the osteophytes along with narrowing of joint space [14].Some authors believed that radiographs are inadequate in assessing the presence and characteristic features of small osteophytes and enthesophytes [15].Tibial “spiking” is one of the features employed for the detection of OA radiographically, which indeed is reported as a reliable marker in the detection of early OA.

However, the reliability of this finding as a feature of an early stage of OA is not clear since tibial spiking is also evident in cases of well-established OA [16]. Esposito A et al believes that direct physical inspection of bone,allows more accurate analysis of the presence, site and characteristics of surface irregularities compared with radiography [17]. Jurmain RD et al said that dry bones would be good for the study of OA [18], osteophytes are readily seen. Small and subtle regions of osteophytosis, often not evident on radiographs, can be picked up from dry bone [19].This study aims at direct inspection of the medial and lateral tibial plateaus in the dry tibia bone, to analyze the frequency and morphological features of osteophytes and to define any relationship between the size of osteophytes and height of the intercondylar tibial spines.

METHODS AND MATERIALS

We conducted this study in the department of anatomy in a private medical college, where we had total 80 (40 right and 40 left side) well preserved dry tibial specimens. Out of these specimens five were excluded from the study as their upper end was distorted or broken. Thus, we evaluated total 75 (39 Left and 36 Right) dry tibia bones for the degree of osteoarthritis (OA). Each tibial plateau at the superior surface of the upper end was divided into four quadrants of a circle. Each quadrant was named with respect to its position relative to the sagittal and coronal planes of the body. Both the authors of the study, individually assessed the four quadrants,[i.e., anteromedial (AM), anterolateral (AL), posteromedial (PM), and posterolateral(PL)] of all specimens by visual and tactile observation for the presence or absence of outgrowths (Figure- 1, 2,3) and the readings were recorded [Table-2,3,4].

The outgrowths were classified on a continuous scale of 0 to 3 (0 = no outgrowth, 1 = small beak-like outgrowth, 3 = large (≥2 mm) or mushroom-like outgrowth, and 2 = outgrowth between grades 1 and 3). If there was more than one outgrowth (with different grades) in a single quadrant, the highest grade was recorded. Thus, in quadrants with multiple outgrowths of different grades, only one osteophyte grade per quadrant was recorded. The osteophytes in marginal regions were visually examined and graded 0, 1, 2, 3, or 4 according to criteria assessing osteophyte proliferation and the appearance of the border and surface of the joint (Reza Hayeri M,2010),[Table-1].

Marginal regions without any eminences were regarded as grade 0. Marginal osteophytes with an obscure border and even surface were graded 1. Marginal osteophytes with a distinct border and uneven surface were graded 2. Marginal osteophytes with a dominant border and rough surface were categorized as grade 3. Marginal osteophytes that displayed severe proliferation both at their border and on their surface were classified as grade 4. To improve the objectivity and stability of the osteophyte scoring system, the dry bone specimens were by two authors independently and then the system was reviewed. The height of the intercondylar tibial spines (medial and lateral) was also measured, from the tip of the spine to its base at the intercondylar surface in both the tibial plateaus using a caliper. All the measurements were expressed in centimeters. Measured values were then normalized in view of the difference in the size of the tibial specimens. Therefore, the “medial/lateral tibial intercondylar spine index” for each specimen was calculated as follows [13]:

$$\frac{\text{Medial/Lateral Intercondylar Tibial Spine Height}}{\text{Anteroposterior Width of the Superior Tibial Surface}}$$

Figure 1: Superior surface of Tibia (Right) showing Grade 3 osteophytes (Red arrows) in posterolateral region of Medial plateau (MTP) and anterolateral region of Lateral tibial plateau (LTP), Grade 2 (Yellow arrow) osteophytes in posteromedial region of LTP.TT: Tibial tuberosity, AICA: Anterior Intercondylar area, PICA: Posterior Intercondylar area, ICE: Intercondylar Eminence.

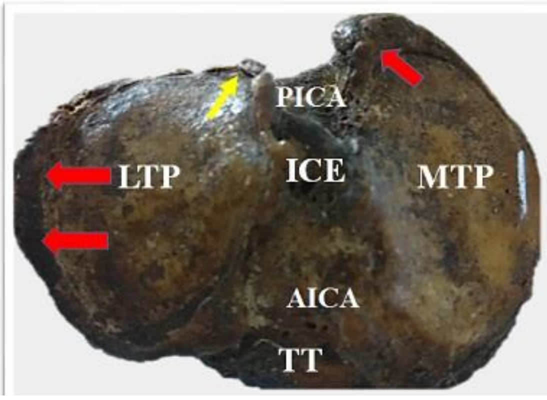

Figure 2: Superior surface of Tibia (Left) showing Grade 2 osteophytes (Yellow arrow) in anterolateral region of Medial tibial plateau (MTP), Grade 3 osteophytes in margins of intercondylar region..TT: Tibial tuberosity, LTP: Lateral tibial plateau, AICA: Anterior Intercondylar area, PICA: Posterior Intercondylar area, ICE: Intercondylar Eminence.

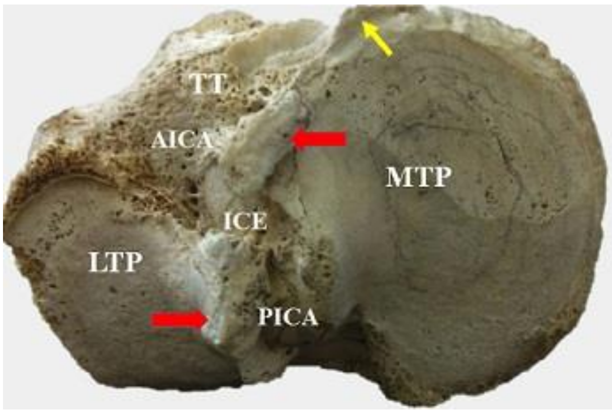

Figure 3: Superior surface of Tibia (Left) showing Grade 2 osteophytes (Yellow arrow) in anterolateral and posterolateral region of Medial tibial plateau (MTP), Grade 1 osteophytes in posteromedial region of MTP. Grade 1 osteophytes in posteromedial region of Lateral tibial plateau (LTP).MTP shows porosity or increased bone density (Asterisk) TT: Tibial tuberosity, AICA: Anterior Intercondylar area, PICA: Posterior Intercondylar area, ICE: Intercondylar Eminence

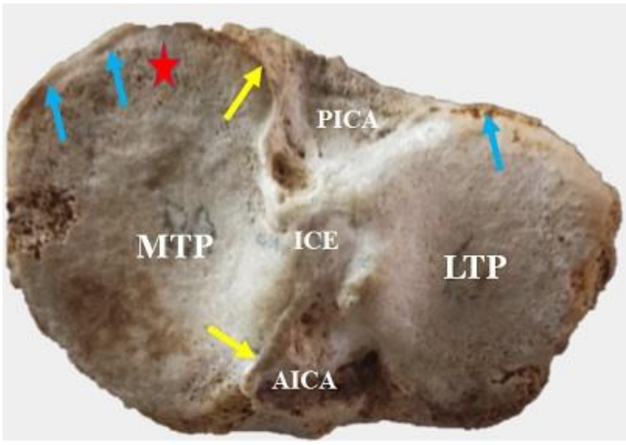

Table 1: Grades of the Osteophytes (OP) considered in our study on gross examination (Grade 0 to 4) [13].

GRADE	FEATURES TO BE INCLUDED
0	No any eminences or spiking
1	Marginal OP with an obscure border and even surface
2	Marginal OP with a distinct border and uneven surface
3	Marginal OP with a dominant border and rough surface
4	Marginal OP that displayed severe proliferation both at their border and on their surface (>2mm)

RESULTS

In the present study, out of 75 dry tibia specimens,52% (N=39) were left and 48% (N=36) were right bones where side was determined by two observers depending upon the anatomical features of the bones. On inspection, osteophytes were found more frequently in the anterior quadrants of both the tibial plateaus than in the posterior quadrants. Grade 1 osteophytes were the most common type of osteophytes, observed in 10(13.3%) in AM quadrant and 05 (6.7%) in AL quadrant of medial tibial plateau (MTP) and 13(17.3%) in AM and 06 (8%) of AL quadrant of lateral tibial plateau (LTP) (N=75). Grade 2 osteophytes were also observed more in the anterior quadrants [AM-06 (8%), AL- 3 (4%) of MTP and AM- 06 (8%), AL- 2(2.7%) in LTP] of both the tibial plateaus than in the posterior quadrants (N=75) [Table-2]. Grade 3 osteophytes were least commonly seen. Grade 4 osteophytes were not observed in any of our specimens.

Table 2: Frequency of Grades of Osteophytes (OP) in different quadrants of Medial and Lateral Tibial Plateaus (MTP & LTP) of both Tibia bones (N=75).

Grade	Medial Tibial Plateau (MTP)				Lateral Tibial Plateau (LTP)			
	AM (%)	**AL(%)**	**PM(%)**	**PL(%)**	**AM(%)**	**AL(%)**	**PM(%)**	**PL(%)**
0	16 (21.3)	11 (14.7)	4 (5.3)	3 (4)	18 (24)	11 (14.7)	6 (8)	5 (6.7)
1	10 (13.3)	5 (6.7)	4 (5.3)	3 (4)	13 (17.3)	6 (8)	1 (1.33)	1 (1.33)
2	6 (8)	3 (4)	2 (2.7)	1 (1.33)	6 (8)	2 (2.7)	2 (2.7)	0
3	2 (2.7)	4 (5.3)	1 (1.33)	0	4 (5.3)	0	0	0

AM: Anteromedial, AL: Anterolateral, PM: Posteromedial, PL: Posterolateral

The "medial/lateral tibial intercondylar spine index" for each specimen was calculated as formula given above in methodology. The mean heights of the medial and lateral intercondylar tibial spines of right tibia were 1.14 and 0.82 and that of left tibia were 1.15 and 0.82 (in cm) respectively. The mean anteroposterior width of the tibial plateau of MTP and LTP of right tibia was 4.04 and 3.78 (in cm) respectively and that of left tibia was 4.16 and 3.7 (in cm) respectively. The mean of Lateral intercondylar tibial index (LICSI) and mean of Medial intercondylar tibial index (MICSI) of right tibia was 0.279 and 0.215 respectively.

The mean of Lateral intercondylar tibial index (LICSI) and mean of Medial intercondylar tibial index (MICSI) of left tibia was 0.282 and 0.215 respectively [Table-5].In specimens with no signs of osteoarthritis the lateral intercondylar tibial index was significantly lower than that in specimens with some degree of OA.The correlation coefficient for osteophyte grades of MTP and Medial tibial spine index was 0.76 (r=0.76).The correlation coefficient for osteophyte grades of LTP and Lateral tibial spine index was 0.76 (r=0.56).Thus there was a positive correlation between the osteophyte grade and spine index [Table-4].

Table 3: Mean of Medial and Lateral Intercondylar Spine Height (MISH & LISH) in Left (N=39) and Right Tibia (N=36).

Tibia	Medial Intercondylar Spine Height	Lateral Intercondylar Spine Height
Left	1.13	0.82
Right	1.13	0.82

Table 4: Mean of Medial and Lateral Intercondylar Spine Index (MISI & LISI) in Right and Left Tibia

	RIGHT TIBIA (N =36)		LEFT TIBIA (N =39)	
	Medial Intercondylar Spine Index	Lateral Intercondylar Spine Index	Medial Intercondylar Spine Index	Lateral Intercondylar Spine Index
Mean	0.279	0.215	0.282	0.215

DISCUSSION

On gross examination, osteophytes were observed more frequently in the anterior quadrants of both the tibial plateaus than in the posterior quadrants which is similar to the findings observed by Reza Hayeri M et al [13]. Studies says that primary process of osteophyte formation is neochondrogenesis in the periosteum at the bone-cartilage junction, with synovial lining derived cells and intramembranous bone formation leading to the definitive osteophyte [11]. Abnormal stresses on the articular surface are thought to be responsible for chondrogenesis and enchondral ossification leading to osteophyte formation [20].Relative preservation of articular cartilage is a possible reason for more frequent osteophyte formation in the anterior quadrants of the tibial plateaus. Capsular traction during knee flexion may lead to tensile stress in the anterior tibial margin and subsequent enthesophyte formation as well [13]. In forensic medicine also, osteophytes had been used for estimation of age [21] but the association is insufficient to yield a predictive power beyond a general estimate.

Very few studies are done on the gross inspection of tibial osteophytes or spiking, as we didn't find much literature. Some authors observed larger osteophytes at multiple joints to be related to increased body mass index (BMI) and obesity [22]. In a study of 51 subjects with a mean age of 60 years, osteophytosis in the knee joint was not accelerated with regular exercise and painless weight-bearing activity [23]. In a study in UK with 499 participants, osteophytosis was found to be associated with heavy physical activity [24]. 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 [25].In the same study they observed steophyte size at the knee and femur is associated with progression of OA .Most reliable marker of early OA of the knee has been reported to be‘spiking' or angulation of the tibial tubercles [26].

Reiff et al in his study of 55 patients with marked signs of OA [16], showed that, compared with controls, the patients with marked OA had significantly higher intercondylar spine height. They concluded that intercondylar spine height can be considered a sign of OA. Alexander in his review study of the radiological features of OA [27], suggested tibial tubercle 'peaking' as a feature of OA is indistinguishable from an osteophyte arising at any other articular margin, and should therefore carry the same significance. In our study, the association between the intercondylar spine indexes and the global grading of osteoarthritis was significant for both the medial and lateral tibial plateaus.

CONCLUSION:

Present study was done to know the frequency of osteophytes (marginal) on the superior surface of dry tibia specimens and also to find out the most common grade of osteophytes. To our best of knowledge, there are only few studies on osteophytes done on dry bones, hence this study would definitely be helpful to the radiologists to make the clinical diagnosis and to orthopedic surgeons to plan the management.

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CONFLICT OF INTEREST:

The authors declare that they have no conflict of interest.

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