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Original Article

Anatomy Section

Morphological Traits Around Patellofemoral Joint in Indian Femora and their Implications

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ABSTRACT

Introduction: Knowledge of structural variations around patellofemoral joint has helped to understand postural behavior patterns of various population groups. The biomechanical impact of postures may lead to certain skeletal modifications which may contribute to knee pathologies like patellofemoral arthritis, patellar subluxation and trochlear dysplasia. This study was conducted to report the incidence of skeletal non-metric markers on femur in Indian population and to understand their correlation with some pathologies of patellofemoral joint. The traits studied were Martin's facet, Peritrochlear groove and Supratrochlear facet.

Materials and Methods: The study material was a collection of 152 adult femora from osteology museum in Department of Anatomy, Maulana Azad Medical College, New Delhi, India, with equal percentage of bones from each side and gender. All bones were evaluated for the above mentioned traits and results were obtained as percentage of incidence and Chi-Square test using SPSS version 17.

Results: The data showed that Martin's facet and Peritrochlear groove showed a higher occurrence in male femora. However, Supratrochlear facet was more commonly found in female bones. Martin's facet had an equal incidence on femora of each side while peritrochlear groove and supratrochlear facet had higher percentage of occurrence on right side. Supratrochlear facet revealed significant side variation.

Conclusion: These data suggest that casual or occupational postures may impose structural adaptations around patellofemoral joint. The stress of these postures may have causal,consequential or co-incidental relationship with joint pathologies. The gender, special occupations like sports and genetic predisposition may possibly have a role to play.

Keywords: Femur, Martin's facet, Non-metric traits, Peritrochlear groove, Supratrochlear facet

INTRODUCTION

Skeletal modifications associated with habitual postures provide a picture of mechanical demands on articular joints. Certain postural behaviours are recognised to leave markers on the skeleton [1,2]. Excessive joint stress may be linked to articular cartilage degradation which may contribute to knee pathologies such as patellofemoral osteoarthritis, chondromalacia patellae, recurrent patellar subluxation and patellofemoral pain syndrome [3,4]. The biomechanics of squatting posture during flexion of the knee may produce specific bone markers that characterise the strong pressure and traction forces on the patellofemoral joint. Such wear patterns on bones and joints may possibly be the result of casual or occupational posture.

The femoral articular surface for patella includes both the condyles displaying trochlear groove in the middle dividing it into two facets [5]. The lateral facet is more prominent with a greater radius and upper margin overhanging a supratrochlear groove [6]. Lateral facet blocks lateral movement of patella once it enters the trochlear groove as flexion begins [6]. The patellofemoral joint reaction force increases steadily as the knee is progressively flexed [7-9]. Knee flexion beyond 60 degree increases the transarticular stress since the contact area becomes very limited [10].

Till date structural variations on bones accounted by different habits of life have been studied to understand behaviour pattern of various races [1,2,11,12]. These variations might subserve as pathological markers if certain postures have deleterious effect on bones or joints. The current work was undertaken to study the incidence of skeletal non-metric markers around patellofemoral joint in Indian population.

MATERIALS AND METHODS

The study was conducted on a sample of 152 adult femora collected from osteology museum in Department of Anatomy, Maulana Azad Medical College, New Delhi, India. Bones were documented for sex and all belonged to North Indian population. The study material consisting of 76 bones for each sex was segregated and assessed separately.The side of each bone was determined and the sample collected involved 76 bones of right side and 76 bones of left side. One femur per case was studied and skeletal features were recorded for 76 right and left side bones.

The markers which were considered in our study were Martins' facet, Peritrochlear groove and Supratrochlear facet.

Martin's facet: It is present on the lateral aspect of the lateral condyle of femur. It is seen as a crescentic facet on the lateral aspect of femoral condyle because of translation of patellar articular surface [Table/Fig-1,2].

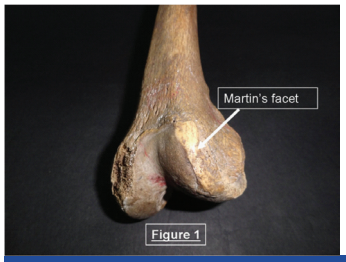
Peritrochlear groove: A groove on the medial trochlear margin extending from supratrochlear area to a notch demarcating the trochlea from the condylar surface [Table/Fig-3,4].

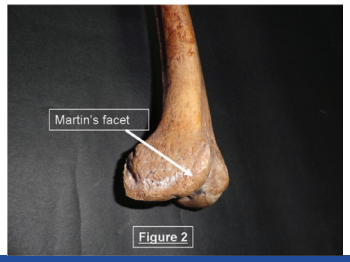
Supratrochlear facet: It is an extension of the upper margin of lateral trochlear surface on the shaft [Table/Fig-3,4].

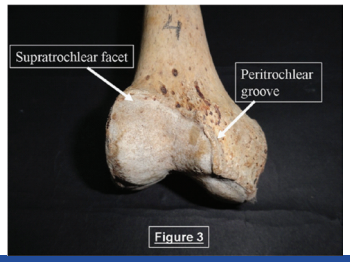
The selected traits were observed and photographed using Sony digital camera HX7. All the above mentioned morphological traits viz. martin's facet, peritrochlear groove, supratrochlear facet, were noted and analysed. Femora exhibiting obscuring pathologies such as cortical bone deterioration were excluded from the study. The results were documented with SPSS version 17.0 using the Chi-square test. All the observations were tabulated and compared with available data.

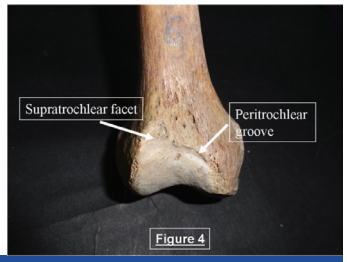
RESULTS

Of the 152 bones observed, martin's facet and peritrochlear groove had an incidence of 52.63% in male femora while in female the incidence was 47.36% and 39.47% respectively. These traits were thus more commonly seen in male femora. However, supratrochlear









[Table/Fig-1]: Male femur left side **[Table/Fig-2]:** Female femur right side. **[Table/Fig-3]:** Male femur right side. **[Table/Fig-4]:** Female femur right side

Trait	Percentage incidence in each gender			Chi-Square	Significance*
	No. of bones	Male (76)	Female (76)		
Martins' Facet	Absolute No.	40	36	0.421	0.516
	Incidence	52.63%	47.36%		
Peritrochlear groove	Absolute No.	40	30	2.648	0.104
	Incidence	52.63%	39.47%		
Supratrochlear facet	Absolute No.	60	66	1.670	0.196
	Incidence	78.94%	86.84%		

[Table/Fig-5]: Percentage incidence, chi-square test and significance of non-metric traits at distal end of femur in male and female
*Significant at 5% level of significance

Trait	Percentage incidence on each side				Chi-Square	Significance*
	No. of bones	Male (76)	Right (76)	Total (152)		
Martins' Facet	Absolute No.	38	38	76	0	1
	Incidence	50%	50%	50%		
Peritro-chlear groove	Absolute No.	34	36	70	0.106	0.745
	Incidence	44.7%	47.4%	46.1%		
Suprat-rochlear facet	Absolute No.	58	68	126	4.64	0.031*
	Incidence	76.3%	89.5%	82.9%		

[Table/Fig-6]: Percentage incidence, chi-square test and significance of non-metric traits at distal end of femur on left and right side
*Significant at 5% level of significance

facet was found to be present in 86.84% of female femora, while in male femora it had an incidence of 78.94%. The chi-square test didn't reveal any significant difference in the occurrence of these traits in each gender. These values are tabulated in [Table/Fig-5].

Further, Martin's' Facet was found in 50% of the femora with equal occurrence on both sides. Peritrochlear groove had an incidence of 46.1% being 44.7% on left and 47.4% on right side. The supratrochlear facet was found in 82.9% of bones with a slightly higher occurrence on femur of right side. The Chi-square results depict that supratrochlear facet is present more commonly on the right side with a significant side variation. These percentage of incidence and chi-square results are tabulated in [Table/Fig-6].

DISCUSSION

Evaluation of patellofemoral dysfunction requires integral knowledge of its morphology, anatomy, function and biomechanics. This study has determined the incidence of morphological markers around patellofemoral joint in a population habitually acquiring squatting posture.

Martin's facet has been reported to be present in the femora of people who are habitual squatters. It is attributable to the tendon of quadriceps muscle passing over the superolateral margin of patellar surface of femur in fully flexed position as occurs in squatting posture [12]. In our study martin's facet was present in 50% of femora on each side. Study done by Kostick on Western Nigerian population, believed to be habitual squatters, reported an incidence of 80% and 78% on the left and right side respectively. Their study also demonstrated a gender variation being higher in males [11]. Our study also showed comparable results regarding sexual dimorphism. The higher occurrence in males could be attributed to regular adoption of squatting posture for a longer duration due to certain occupational demand as in field workers.

Peritrochlear groove, which demarcates trochlea from condylar surface, could be converted into a tunnel in periarticular osteoarthritis [13]. Independent of aetiology, osteoarthritis is heralded by hypertrophic changes in adjacent bone along with damage to articular cartilage with diffuse fraying and fibrillation [14]. Certain types of occupations involving repeated kneeling, squatting and heavy lifting or stair climbing have been associated with increased risk of developing osteoarthritis [15]. The peritrochlear groove has been reported to be associated with squatting, prolonged standing and walking [13]. Although, its association in the pathophysiology of patellofemoral arthritis has not been recognised [16], it could possibly be a bony reaction due to increased vascularity [13]. Peritrochlear groove has been reported in 11.7% of femora in Western Nigerian population [11] which is substantially a smaller percentage than what we found. Its presence to the extent of 46.1% in our study could be a reflection of osteoarthritic changes occurring around patellofemoral joint because of assumption of varied postures. Patellofemoral arthritis is reported in patients who often demonstrate malalignment of articular surface of patella on femur leading to poor positioning and poor tracking of patella [16]. This spectrum of morphological features could be valuable in emphasising anatomic descriptions of patellofemoral arthritis.

It was postulated by Kostick that the supratrochlear facet is a bony reaction to pressure exerted by patella due to its natural tendency of lateral displacement [11]. Persons with high Q-angle have a tendency to patella displacements. The Q-angle considered as an expression of patellar kinematics is measured between the central line of pull of quadriceps muscle from anterior superior iliac spine to the center of patellaand the line from center of patella to tibial tuberosity. This Q-angle being more in females puts them at higher risk of patellar displacements [17]. In our study the supratrochlear facet showed a higher incidence of 87% in female femora when compared with male. Kinematic studies of patellofemoral joint have shown that the patellofemoral contact pressure increases significantly in women at variable range of knee flexion when compared with men [18]. The higher incidence of supratrochlear facet in women could possibly be a factor to prevent dislocation or a reaction to increased joint contact pressure. Previous study reported an incidence of 33.86% [11], our findings showed that it is present to the extent of 82.9% with a significantly higher occurrence in female femora. The aetiology for the higher incidence of supratrochlear facet might be multifactorial apart from posture, but no accord could be stated so far. The tendency of lateral dislocation of patella is normally counteracted by an anterior projection on the lateral femoral condyle

lateral to patellar groove [6]. It is a bony factor which prevents lateral dislocation of the patella and hence adds to its stability. The passive stability of the patellofemoral joint depends on the shape of the trochlea and the patella while its active stability has been ascribed to the surrounding strong muscles [19]. Elevation of lateral facet of trochlea improves the patellofemoral congruence and has been used in surgical treatment of trochlear dysplasia along with other forms of trochleoplasty [19]. The higher incidence of supratrochlear facet, which is an extension of lateral trochlear margin onto the shaft, perhaps be attributed to certain casual and occupational postures for favourable morphological modifications in trochlear groove to prevent patellar dislocation and minimising surgical treatment.

Previous studies have suggested that epidemiological and clinical evaluation of knee osteoarthritis cannot be performed without consideration of patellofemoral compartment [20]. Thus, this study which provides insight into incidence of bony modifications around patellofemoral joint may contribute to better understanding of its pathological changes. These bony variations may also be influenced by various environmental and genetic factors apart from posture. Such discontinous variations in human skeleton which classify individuals into divergent categories determined by developmental threshold of a given population are known as epigenetic variations [21]. They have anthropological and anatomical implications to genetically characterise population. Hence, the association of these morphological variations with such additional genetic and environmental factors needs further work to provide a comprehensive knowledge of their occurrence and further correlation.

CONCLUSION

Certain postures may impose structural adaptations on femur around patellofemoral joint. This study has reported side and gender related dimorphism in skeletal traits of femur. They have also been postulated to be associated with posture. The transarticular stress of these postures may have causal, consequential or co-incidental relationship with joint pathologies. Gender, special occupations like sports and genetic predisposition may possibly have a role to play in their occurrence.Thus, this work needs to be explored further considering gene-environment interaction in various population groups. However, the data collected in current study can act as a baseline reference for orthopaedicians and radiologists while evaluating various patellofemoral joint pathologies.

REFERENCES

[1] Kennedy KAR. Skeletal markers of occupational stress. In: Reconstruction of Life from the skeleton (edited by Iscan MY & Kennedy KAR), *Alan R. Liss, New York.* 1989: 129-60.

[2] Stirland A, Diagnosis of occupationally-related palaeopathology: Can it be done? In: Human Palaeopathology (edited by Ortner DJ and Aufderheide AC), *Smithsonian Institution Press, Washington.*1991;40-47.

[3] Fulkerson JP, Shea KP. Mechanical basis for patellofemoral pain and cartilage breakdown. In: Ewing JW(ed), Articular cartilage and knee joint function: Basic science and arthroscopy, Raven press, New York, 2001; 93-101.

[4] Grana WA, Kriegshauser LA. Scientific basis of extensor mechanism disorders. *Clin Sports Med.* 1985; 4(2):247-57.

[5] Standring S. Gray's Anatomy, Pelvic girdle, gluteal region and thigh, 40th ed. Elsevier Churchill Livingstone, Edinburgh. 2008;1362.

[6] O'Brien M. Clinical anatomy of the patellofemoraljoint. *Int Sport Med J.* 2001;2(1): 1-8.

[7] Dahlkvist NJ, Mayo P, Seedhom BB. Forces during squatting and rising from a deep squat. *Eng Med*. 1982;11:69-76.

[8] Escamilla RF, Fleisig GS, Zheng N, Barrentine SW, Wilk KE, Andrews JR. Biomechanics of the knee during closed kinetic chain and open kinetic chain exercises. *Med Sci Sports Exerc.* 1998;30:556-69.

[9] Reilly DT, Martens M. Experimental analysis of the quadriceps muscle force and patello-femoral joint reaction force for various activities. *Acta Orthop Scand.* 1972; 43: 126-37.

[10] Wallace DA, Salem GJ, Salinas R, Powers CM. Patellofemoral joint kinetics while squatting with and without an external load. *J Orthop Sports PhysTher.* 2002; 32(4): 141-48.

[11] Kostick EL. Facets and imprints on the upper and lower extremities of femora from a Western Nigerian population. *J Anat Lond.* 1963;97(3): 393-402.

[12] Martin CP. Some variations in the lower end of the femur which are especially prevalent in the bones of primitive people. *J Anat.* 1932; 66 (Pt 3): 371–83.

[13] Capasso L, Verginelli F, Caramiello S, Palmirotta R, D'Anastasio R, Mariani-Costantini R(1999). Identificazione e diagnosimolecolare di condizionipatologiche in repertischeletriciumaniantichi. In Rollo F, (ed) Il DNA nello studio deirestiumaniantichi. Medical Books. pp.104.

[14] Moskowitz RW, Altman RD, Hochberg MC, Buckwalter JA, Goldberg VM. Osteoarthritis Diagnosis and medical/surgical management, Fourth Edition, Lippincott, Williams and Wilkins. 2007; 395.

[15] Lane NE, Wallace DJ. All about Osteoarthritis. Oxford University Press, 2002, 17-18.

[16] Grelsamer RP, Dejour D, Gould J. The pathophysiology of patellofemoral arthritis, *Orthop Clin N Am*. 2008;39:269-74.

[17 Floyd RT, Manual of structural kinesiology. 17th edition, Mc-Graw Hill-Higher Education, Boston, 2009.

[18] Csintalan RP, Schulz MM, Woo J, McMahon PJ, Lee TQ. Gender differences in patellofemoral joint biomechanics. *Clinic Orthop Relat Res*. 2002; 402: 260-9.

[19] Dejour D, Evaluation and treatment of patellar instability, *COROLYN Clinique Sauvegarde,* www.soy.fi/files/134.pdf.

[20] McAlindon TE, Snow S, Cooper C, Dieppe PA. Radiographic patterns of osteoarthritis of the knee joint in the community: the importance of the patellofemoral joint. *Annals of the Rheumatic Diseases*.1992;51:844-49.

[21] Berry AC, Berry RJ. Epigenetic variation in the human cranium. *J Anat.* 1967; 101: 361-79.

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