www.ijmse.com

International Journal of Medical Science and Education
pISSN- 2348 4438 | eISSN-2349- 3208
Published by Association for Scientific and Medical Education (ASME)
Int.J.Med.Sci.Educ. Nov.-December 2020; 7(6) : 88-92
Available Online at www.ijmse.com

Original Research Article

MORPHOMETRIC ANALYSIS OF THE PATELLA BONE AS ASSESSED BY MAGNETIC RESONANCE IMAGING IN NORTH INDIAN POPULATION

Ravindra Kumar[1], Raman Grover[2*], Jaswant Goyal[3], Pragya Gupta[4], Naveen Meena[5], Devendra Kumar[6]

1. Assistant Professor, Department of Radiology, 2. Assistant Professor, Department of Dentistry, 3. Associate Professor, Department of Pharmacology, 4. Statistician, Department of Community Medicine, 5. Associate Professor, Department of Radiology, 6. Assistant Professor, Department of Radiology, Jaipur National University Institute for Medical Sciences and Research Centre, Jagatpura, Jaipur.

*Corresponding author – **Raman Grover**

Email id – ramangrov0211@gmail.com

Received:* 04/12/2020** ***Revised:15/12/2020 ***Accepted: 21/12/2020***

ABSTRACT

Background: Anatomic variations based on ethnicity and gender play an important role in designing of prosthesis for knee surgeries and commercially available prostheses are majorly based on Caucasian morphometry. The present study aimed to assess the patella bone by magnetic resonance imaging in North Indian population. **Materials and Method:** The present retrospective study comprised of axial magnetic resonance images of the knee joint of 60 North Indian adults (35 males, 25 females; aged between 20–70 years). The patellar width, thickness, lateral facet width, facet thickness, ratio of the lateral facet, the relative thickness and ratio of facet thickness were measured in the by using the digital ruler. The statistical analysis was done by unpaired t test and performed by using the R statistical software. **Results:** Patellar width, thickness and lateral facet width demonstrated statistically highly significant gender wise variations suggesting sexual dimorphism ($P \leq 0.001$). The mean value was higher in males than females except for patella relative thickness and patella facet thickness ratio. It was observed that the males exhibit increased variance than females in all the measurements of patella except patella lateral facet ratio. **Conclusion:** The present study provides an important reference guide for designing gender specific prosthetic implants for North Indian population and lead to successful treatment planning in cases of anterior knee pain and patellofemoral joint disorders requiring surgical procedures such as arthroplasty of the total knee, patellofemoral arthroplasty, resurfacing of patella, and designing the prosthetic implant.

Keyword: Morphometric analysis, Patellar width, Patellar thickness, Patellar lateral facet width

INTRODUCTION

Patellar disorders are one of the most prevalent disease conditions and demand detailed and incisive knowledge of its musculoskeletal architecture for efficient treatment planning. Although the knee joint has existed with negligible change over time since about 320 million years, the patellofemoral joint that forms a significant part of the knee joint began to develop only 65 million years ago, indicating a phase of evolution of the knee joint structure in the skeletal system **(1)**. The patella with the thickest articular cartilage is the most common anatomical site of degeneration. Its subcutaneous placement renders it more prone to frequent trauma and systemic skeletal disorders. Embryologically, since it takes part in the formation and development of knee joint, the disorders of the patella are often differentially diagnosed as intra capsular derangements of knee joint. However, the study of patella in terms of morphological variations based on gender and ethnicity has various clinical and surgical implications. Determining the appropriate patellar implant size is one of the most important surgical implications for a successful surgical outcome in cases of total knee arthroplasty (TKA) or patellofemoral arthroplasty (PFA). Conventionally, intra-operative measurement of the patella poses chances of error due to the diseased joint and hence abnormal anatomy. Sexual dimorphism or gender variability in regards to external and internal morphology of patella may also serve as decisive factors and important implications for implant design and a successful functional outcome after PFA or TKA. Significant evidence based ethnical differences in the morphometry of the knee joint amongst Asian and Caucasian population has already been documented **(2)**. Majority of the available knee prosthesis for TKA or PFA have been commercially designed based upon the dimensional analysis from the anthropometric baseline data of the Caucasians, which certainly may not be applicable for the Asian population **(3-6)**.

The present study aims to investigate and analyse the anatomy of patella bone in North Indian population using magnetic resonance imaging (MRI), collect morphometric baseline data and describe gender based variations to address the clinical and surgical implications for utilization of appropriately designed patellar implants for male and female patella in North Indian population.

MATERIALS AND METHOD

The present investigation is a retrospective study, conducted between 2018 and 2020 at tertiary care hospitals at Jaipur, Rajasthan, India. A total of 60 patients were studied. The randomly selected knee joint MRI films among 35 males and 25 females, aged between 20 and 70 years were included. The patients with congenital anomaly, history of trauma, surgery, acute patellar dislocation, patellar fracture, knee joint tumour, and rheumatoid arthritis were excluded from the study. The present study has the approval from the institutional ethics committee.

Although, computed tomography (CT) scan provides an ideal bone window for studying the patella but due to less number of CT scans done for the knee ascompared to X-rays and MRI, CT scans were disregarded and MRI was chosen as the preferred assessment tool. With an excellent ability to study soft tissue anatomy, MRI outlines the cartilage boundary better. However, wear and tear owing to the physiological process of ageing leads to variation in the measurements of the cartilage. Henceforth, it is not included in the measurements of the present study because of the age based variation.

Magnetic resonance imaging was performed with a Siemens Magnetom 1.5 Tesla MRI System (Siemens, Germany). Every patient was advised to lie down in supine position with the knee extended during the procedure. The T2 weighted axial magnetic resonance (MR) images of knee joint with slice thickness of 4 mm were studied. The mid transversal layer of the axial MRIs **(7)**, which allowed the visualisation of maximum transverse diameter were examined to assess the anatomy and morphological variation of the patella. The following parameters were measured in the present study:

1. Patellar width (PW): the distance between the most me¬dial and lateral ends of the patella (Fig. 1).
2. Patellar thickness (PT): the distance between the patellar central ridge point (A) to the anterior point (B) of patella (a perpendicular line was put from the patellar central ridge point [A] to the line PW, “line a”). The patellar anterior point (B) is defined as the intersection point of “line a”, and the patellar anterior bony surface. The central point of patella (O) is defined as the point of intersection between line a, and line PW (Fig. 1).
3. Patellar lateral facet width (PLFW): the distance of most lateral point of patella from the central point of patella (Fig. 1).
4. Patellar facet thickness (PFT): the distance of patellar central ridge point to the central point of patella (Fig. 1).
5. Patellar lateral facet ratio (PLFR=PLFW/PW): the PLFW was divided by the PW.
6. Patellar relative thickness (PRT=PT/PW): the PT was divided by the PW.
7. Patellar facet thickness ratio (PFTR=PFT/PT): the PFT was divided by the PT.

Data were presented as mean ± standard deviation (SD) and statistical analyses were done using unpaired t-test for each parameter to derive comparisons between genders. $P \leq .001$ was considered statistically significant. Self written programming in the statistical language R (version 4.0.3) used for the data analysis.

RESULTS

Among the dimensional parameters, the patellar width (PW), the patellar thickness (PT) and the patellar lateral facet width (PLFW) demonstrated statistically highly significant ($P \leq 0.001$) gender wise comparisons indicating sexual dimorphism (Tables 1). The mean values of all dimensional parameters were higher in males with the exceptions of patella relative thickness (PRT) and patella facet thickness ratio (PFTR) where females demonstrated higher mean values as shown in Table 1. The male patella exhibits higher variability than female patella with the exceptions of patella lateral facet ratio (PLFR).

Table 1: Gender wise comparison of the dimensional parameters

Parameter	Male	Female	*P*-value
Patella width(mm)	44.42± 3.59	39.11±2.53	<0.001*
Patella thickness(mm)	19.37± 2.33	17.74± 1.28	0.001*
Patella lateral facet width (mm)	25.05± 2.88	22.21± 2.08	<0.001*
Patella facet thickness (mm)	11± 1.20	10.56± 1.07	0.14
Patella relative thickness (mm)	0.44± 0.06	0.45± 0.04	0.16
Patella lateral facet ratio	0.56± 0.04	0.57± 0.05	0.64
Patella facet thickness ratio	0.57± 0.06	0.60± 0.05	0.10

* Statistically significant

Table 2: Comparison of the patella width and thickness with the data from literature

Population Studied	Patella width (mm)		Patella thickness (mm)		Study
	Male	Female	Male	Female	
Western	50.3	43.5	23.9	21.8	Baldwin and House
Korean	47	41.2	23.1	21.2	Yoo et al.
South Chinese	47	41.2	23.9	21.5	Shang et al.
South Indian	42.2	36.1	20.3	16.2	Reshma et al.
North Indian	44.8	39.6	19.3	17.9	Present study

A comparative analysis of the patella width and thickness between various ethnicities including Western, Korean, South Chinese, South Indian and the current study of North Indian population is presented in Table 2.

DISCUSSION

Multiple assessment tools over a period of many decades have been employed for morphometric analyses of the human skeleton including patella. Direct methods include cadaveric or dried bone examinations **(6,8)** and the intraoperative measurement of the surgical sites of the patients undergoing PFA or TKA surgeries with the help of calipers performed by the operating surgeon **(9-11)**. However, both these methods have the disadvantage of limited clinical material for a substantial clinical research. Indirect methods employ non-invasive radiographic measurements and analysis with an added advantage of digital reproducible data for future references with enhanced accuracy while performing techniques of geometrical morphometry. Magnetic resonance imaging was employed as the preferred assessment tool in the present study owing to its excellent reproducibility, non-invasiveness and most importantly the ability to study soft tissue details of the patellofemoral joint including the cartilage.

As per the morphometric analysis in the present study, magnetic resonance imaging demonstrated statistically significant gender based variations ($P \leq .001$) suggesting sexual dimorphism in regards to the patellar width, patellar thickness and patellar lateral facet thickness. It was observed that the male patellae had wide commutative range than the female patellae. These findings were in accordance with the extensive studies conducted by Baldwin and House in the Western Population **(9)**, Shang et al in Chinese population **(12)**, Yoo et al in Korean population and Reshma et al in South Indian population **(13,14)**. In the present study we found that patella in males demonstrated higher mean values as compared to the female counterparts in majority of dimensional parameters except patellar relative thickness and patellar facet thickness ratio. Higher variation in the male patellae than females with the exception of patellar lateral facet ratio were also observed in the present study. Similar trends were observed for the South Indian population **(14)**.

In the present study, the mean patellar width in males and females were 44.42± 3.59 mm and 39.11 ±2.53 mm respectively which was smaller than the Western population **(9)**, Korean population **(13)** and Chinese population **(12)**, although there were important differences between males and females patellae amongst the South Indian population and the North Indian population in our study. The South Indian population has lower mean values for the males and females patella as compared to the North Indian population. In regards to the patellar thickness, the North Indian population in our study exhibited lesser mean values as compared to the Western, Korean and South Indian population (Table 2). However, it was reported that the South Indian population has smallest mean values for males. Parallel results were found in the present study too suggesting that the Indian population exhibit thinnest patella as compared to other ethnic groups and are more susceptible for patellofemoral disorders, henceforth, becoming an important predisposing factor for designing prosthetic implants in cases of knee arthroplastic surgeries. It is important to note that in the present study, the mean patellar thickness for males is lower than females as compared to the South Indian population. Patellar thickness remains one of the most pertinent factors for a successful surgical outcome. Although total knee arthroplasty is consistently the most potent surgical management yet post-surgical complications in the form of patellofemoral joint derangement cannot be neglected. The latter certainly depends upon the patellar thickness and the nature of defect **(15)**. No denying the fact that thinner patellae reduce the frictional stresses but simultaneously are prone for stress fractures and instability. They can cause decreased range of movements in the knee leading to subluxation and derangement. Increase in thickness of the patella increases the movement of quadriceps at a low flexion angle. Any variation in the thickness of patella results in lower contact area as compared to the normal anatomical morphology. It certainly is a wise decision to reference the morphometric data in regards to ethnicity, gender and age during the process of designing the prosthetic implant and surgical planning of implantation. The present study is of utmost use as it provides important baseline data for the North Indian population.

The ratio of patellar thickness to width (PRT) is another important factor to approximate the thickness of premorbid patella and henceforth the size of the prosthetic implant as studied by Iranpour et al **(16)**. The present study demonstrates smaller PRT indicating smaller patella that predisposes to greater risk of patellar dislocation in the North Indian population particularly females.

North Indian males and females in our study exhibited mean PLFW values of 25.05 mm and 22.21 mm respectively. North Indian population have lower mean of PLFW as compared to Western population where males and females demonstrated higher mean values 29.7 mm and 25.3 mm respectively **(9)**. Similarly, South Chinese population also reported with higher mean values of 26.91 mm in males and 23.30 mm in females **(12)**. Contrarily, North Indian population elicits higher mean PLFW as compared to South Indian population (males: 22.59 mm, females: 19.47mm) **(14)**. The PFT for North Indian population was reported to be 11 for males and 10.56 for females, although it was statistically insignificant. Additionally, Yang et al reported higher risk for lesions of the patellar femoral cartilage in cases of the dominant lateral articular facet **(7)**. In present study, the PFTR was 0.57 for males and 0.60 for females.

The patella holds extreme importance as being the largest sesamoid bone in the human body and a core component in the extensor mechanism of the lower extremity. Gender based anatomical variation of the patella as evidenced from the obtained morphometric data can also have medicolegal implications for gender identification in the field of forensic anthropology **(17-20)**.

Overall, based on the axial MR images of the patella obtained from the North Indian population in the present study, males have a larger sized patella as compared to females. The North Indian population has smaller and thinner geometric morphology as compared to other ethnicities primarily Western, Chinese and Korean population. In the present study we also observe changes between North Indian and South Indian population. The North Indian population has larger and broader dimensions as compared to South Indian population.

CONCLUSION

The present study provides an important reference guide for designing gender specific prosthetic implants for North Indian population and lead to successful treatment planning in cases of anterior knee pain and patellofemoral joint disorders requiring surgical procedures such as arthroplasty of the total knee, patellofemoral arthroplasty, resurfacing of patella, and designing the prosthetic implant. Magnetic resonance imaging provides useful morphometric data with optimum accuracy and desired reproducibility.

Funding: None

Conflict of interest: None

REFERENCES

1. Dye SF. Functional morphologic features of the human knee: an evolutionary perspective. Clin Orthop. 2003;410(410):19-24. doi: 10.1097/01.blo.0000063563.90853.23, PMID 12771813.
2. Faraj AA, Nevelos AB. Ethnic factors in Perthes disease: a retrospective study among white and Asian population living in the same environment. Acta Orthop Belg. 2000;66(3):255-8. PMID 11033915.
3. Ho WP, Cheng CK, Liau JJ. Morphometrical measurements of resected surface of femurs in Chinese knees: correlation to the sizing of current femoral implants. Knee. 2006;13(1):12-4. doi: 10.1016/j.knee.2005.05.002, PMID 16122927.
4. Kwak DS, Han S, Han CW, Han SH. Resected femoral anthropometry for design of the femoral component of the total knee prosthesis in a Korean population. Anat Cell Biol. 2010;43(3):252-9. doi: 10.5115/acb.2010.43.3.252, PMID 21212865.
5. Lim HC, Bae JH, Yoon JY, Kim SJ, Kim JG, Lee JM. Gender differences of the morphology of the distal femur and proximal tibia in a Korean population. Knee. 2013;20(1):26-30. doi: 10.1016/j.knee.2012.05.010, PMID 22721912.
6. Vaidya SV, Ranawat CS, Aroojis A, Laud NS. Anthropometric measurements to design total knee prostheses for the Indianpopulation. J Arthroplast. 2000;15(1):79-85. doi: 10.1016/s0883-5403(00)91285-3, PMID 10654467.
7. Yang B, Tan H, Yang L, Dai G, Guo B. Correlating anatomy and congruence of the patellofemoral joint with cartilage lesions. Orthopedics. 2009;32(1):20. doi: 10.3928/01477447-20090101-27, PMID 19226043.
8. Introna F Jr, Di Vella G, Campobasso CP. Sex determination by discriminant analysis of patella measurements. Forensic Sci Int. 1998;95(1):39-45. doi: 10.1016/s0379-0738(98)00080-2, PMID 9718670.
9. Baldwin JL, House CK. Anatomic dimensions of the patella measured during total knee arthroplasty. J Arthroplast. 2005;20(2):250-7. doi: 10.1016/j.arth.2004.09.027, PMID 15902866.
10. Hitt K, Shurman JR 2nd, Greene K, McCarthy J, Moskal J, Hoeman T, Mont MA. Anthropometric measurements of the human knee: correlation to the sizing of current knee arthroplasty systems. J Bone Joint Surg Am. 2003;85-A;Suppl 4:115-22. doi: 10.2106/00004623-200300004-00015, PMID 14652402.
11. Kim TK, Chung BJ, Kang YG, Chang CB, Seong SC. Clinical implications of anthropometric patellar dimensions for TKA in Asians. Clin Orthop Relat Res. 2009;467(4):1007-14. doi: 10.1007/s11999-008-0557-0, PMID 18855087.
12. Shang P, Zhang L, Hou Z, Bai X, Ye X, Xu Z, Huang X. Morphometric measurement of the patella on 3D model reconstructed from CT scan images for the southern Chinese population. Chin Med J (Engl). 2014;127(1):96-101. PMID 24384431.
13. Yoo JH, Yi SR, Kim JH. The geometry of patella and patellar tendon measured on knee MRI. Surg Radiol Anat. 2007;29(8):623-8. doi: 10.1007/s00276-007-0261-x, PMID 17898923.
14. Muhamed R, Saralaya VV, Murlimanju BV, Chettiar GK. In vivo magnetic resonance imaging morphometry of the patella bone in South Indian population. Anat Cell Biol. 2017;50(2):99-103. doi: 10.5115/acb.2017.50.2.99, PMID 28713612.
15. Hsu HC, Luo ZP, Rand JA, An KN. Influence of patellar thickness on patellar tracking and patellofemoral contact characteristics after total knee arthroplasty. J Arthroplast. 1996;11(1):69-80. doi: 10.1016/s0883-5403(96)80163-x, PMID 8676121.
16. Iranpour F, Merican AM, Amis AA, Cobb JP. The width:thickness ratio of the patella: an aid in knee arthroplasty. Clin Orthop Relat Res. 2008;466(5):1198-203. doi: 10.1007/s11999-008-0130-x, PMID 18330664.
17. Akhlaghi M, Sheikhazadi A, Naghsh A, Dorvashi G. Identification of sex in Iranian population using patella dimensions. J Forensic Leg Med. 2010;17(3):150-5. doi: 10.1016/j.jflm.2009.11.005, PMID 20211456.
18. Bidmos MA, Steinberg N, Kuykendall KL. Patella measurements of South African whites as sex assessors. Homo. 2005;56(1):69-74. doi: 10.1016/j.jchb.2004.10.002, PMID 15901119.
19. Dayal MR, Bidmos MA. Discriminating sex in South African blacks using patella dimensions. J Forensic Sci. 2005;50(6):1294-7. doi: 10.1520/JFS2004306, PMID 16382821.
20. Kemkes-Grottenthaler A. Sex determination by discriminant analysis: an evaluation of the reliability of patella measurements. Forensic Sci Int. 2005;147(2-3):129-33. doi: 10.1016/j.forsciint.2004.09.075, PMID 15567616.

How to cite this article: Kumar R., Gupta P., Grover R., Goyal J., Meena N., Kumar D., Morphometric analysis of the patella bone as assessed by magnetic resonance imaging in north Indian population. Int.J.Med.Sci.Educ 2020;7(6):88-92