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Original Investigation

Morphometric Analysis of Patella and Patellar Ligament in the Cadavers of Nepalese Origin

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ABSTRACT

INTRODUCTION: The patella is the largest sesamoid bone in the body which develops within the tendon of the quadriceps femoris muscle. The patellar ligament is the continuation of distal part of the quadriceps femoris which finally ranges from the tip of patella to the tibial tuberosity of the tibia. The objectives of the study was to establish the morphometry of the Patella and Patellar ligament in correlation with gender and prevalence of types of patella. **MATERIALS AND METHODS:** The present study was conducted at the department of Anatomy of Nobel Medical College, Biratnagar, Nepal from Jan 2018 to June 2021. Twenty-six well embalmed adult cadavers (n=52) of known sex (13 Females and 13 Males) without any gross damage to the lower limbs were considered for the study. **RESULTS:** Out of the 52 limbs studied, the mean value of the length of patella, width of patella, thickness of patella in male were respectively 36.23±4.20mm, 37.15±6.09mm, 17.00±1.87mm. In female the values were 33.53±4.80mm, 34.53±6.07mm, 16.00±1.95mm which are highly significantly ($p<0.005$). In contrast it was also observed that the length of patellar ligament did not showed the significance differences between the male 45.92mm and female 44.92mm ($p>0.05$). So from here we can conclude that the morphometry of the patella plays an important role in the gender determination. **CONCLUSIONS:** The obtained data will be useful for the Comparative anatomy, Anthropology, Forensic Science and Evolutionary biology, anthropological records in context of Nepal and reference for the Orthopaedic surgeons in conducting the Knee replacement surgery as well.

Keywords: Gender determination, patella, patellar ligament.

INTRODUCTION

Morphologically the patella is the largest sesamoid bone in the body that develops in the tendon of the quadriceps femoris muscle. It is a flat bone that is placed "like a shield" on the front surface of the femoral condyle. It has two surfaces (front and back), three edges (upper, middle, and outer), and a downward vertex. The front surface is covered by the continuous fiber surface of the rectus femoris tendon. The quadriceps muscles converge to form a tendon. In addition, the medial femoral muscle attaches to the tendon from the inside before fusing with the distal end of the patellar ligament. The posterior surface of the patella can be divided into two parts: upper (articulated) and lower (non-articulated). The lower part forms the apex of the patella, which serves as the insertion site for the patellar ligament. However, the upper part is subdivided into outer and inner facets, which are separated by vertical ridges [1]. The proper size and thickness of the patella implant are important to ensure the functional success of the arthroplasty. Disproportionate implantation of the patellofemoral joint will result in ineffective lever support, restricted movement, excessive wear and instability

of the patella, and associated knee pain. Patella instability is usually related to abnormal patella position, variable patella shape, narrow medial articular surface, or abnormal stress on the patella. In addition, the disproportionate length of the patella-patella ligament can result in a significantly higher position of the patella (patella alta) or a lower position of the patella (patella low) at the patella-femoral joint. The size and classification of the patella, as well as the determination of the relationship between the patella and the patellar ligament in different populations, are anthropologically and clinically important in determining the size of the patellar implant [2].

The patellar ligament is a continuation of the patellar ligament. The distal end of the quadriceps, eventually from the tip of the patella to the tibial tubercle of the tibia. It is also called the patellar tendon. Its length varies from 3 to 6 cm, and the average length of an adult is about 4.5 cm [3]. Applied quadriceps tension can affect the size of the patella, so the patella is generally associated with the quadriceps. There are few morphological studies of the patella and patellar ligament, which play an important role in the design of prostheses and other knee implants [4].

Some standard anatomical texts contain major omissions about the complex shape of the patella. The details of which are very important to fully understand the function and pathological appearance of the patella complex. In some animals with very powerful knee extensions, the loss of the patella and the patellar ligament is considered to be evidence that the patella does not play a useful role in this exercise [5]. Wiberg [6] reported that the patella can be divided into three types according to the width of the medial articular surface (MAF) and lateral articular surface (LAF) and the curvature of the articular surface. According to the Wiberg classification, type I patella is defined as a patella with a concave width and equal WMAF and WLAF. Type II patella is a patella in which WMAF is flat or slightly protruding and smaller than WLAF. However, in type III patella, WMAF is convex and much larger than WLAF. Wiberg also reported that type II patella is the most common, which is consistent with the report of Fucentese et al. [7] in which they used magnetic resonance imaging to compare the patella morphology of the trochlear dysplastic knee joint with the morphology of the normal knee joint. Although, several studies have been reported from various parts of the world but there is scarce of data on morphometric study in the patella and patellar ligament of any Nepalese population.

The goal of this research was to determine the morphometry of the patella and patellar ligament in relation to gender, as well as the prevalence of different patella types, which will aid in determining evolutionary tendencies in other animals.

MATERIALS AND METHODS

Study design and setting

The present study was conducted during the normal practical routine of dissection of lower limbs in the cadaver for the MBBS 1st year students at the department of Anatomy of Nobel Medical College Teaching Hospital, Biratnagar, Nepal. This medical college is affiliated with Kathmandu University located in Biratnagar is one of the key academic center in Nepal's eastern region enrolling in both medical and paramedical programmes along with the super-speciality departments. At full capacity, the hospital has 764 beds available. It serves patients from a variety of ethnic groups in Nepal and India's Bihar State. The study was conducted in the time period of Jan 2018 to June 2021.

Participants and procedure

For the study 26 well embalmed adult cadavers (n=52) of known sex (13 Females and 13 Males) without any gross damage to the lower limbs were considered. The knees and upper part of legs of the cadaver were exposed according to standard procedures in the Grant's Dissector Manual[8]. All

the dissection procedures are performed with the cadaver in supine on the dissection table. A 15-cm incision was made inside the knees of the cadaver, and the skin and fascia were then carefully removed to expose the quadriceps tendon, patella, and patellar ligament. The quadriceps tendon and patellar ligament were carefully released from the underlying structure without causing any damage or changes to the desired structure. With the knee flexed as much as possible but not in excess of 45 degrees.

Bilateral exposure of the knee was done to expose the patella and patellar ligament. Length of Patella, Width of Patella, Thickness of patella, Thickness of patella, Length of patellar ligament, Width of patellar ligament as well as the maximum widths of the medial (WMAF) and the lateral articular facets (WLAF) were measured by the help of Digital Vernier Cliper. Based on the dimension of WMAF in relation to WLAF, each patella was classified into one of three categories: Type I (WMAF=WLAF), Type II (WMAF<WLAF) or Type III (WMAF>WLAF).

Well embalmbed cadavers with intact lower limbs of known sex of Nepalese origin were considered for the study. Dry cadavers, difficult to dissect with damaged lower limbs of unknown sex and cadavers with osteoarthritic changes to the knee, visible surgical scars in the knee region, physical signs of deformity of the patella or signs of patellofemoral disease were excluded from the study.

Statistical analysis and data management

Data was entered into SPSS 20 for analysis. Frequency, mean and standard deviation was calculatedand reported. Student 't' test was applied. The p-value ≤0.05 was considered to be statistically significant.

Ethical considerations

Ethical approval was obtained from the Institutional Review Committee of Nobel Medical College Teaching Hospital, Biratnagar (Reference No.425/21).

RESULTS

Table 1 shows the mean value of the various parameters of right and left side for the male cadavers. The mean values of the length of patella, width of patella, thickness of patella in male were respectively 36.23±4.20mm, 37.15±6.09mm, 17.00±1.87mm. Likewise, in female the values were 33.53±4.80mm, 34.53±6.07mm, 16.00±1.95 mm which are highly significantly (p<0.005) (Table 2). Out of the 52 limbs studied, regarding the patella and patellar ligament it was found that there was no significance difference between the right and left side of the patella and patellar ligament in each of the gender, which served as symmetry of the limb (Table 1 and 2).

Table 1 | Measurements of patella and patellar ligament (Male)

Parameters	Right side Mean±SD	Left side Mean±SD	p-value
Length of patella	36.23±4.20	36.15±4.29	0.794
Width of patella	37.15±6.09	37.00±6.15	0.337
Thickness of patella	17.00±1.87	17.00±1.63	1.000
Length of patellar ligament	45.92±10.23	45.92±10.23	1.000
Width of patellar ligament	27.07±4.19	27.07±4.19	1.000
Width of medial articular facet	20.46±1.76	20.46±1.22	1.000
Width of lateral articular facet	23.84±2.57	23.54±2.14	1.000

While comparing the various parameters between the male and female, it was observed that there was significant difference in the length of patella, width of patella, thickness of patella, width of patellar ligament, width of medial and lateral articular facets (p<0.005) except length of Patellar ligament (p=0.679) shown in Table 3.

Table 2 | Measurements of patella and patellar ligament (Female)

Parameters	Right side Mean±SD	Left side Mean±SD	p-value
Length of Patella	33.53±4.80	33.30±4.76	0.190
Width of Patella	34.53±6.07	34.46±5.99	0.584
Thickness of Patella	16.00±1.95	16.84±1.99	0.165
Length of Patellar ligament	44.92±9.12	44.76±9.06	0.165
Width of Patellar ligament	23.84±4.46	23.76±4.30	0.337
Width of medial articular facet	15.69±2.09	15.69±2.13	1.000
Width of lateral articular facet	18.53±3.01	18.54±2.34	1.000

Table 3 | Measurements of patella and patellar ligament (Male vs Female)

Parameters	Male Mean±SD	Female Mean±SD	p-value
Length of Patella	36.23±4.20	33.53±4.80	0.001
Width of Patella	37.15±6.09	34.53±6.07	0.001
Thickness of Patella	17.00±1.87	16.00±1.95	0.005
Length of Patellar ligament	45.92±10.23	44.92±9.12	0.679
Width of Patellar ligament	27.07±4.19	23.84±4.46	0.005
Width of medial articular facet	20.46±1.76	15.69±2.09	0.001
Width of lateral articular facet	23.84±2.57	18.53±3.01	0.001

While observing the patella in male and female for various types, Type II was the most prevalent type of patella (84.7%) among both the sexes whereas Type I was 15.3%.

Table 4 | Prevalence of types of Patella in Male and Female

Gender	Type I	Type II/III	No. of Patella
Male	4 (15.3%)	22 (84.7%)	26
Female	4 (15.3%)	22 (84.7%)	26
Total	8 (15.3%)	42 (84.7%)	52

DISCUSSION

The study done on other parts of the world by Yoo et al. showed the mean value of length of patella as 44.6mm, width of patella as 45.8mm, thickness of patella as 22.3mm [9]which is more than the value obtained in the present study. In the present study the mean length of patella, width of patella, thickness of patella, length of patellar ligament and width of patellar ligament in males were 36.23mm, 37.15mm, 17.00mm, 45.92mm and 27.07mm respectively and in case of females the values were 33.53mm, 34.53mm, 16.00mm, 44.92mm and 23.84mm respectively. The maximum length and the width of the patella can be very much useful in close determination of the gender from the forensic point of view. So the data obtained here in relation to Nepalese origin which will help in designing the implant in contest of our country. Study done by Iranpour et al, in London showed the mean value of length of patella as 34.3mm, width of patella as 44.8mm, thickness of patella as 22.4mm [10] which is nearly equal to the value obtained in our study. The study done by Baldwin and House in USA showed that the mean thickness of patella as 22.6mm and width of patella as 46.1mm [11]. The correlation between the right and left side of the limb showed that the right limb measurement was greater than that of the left limb parameters. In a similar study done by Oladiran I. et al., in South Africa concluded that the mean value of length of Patella, width of patella, thickness of patella, length of patellar ligament, width of patellar ligament in males were 46.94mm, 48.03mm, 25.55mm, 69.74mm, 31.52 mm respectively. Whereas in case of female the mean values of the parameters were 41.05mm, 42.71mm, 22.89mm, 62.66mm, 28.58mm respectively [12]. The various mean values calculated in our study is in contrast with the above value may be because of the geographical locations. The shrinkage of the soft tissue in the formalin fixed cadavers may alter the measurements of the structure so those short of error are neglected in the present study. In the present study it was also observed there was no significant differences in the length of the patellar ligament in males and females the mean value was 44.92mm in female and 45.92 mm in male which is in accordance with the study done by Gloria M. Hohenberger et al in his study the length of patellar ligament was 42.9mm in female and 44.2mm in male [13]. The reason behind the little asymmetry between the parameters may be because of the muscle tone on the right side of the limb due to which the parameters are a little bit higher. From the present study, it was observed

that the Type II patella was the most prevalent patella among the Nepalese populations, which is in accordance with the study done by Reider et al., Fucentese et al. and Koyuncu et al. [14]. Some variations in results may be due to difference in ethnicity, genetic makeup and environmental factors of Nepal which can be further explored. The study was limited to the cadaveric study only and was not done on the living individuals.

CONCLUSIONS

The findings of this study show that the morphometry of the patella is essential in determining gender. Males had longer patella lengths, wider patella widths, and thicker patella thicknesses than females. In addition, there were statistical differences in the length of the patellar ligament between males and females. The findings will be useful for the comparative anatomy, anthropology, forensic Science and evolutionary biology as well as local anthropological records in context of Nepal. It may also serve as a useful reference range for orthopaedic surgeons while performing knee replacement surgery. The prevalence of different patella types will be helpful in determining evolutionary trends in other mammals.

ADDITIONAL INFORMATION AND DECLARATIONS

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Data Availability: Data will be available upon request to corresponding authors after valid reason.

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