

Morphologic Evaluation of the Patella: The Impact of Gender and Age

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Introduction: The patellofemoral joint is a complex joint that plays a crucial role in knee joint function and stability. This study aims to describe the MRI characteristics of the patellofemoral joint in Vietnamese adults.

Subjects and Methodology: A cross-sectional study was conducted on 280 patients at Hue UMP Hospital from May 2020 to May 2021. All patients underwent knee MRI using Siemens Magnetom Amira 1.5 Tesla. The evaluation parameters included the morphology of the patella and the femoral trochlea.

Results: The study found that the morphological parameters of the patellar joint varied significantly between genders and age groups. The mean largest patellar transverse diameter was 4.26 ± 0.37 cm, the average length of the lateral joint facet was 2.5 ± 0.26 cm, and the medial joint facet was 2.0 ± 0.25 cm. The patellar height was 4.07 ± 0.35 cm. The indexes of patellar morphology were higher in men than in women, except for the lateral-medial facet ratio. The most common Wiberg classification was type B (63.9%), followed by type C (25.4%), and type A was the least common (10.7%). There was a statistically significant difference in the patellar measurements between different age groups. There was a weak negative linear correlation between the dimensions of the largest transverse diameter, the length of the articular surface, the patellar articular angle, and the age of the patient. Additionally, there was a moderate inverse linear relationship between patellar height and patient age.

Conclusion: This study highlights the significant variations in patellar morphology based on gender and age. The findings emphasize the importance of careful assessment and consideration of these variations in the imaging evaluation of the patellofemoral joint.

Keywords: patellofemoral joint, anterior knee pain, patellar morphology, Vietnamese, Insall-Salvati ratio

Introduction

The patellofemoral joint is a complex joint in terms of both kinematics and balance, ensuring knee joint function and stability.¹ Anterior knee pain is a common condition in clinical practice, accounting for 11–17% of all cases of knee pain.^{2,3} It is characterized by pain in the anterior knee, around the patella, which occurs during activities such as squatting, walking up and down stairs, or sitting with knees bent.⁴ This condition reduces the ability to perform daily activities and affects the quality of life.^{5,6} It can occur at any age, including in adolescents, middle-aged individuals, and the elderly.^{4,7} Women are two to three times more likely to experience this condition than men.^{8,9} Anatomical variations leading to joint or patellar instability have been linked to increased joint pressure, which in turn is associated with pathological changes in the surrounding soft tissues and symptoms of patellar pain.^{10,11}

Anterior knee pain can be long-lasting and requires appropriate treatment if risk factors persist.⁸ Therefore, it is important for radiologists to scrutinize the morphology of the patellofemoral joint and the surrounding soft tissues when evaluating the joint. Additionally, clinicians dealing with these disorders must have a thorough understanding of the basic anatomy and biomechanics of the patellofemoral joint. Imaging techniques are frequently required to assess the patellar joint, determine the source of pain, and exclude associated pathologies.

Radiographs are typically the initial imaging method employed for patients experiencing knee pain. Magnetic resonance imaging (MRI) assists in examining the joint from various perspectives, assessing cartilage damage, and

investigating soft tissue involvement. Certain research has indicated that ethnic variances may impact the morphological aspects of the patellar joint.^{12–14} Therefore, this study was undertaken to delineate the MRI features of the patellofemoral joint in Vietnamese adults.

Research Subjects and Methodology

A cross-sectional study involving 280 patients was conducted at the Hue University of Medicine and Pharmacy Hospital in Vietnam from May 2020 to May 2021. Patients who had undergone knee MRI were included. Patients who had undergone previous knee surgery, experienced trauma, or exhibited bone deformities in the joint area, those with tumor-like lesions in the soft tissue surrounding the joint, and individuals with severe osteoarthritis resulting in joint deformity were excluded.

All patients underwent knee MRI scans using a Siemens Magnetom Amira 1.5 Tesla, Siemens, Erlangen, Germany with a dedicated knee coil. Evaluation was performed by two radiologists, one with 20 years of experience and the other with 3 years of experience. If there is disagreement, they discuss the issue and conclude by consensus. The evaluation parameters encompassed the imaging morphology of the patella. Statistical analysis was done using IBM SPSS Statistics version 24. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the University of Medicine and Pharmacy, Hue University, Vietnam. Approval number: H2020/161. All patients gave written informed consent.

Morphologic Parameters

- Transverse diameter: the largest transverse diameter of the patella on the axial plane.
- Patellar height: distance from the patellar apex to the basal pole on the sagittal plane.
- Length of patellar ligament: measured at the medial margin of the ligament, from the point of patellar attachment to the tibial tubercle.
- Insall-Salvati ratio: ratio of patellar ligament length and patellar height. According to a previous study,¹² the normal range of the Insall-Salvati ratio is [0.72; 1.32]. A value less than 0.72 is defined as patella baja, while a value greater than 1.32 indicates patella alta.
- Lateral and medial patellar facets: measured in the axial plane at the slice through the largest transverse diameter of the patella.
- Medial-lateral facet ratio: the ratio of medial and lateral patellar facet.
- The patellar joint angle: the angle between the subchondral bones in the axial plane through the largest transverse diameter of the patella.
- Wiberg classification of patella: based on the asymmetry between the medial and lateral articular surfaces of the patella on the axial plane.
 - Type A: the medial joint surface is concave and almost equal to the outer joint.
 - Type B: the medial joint surface is concave and smaller than the outer joint.
 - Type C: the medial joint is convex and much smaller than the outer joint.

Illustrations of the morphologic measurements and Wiberg classification are given in [Figures 1 and 2](#).

Results

Demographics

The mean age of the study group was 39 ± 14.9 . Individuals aged 21 to 40 years constituted the largest proportion at 46.8%. Furthermore, the mean age was significantly higher in women than in men ($p < 0.05$; Mann–Whitney *U*-test). Please refer to [Table 1](#) for more details.



Figure 1 Patellar morphologic parameters. a: patellar ligament length, b: patellar height, c: patellar transverse diameter, d: lateral patellar facet, and e: medial patellar facet. (A) Midsagittal T2-weighted image. (B) Axial T2-weighted image.

Wiberg classification of patella morphology

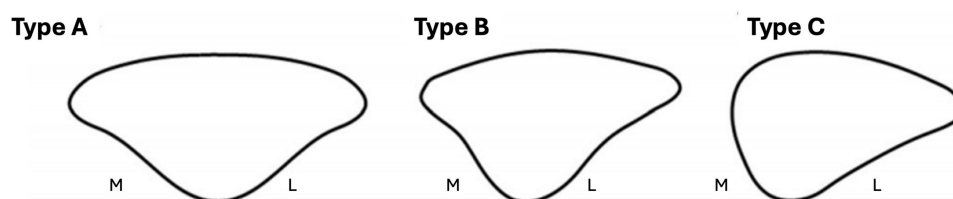


Figure 2 Wiberg classification of patellar morphology. **Type A:** the medial facet is almost equal to the lateral facet. **Type B:** the medial facet is smaller than the lateral facet. **Type C:** the medial facet is much smaller than the lateral facet.

Abbreviations: M, Medial; L, Lateral.

Patellar Morphology

The mean transverse diameter of the patella was 4.26 ± 0.37 cm. The average lateral facet was 2.5 ± 0.26 cm, while the average medial facet was 2 ± 0.25 cm. The mean patellar joint angle was 128.3 ± 8.20 degrees. The average patellar height was 4.07 ± 0.35 cm. The indices of patellar morphology in men were statistically significantly higher than in women (except for the ratio of lateral-medial facet) ($p < 0.05$; *t*-test). Please refer to [Table 2](#) for more details.

Table 1 Demographic of Participants

Age	Patients		Male (n = 150)	Female (n = 130)	p
	n= 280	%			
≤20	10	3.6	9	1	<0.001
21–40	131	46.8	88	43	
41–60	106	37.9	41	65	
>60	33	11.8	12	21	
Mean (lowest; highest)	39 ± 14.9 (17; 87)		36.23 ± 14.2 (18; 80)	46.65 ± 13.83 (17; 87)	

Table 2 Patellar Morphologic Parameters

Index	Patients	Male (n=150)	Female (n=130)	p
Transverse diameter (cm)	4.26 ± 0.37 (3.24–5.01)	4.49 ± 0.25	4.0 ± 0.31	<0.001
Lateral facet (cm)	2.5 ± 0.26 (1.55–3.91)	2.63 ± 0.24	2.36 ± 0.21	0.014
Medial facet (cm)	2.0 ± 0.25 (1.14–3.15)	2.1 ± 0.23	1.9 ± 0.23	0.01
Medial-lateral facet ratio	0.81 ± 0.13 (0.37–1.8)	0.81 ± 0.13	0.81 ± 0.14	0.455
Patellar facet angle (°)	128.3 ± 8.2 (99.7–152.8)	130 ± 7.9	126 ± 8	<0.001
Patellar height (cm)	4.07 ± 0.35 (3.3–4.87)	4.3 ± 0.26	3.81 ± 0.26	<0.001

Table 3 Wiberg Classification of Patella

Wiberg Classification	Patients		Male (n=150)	Female (n=130)	p
	N	%			
Type A	30	10.7	14	16	0.462
Type B	179	63.9	94	85	
Type C	71	25.4	42	29	

According to Wiberg classification, patellar shapes in men and women were classified as follows: type A (9.3% and 12.3%), type B (62.7% and 65.4%), and type C (28% and 22.3%), respectively (Table 3). No significant difference was found in the classification between the two sexes.

Patellar Morphology with BMI and Age

There was no statistically significant difference when comparing patellar sizes between BMI groups ($p>0.05$) (Table 4). However, there was a statistically significant difference when comparing the transverse diameter, lateral and medial facet length, and patellar height between age groups. Specifically, the transverse diameter and lateral facet were greatest in the 21–40 age group and smallest in the 41–60 age group. The medial facet was greatest in the group of 21–40 years old and smallest in the group of ≤ 20 years old. The patellar height was greatest in the age group ≤ 20 years old and smallest in the 41–60 age group (p values < 0.05 ; ANOVA and Kruskal–Wallis tests). There was a weak negative linear correlation between the transverse diameter, the lateral facet, the patellar facet angle, and the patient's age. There was a moderate inverse linear relationship between patellar height and patient age. Please refer to Table 5 and Table 6 for more details.

Table 4 Patella and BMI

Index	BMI			p
	<18.5	18.5–23	≥ 23	
Transverse diameter (cm)	4.36 ± 0.28	4.24 ± 0.41	4.26 ± 0.33	0.303
Lateral facet (cm)	2.51 ± 0.28	2.51 ± 0.28	2.5 ± 0.23	0.981
Medial facet (cm)	2.09 ± 0.23	1.99 ± 0.28	2.01 ± 0.19	0.106
Patellar facet angle (°)	127.2 ± 7.4	128.8 ± 8.6	127.9 ± 7.7	0.485
Patellar height (cm)	4.16 ± 0.28	4.05 ± 0.37	4.09 ± 0.34	0.275

Abbreviation: BMI, Body mass index.

Table 5 Patella and Age

Index	Age				p
	≤20	21–40	41–60	>60	
Transverse diameter (cm)	4.34 ± 0.31	4.37 ± 0.35	4.14 ± 0.37	4.22 ± 0.34	0.01
Lateral facet (cm)	2.6 ± 0.26	2.56 ± 0.26	2.44 ± 0.24	2.51 ± 0.3	0.02
Medial facet (cm)	1.92 ± 0.29	2.06 ± 0.24	1.96 ± 0.23	1.97 ± 0.27	0.01
Patellar facet angle (°)	132.6 ± 7.4	129 ± 8	127.2 ± 8	128.1 ± 9.1	0.118
Patellar height (cm)	4.31 ± 0.35	4.12 ± 0.33	3.96 ± 0.34	3.97 ± 0.32	<0.001

Table 6 Linear Correlation Between Patellar Indices and Age

Index	r	p
Transverse diameter (cm)	−0.248	0.021
Lateral facet (cm)	−0.157	0.006
Medial facet (cm)	−0.155	0.012
Patellar facet angle (°)	−0.158	<0.001
Patellar height (cm)	−0.331	<0.001

Insall-Salvati Ratio

The Insall-Salvati values of the study sample ranged from 0.52 to 1.41, with a mean of 0.96 ± 0.14 . The Insall-Salvati ratio was statistically higher in women compared to men ($p < 0.05$; t -test). 95.4% of patients had an Insall-Salvati ratio within the normal range. The percentage of patella alta was 0.4%, while the percentage of patella baja was 4.3%. Please refer to [Table 7](#) for more details.

Discussion

Patellar Morphology

Our findings in the Vietnamese population align with previous studies indicating that Asians generally have thinner and smaller patella compared to Europeans.^{15–17} The mean value of the largest transverse diameter in our study is smaller than the results reported by Baldwin et al for the European population.¹⁸ Similarly, the mean patellar height in our study (4.3 ± 0.26 cm in men and 3.81 ± 0.26 cm in women) is smaller than the measurements in Koreans, Chinese, and Indians ([Table 8](#)).^{15,17,19}

In terms of gender differences, our study found that the sizes of the patella in men were larger than in women, except for the medial-lateral facet joint ratio. This finding is consistent with previous reports.^{15,16,18,20}

Table 7 Insall-Salvati Ratio

Index	Insall – Salvati ratio	p
Male	0.93 ± 0.15	0.001
Female	0.99 ± 0.13	
Total	0.96 ± 0.14 (lowest: 0.52 – highest: 1.41)	

Table 8 Comparison of the Largest Transverse Diameter and Patellar Height with the Results of Some Previous Studies

Indices	Research	Nation	Total	Male	Female
Transverse diameter (cm)	Baldwin et al ¹⁸	European	4.61	5.03	4.35
	Yoo et al ²⁰	Korean	4.58	4.66	4.17
	Li et al ¹⁹	Chinese	4.38	4.69	4.05
	Shang et al ¹⁶		4.41	4.7	4.13
	Muhammed et al ¹⁵	Indian		4.22	3.61
	Our study	Vietnam	4.26	4.49	4.0
Height (cm)	Yoo et al ²⁰	Korean	4.46	4.56	4.0
	Li et al ¹⁹	Chinese	4.21	4.52	3.88
	Shang et al ¹⁶		3.99	4.28	3.71
	Upadhyay et al ²¹	Indian	4.22	4.63	3.8
	Our study	Vietnam	4.07	4.3	3.81

According to the Wiberg classification, in our study type B was the most common type of patella in both men and women (62.7% and 65.4%). No significant difference was found in the classification between the two sexes. This distribution is consistent with previous studies.^{19,22}

Our study did not find any difference in patellar sizes between BMI groups, nor did we observe a linear correlation between patellar sizes and BMI values. We observed differences in the transverse diameter, patellar height, and medial and lateral aspect length among different age groups. There is a weak negative linear correlation between patellar size and patient age, suggesting that the size of the patella slightly decreases with age, although the reason for this correlation remains unclear. This result aligns with a study by Prathum et al which found a correlation between age and morphological changes in the knee joint.²³

Insall-Salvati Ratio

The position of the patella is crucial for the functioning of the patellar joint. Patella alta is associated with reduced joint contact, resulting in pain and instability of the patellar joint.^{24,25} Study by Leung et al demonstrated that the patella position of the Chinese population in the Northern region is approximately 15–20% higher than that of the Western population.²⁶ This difference can be attributed to the long-term stretching of the patellar tendon resulting from common activities like squatting and kneeling in certain countries like India, China, Vietnam, and the Middle East.^{12,21,27,28}

In our study, we observed that the Insall-Salvati ratio is higher in women compared to men, and this difference is statistically significant. The ratio for women and men in our study was 0.99 ± 0.13 and 0.93 ± 0.15 , respectively. These results are consistent with other studies.^{21,29,30}

Conclusion

This study highlights the significant variations in patellar morphology based on gender and age. The findings emphasize the importance of careful assessment and consideration of these variations in the imaging evaluation of the patellofemoral joint.

Ethical Statement

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the University of Medicine and Pharmacy, Hue University, Vietnam. Approval number: H2020/161. All patients gave written informed consent.

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Disclosure

The authors report no conflicts of interest in this work.

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