GENDER IDENTIFICATION BASED ON PATELLAR MEASUREMENTS IN A SAMPLE OF EGYPTIAN POPULATION

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Abstract

Introduction: Identification of gender is an important feature of the biological profile since it facilitates knowledge of other sex-dependent characteristics at death such as stature and age. The patella hasn't received as much attention as other bone elements regarding discriminant function analysis for sex estimation. This study aimed to discriminate gender discrimination using MRI patellar measurements in a convenient sample of the adult Egyptian population and to assess the accuracy of sex prediction for each of the right and left sides' measurements.

Methods: This was a cross-sectional study conducted on 128 participants (82 male and 46 female) during the period from 1st of July 2023 to 31st of December 2023. They were chosen by a convenient non-random sample from attendants of Radiology Department at Menoufia University Hospitals after exclusion of non-responders and application of exclusion criteria. 11 patellar measurements were taken off-axial Pd-fat sat and T2- weighted sagittal MRI scans of the knee.

Results: The mean age of the cases was 39.9 and 44.63 years for males and females respectively. The mean length, width, and thickness of patella in males were 4.38±0.34, 4.55±0.31, and 2.09±0.22 cm respectively. Values for females were 3.90±0.31, 4.10±0.29, and 1.85±0.23 cm respectively. The difference between males and females was significant in 9 out of 11 indices, where patellar length and width demonstrated far greater sexual dimorphism. As regards each side solely, it was found that right-side patellar measurements yielded higher accuracy in classifying males and females than left-side measurements (89.7% and 62% respectively). Left-side measurements yielded lower sensitivity and specificity values.

Conclusion: The results of the current study indicate that patellar measurements are sexually dimorphic and can be used as a diagnostic tool for sex estimation, with the patellar width followed by patellar length, then maximum axial perimeter, and the maximum axial area having the highest discriminant loading. Right-side patellar measurements yielded higher accuracy in classifying males and females than left-side measurements.

Keywords: gender, sex determination; patella measurement; magnetic resonance imaging; forensic identification.

INTRODUCTION

Gender determination is one of the most difficult tasks for a forensic anthropologist in a medicolegal scenario. Identification of gender is an important feature of the biological profile since it facilitates knowledge of other sex-dependent characteristics at death such as stature and age (**Ahmed et al., 2022).**

Skeletal gender differentiation can be conducted qualitatively (morphological approach) or quantitative (metric approach). Qualitative morphological approach depends on the sexual dimorphism, where sexes of the same species exhibit different morphological characteristics, particularly characteristics not directly involved in reproduction). Parts of the skeleton that can determine more sexual dimorphism, such as the hip bone or skull, must be available, and the examiners' experimental skills are essential **(Rahmani et al., 2020).**

Instead, quantitative metric approaches depend on precise measurements using standard tools and technology, resulting in information that is far more trustable, repeatable, objective, and can be used even on damaged skeletal remains. The examiner's experimental skills are not as relevant or influential **(Krishan et al., 2016).** Bones used in the quantitative methods are characterized by higher density and more resistance to post-mortem changes rendering this method more efficient (**Rahmani et al., 2020).**

When the complete skeleton is available for examination, gender identification is more accurate. However, long bones, skull, and pelvis are commonly absent, fragmented, burned, or damaged in circumstances of mass mortality like blast injury or aircraft accident, therefore sex prediction must be tried from other areas of the skeleton (**Peckmann et al., 2016)**. The patella can be used to determine sex because it is a preservationally preferred bone **(Kaledzera et al., 2023).**

The patella is a flat bone located in front of the knee joint, having inverted triangular shape. It is the biggest sesamoid bone that grows in the quadriceps femoris muscle-tendon and is used extensively in forensics, evolutionary biology, and morphometric researches. Shape and size of the patella are affected by strength of the muscle mass; it is likely that stronger muscle masses could alter the shape and size of this bone **(Jakubik's, 2023)**. Females tend to be smaller-built than males, and there's the potential chance that some patellar measurements will show signs of sexual dimorphism **(Abdel Moneim et al., 2008).**

The patella has not gotten as much attention as other bone features when it comes to discriminant function analysis for sex estimation **(Zhan et al., 2020),** therefore the current work aimed to gender discrimination using MRI patellar measurements in a convenient sample of adult Egyptian population and to assess the accuracy of sex prediction for each of the right and left sides' measurements.

SUBJECTS AND METHODS

The current work was a cross sectional study conducted on 128 participants (82 male and 46 female) during the period from 1st of July 2023 to 31st of December 2023. They were chosen by a convenient non-random sample from attendants of Radiology Department at Menoufia University Hospitals after exclusion of non-responders and application of exclusion criteria. The study was done after approval of Ethics Committee, Faculty of Medicine; Menoufia University number (5/2023FORE18).

- **Inclusion Criteria:** knee joint MR images were obtained form participants undergoing investigation of several purposes in the Radiology Department. Subjects' sex was known and their age was 20 - 70 years.
- **Exclusion Criteria:** Any subject having congenital abnormalities in the knee, diseased or deformed patella, edema, previous surgery, severe trauma leading to acute dislocation of patella or fracture patella with or without mal-union, tumor in the knee joint, rheumatoid arthritis, erosions of bone, and any pathological changes was excluded from the study.

MRI Protocol (American College of Radiology, 2024):

The patellar measurements included in the current study were obtained from sagittal T2WI images and axial proton density fat saturation (Pd-fat sat) of the knee MRI performed for each patient, retrieved from the radiology department PACS system.

Patients were examined by a 1.5 tesla closed MRI machine (MAGNETOM Altea, Siemens Healthineers, Germany) using a dedicated MRI coil. Patients were examined in the supine position with the knee secured in the neutral position at the dedicated knee coil with cushions.

Axial PD with fat saturation images were obtained by planning the axial slices on the coronal and sagittal planes perpendicular to the line of the femur and tibia with the field of view covering the knee joint from the tibial tuberosity up to the superior border of the patella. Saturation bands above and below the axial block were added to reduce popliteal artery pulsation artifacts.

Parameters used were TR (time of repetition) 3000-4000, TE (time of echo) 15-20, slice thickness of 3 mm, flip angle130-150, phase right to left, fat saturation on, matrix 320X320 and FOV (field of view) 150-160 mm.

Sagittal T2WI images were obtained by planning on the axial plane with angle parallel to the anterior cruciate ligament with slices covering the whole knee joint from right to left. Saturation bands above and below the block were also added to reduce popliteal artery pulsation artifacts.

Parameters used were TR 3000-4000, TE 110, slice thickness of 2 mm, flip angle130, phase from head to feet, matrix 256X256 and FOV of 160-170 mm.

The images were revised and interpreted by a radiologist with more than 10 years' experience in musculoskeletal MR imaging for morphological assessment of the patella using a dedicated radiology images viewer.

The following parameters for morphological anatomical assessment of the patella were chosen, first and second parameters were found before in the literature **(Ahmed et al., 2022; Singh et al., 2023; Tomaszewska et al., 2022).** We introduced new measurement techniques to be used at both imaging and osseous parts as done for parameters 3-9. Our new measurements techniques were applied from the outer aspects of the bone excluding the cartilage. The measured parameters in details are as follows:

1- Patellar length was assessed on mid-sagittal T2WI image by using the length tool in the viewer with both calibers put at the identified upper and lower poles of the patella **(fig 1).**

2- Patellar maximum width and thickness was assessed on axial Pd-fat sat image at the mid-patella by using the length tool in the viewer with both calibers put at the identified most medial and lateral osseous aspects of the patella for width and most anterior and posterior osseous borders for the thickness, taking in consideration the exclusion of the retro-patellar cartilage **(fig 2).**

3- Patellar maximum mid-area and perimeter was assessed on axial Pd-fat sat image at the mid-patella by using the closed polygon tool in the viewer with the dots carefully placed on the osseous margins of the patella excluding the cartilage **(fig 2).**

Figure (1): 35 years old female patient right knee MR mid-sagittal T2WI image showing patellar length= 3.97 cm

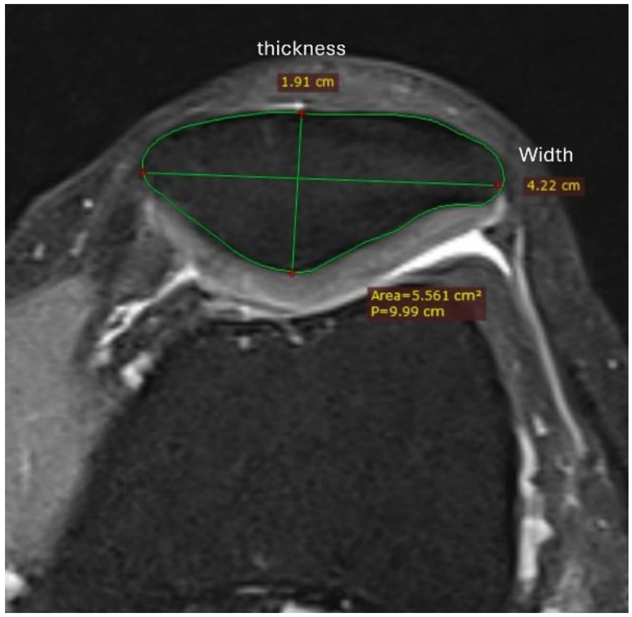

Figure (2): 56 years old male patient left knee axial Pd-fat sat MR image at the mid-patella showing: patellar thickness = 1.91 cm, patellar width = 4.22 cm, patellar maximum mid-area = 5.561 cm^2 , patellar perimeter = 9.99 cm.

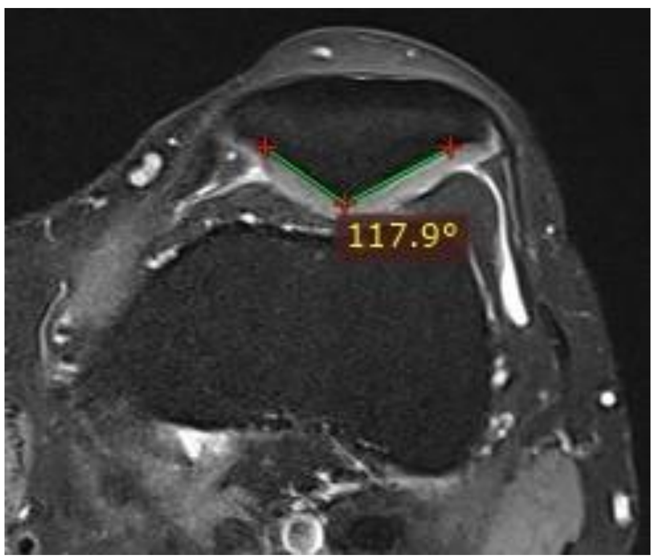

Figure (3): 29 years old female left knee axial Pd-fat sat MR image showing patellar angle = 117.9 degrees

4- Patellar angle was assessed on axial Pd-fat sat image at the mid-patella by using the angle tool in the viewer with the limbs of the angle placed at the lateral and medial facets and the vertex at the median patellar ridge **(fig 3).**

5- Patella Lateral Facet length was assessed on axial Pd-fat sat image at the mid-patella by using the length tool in the viewer with the calibers placed at both ends of the lateral facet **(fig 4).**

6- Patella Lateral Facet thickness was assessed on axial Pd-fat sat image at the mid-patella at the same level of lateral facet length assessment by using the length tool in the viewer with the calibers placed at median patellar ridge and the intersection of the line connecting both medial and lateral poles of the patella **(fig 4).**

7- Patella lateral facet angle was assessed on axial Pd-fat sat image at the mid-patella by using the angle tool in the viewer with the limbs of the angle placed at the lateral facet sides and the vertex at the most indented area of the facet **(fig 5).**

8- Patella medial Facet length was assessed on axial Pd-fat sat image at the mid-patella by using the length tool in the viewer with the calibers placed at both ends of the medial facet **(fig 4).**

9- Patella medial Facet thickness was assessed on axial Pd-fat sat image at the mid-patella at the same level of medial facet length assessment by using the length tool in the viewer with the calibers placed at median patellar ridge and the intersection of the line connecting both medial and lateral poles of the patella **(fig 4).**

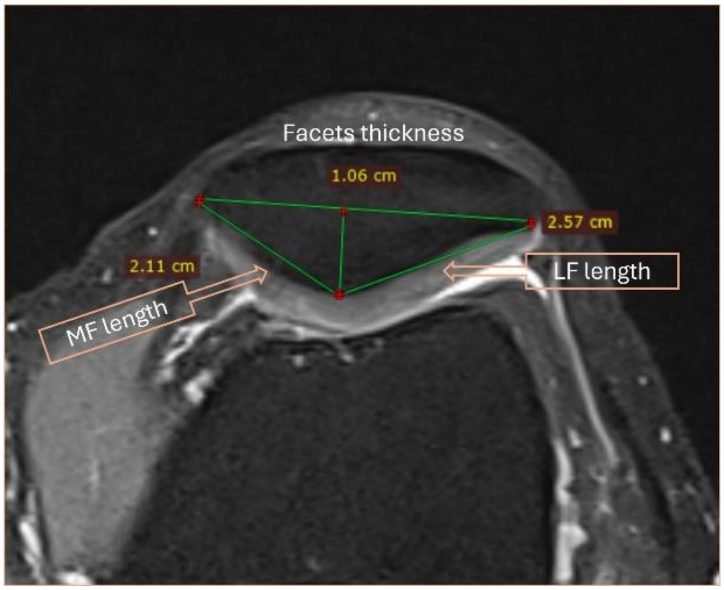

Figure (4): 53 years old male patient left knee axial Pd-fat sat MR image at the mid-patella showing: lateral facet (LF) length = 2.57 cm, Medial Facet (MF) length = 2.11 cm, thickness of each facet = 1.06 cm

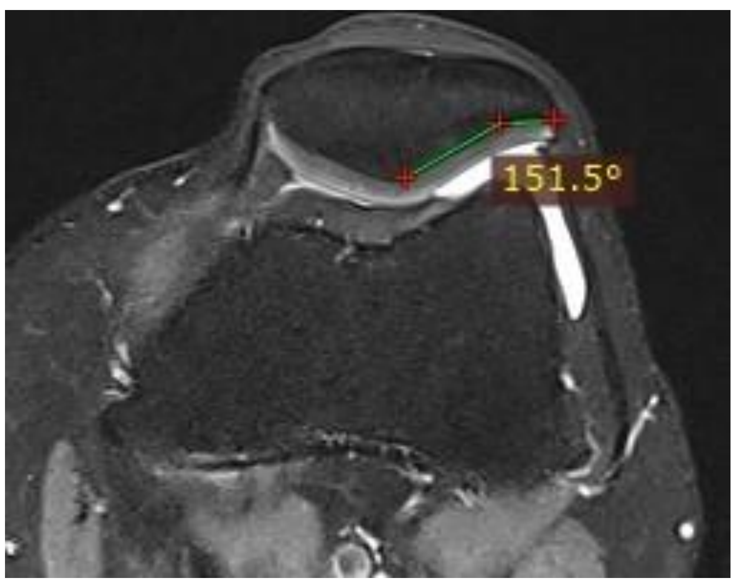

Figure (5): 61 years old male left knee axial Pd-fat sat MR image at the mid-patella showing patellar lateral facet angle = 151.5 degrees

RESULTS

As shown in **table (1) and fig (6),** there were significant higher mean values of all patellar measurements in males compared to females ($p < 0.05$).

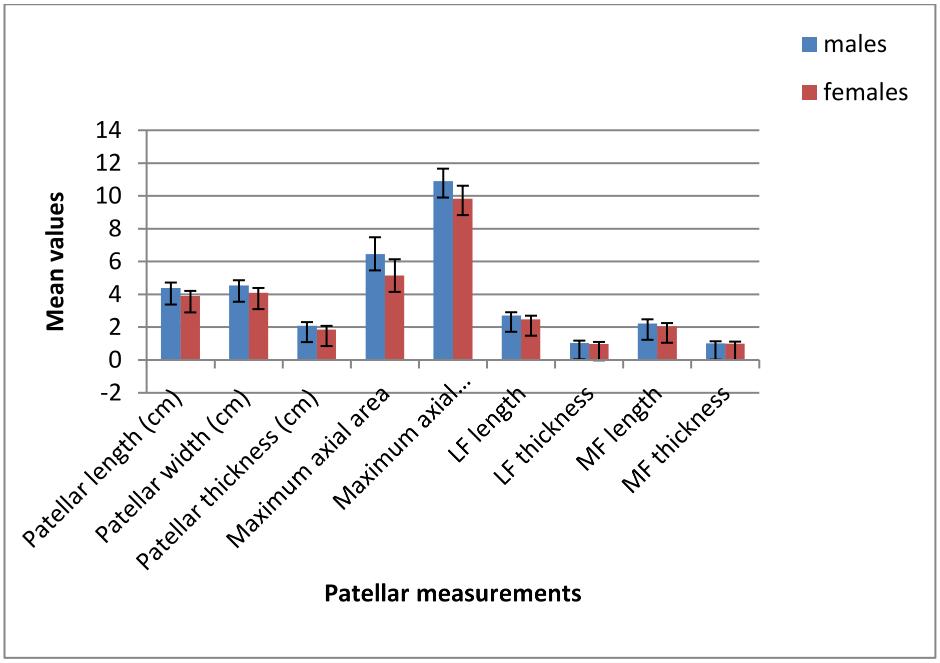

Figure (6): Mean of patellar measurements by MR imaging in males and females.

Table (1): Mean age and patellar measurements by magnetic resonance imaging (MRI) according to sex in the studied cases.

Variables	Males (n=82) Mean± SD	Females (n=46) Mean± SD	t-test	p-value
Age (years)	39.90±10.57	44.63±11.85	2.32	0.022
Min-Max	20-63	20-70		
Patellar length (cm)	4.38±0.34	3.90±0.31	7.86	<0.001
Min-Max	3.7-5.3	3.2-4.4		
Patellar width (cm)	4.55±0.31	4.10±0.29	7.95	<0.001
Min-Max	3.9-5.1	3.6-4.6		
Patellar thickness (cm)	2.09±0.22	1.85±0.23	5.87	<0.001
Min-Max	1.6-2.7	1.5-2.3		
Patellar angle (◦)	126.37±6.73	126.28±7.37	0.07	0.947
Min-Max	115.0-147.6	114.7-144.2		
Maximum axial area	6.46±1.02	5.15±0.99	6.96	<0.001
Min-Max	4.6-8.9	3.4-7.4		
Maximum axial perimeter	10.90±0.76	9.83±0.79	7.59	<0.001
Min-Max	9.3-12.4	8.3-11.4		
LF length	2.72±0.19	2.48±0.22	6.56	<0.001
Min-Max	2.4-3.2	2.1-2.8		
LF thickness	1.04±0.14	0.98±0.12	2.037	0.019
Min-Max	0.74-1.3	0.75-1.2		
LF angle	152.95±9.16	156.70±7.83	2.34	0.021
Min-Max	129.3-173.7	145.4-173.5		
MF length	2.23±0.25	2.05±0.20	4.11	<0.001
Min-Max	1.6-2.7	1.7-2.5		
MF thickness	1.02±0.12	1.00±0.12	0.75	0.452
Min-Max	0.75-1.3	0.75-1.3		

Table (2) and **fig (7)** demonstrates the most significant good predictors' measures for males versus females were patellar length (AUC=0.849, cutoff point ≥ 4.15 with sensitivity 76% and specificity 77%), patellar width (AUC=0.847, cutoff point ≥ 3.35 with sensitivity 71% and specificity 77%), maximum axial perimeter (AUC=0.835, cutoff point ≥ 10.45 with sensitivity 71% and specificity 68%) and maximum axial area (AUC=0.819, cutoff point ≥ 5.55 with sensitivity 79% and specificity 73%); respectively. Fair predictors include LF length (AUC=0.772, cutoff point ≥ 2.55 with sensitivity 82% and specificity 59%), patellar thickness (AUC=0.758, cutoff point ≥ 1.85 with sensitivity 87% and specificity 68%) and MF length (AUC=0.706, cutoff point ≥ 2.05 with sensitivity 71% and specificity 39%). The other measures were non- significant predictors.

Table (2): Sensitivity, specificity, cutoff points and area under the curve (AUC) for different patellar measurements in predicting males versus females in the studied cases

Variable	Cutoff point	Sensitivity	Specificity	AUC	P -value	95%CI (lower limit-upper limit)
Patellar length (cm)	≥ 4.15	76%	77%	0.849	<0.001	0.75-0.947
Patellar width (cm)	≥ 3.35	71%	77%	0.847	<0.001	0.752-0.942
Patellar thickness (cm)	≥ 1.85	87%	68%	0.758	0.001	0.632-0.894
Patellar angle (◦)	≥ 119.45	90%	18%	0.513	0.872	0.359-0.666
Maximum axial area	≥ 5.55	79%	73%	0.819	<0.001	0.701-0.937
Maximum axial perimeter	≥ 10.45	71%	68%	0.835	<0.001	0.730-0.940
LF length	≥ 2.55	82%	59%	0.772	<0.001	0.644-0.900
LF thickness	≥ 0.975	76%	50%	0.603	0.187	0.453-0.753
LF angle	≥ 147.7	74%	48%	0.412	0.260	0.264-0.560
MF length	≥ 2.05	71%	39%	0.706	0.008	0.573-0.839
MF thickness	≥ 0.985	76%	54%	0.612	0.151	0.457-0.766

AUC=Area under the curve CI: confidence interval

NB: AUC:
0.90-1 = excellent (A)
0.80-0.90 = good (B)
0.70-0.80 = fair (C)
0.60-0.70 = poor (D)
0.50-0.60 = fail (F)

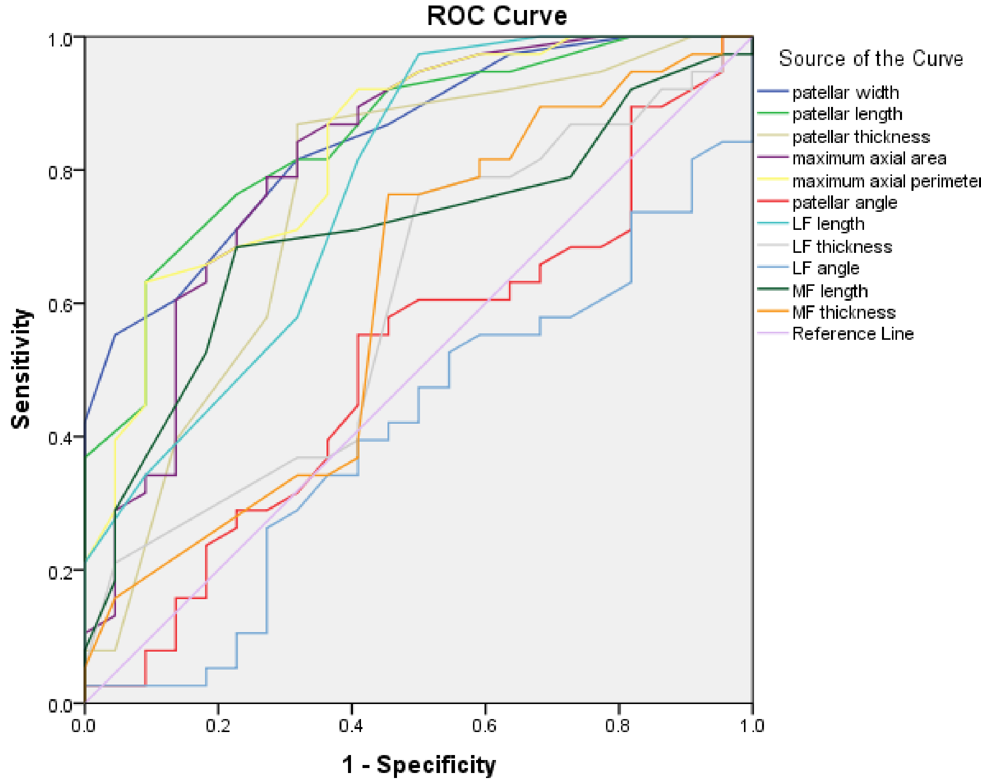

Figure (7): Receiver Operator characteristic (ROC) curve for different patellar measurements in predicting males versus females in the studied cases.

As described in **table (3),** the discriminant model of patellar measurements in discriminating gender was significant (canonical correlation=0.643, p=0.002). The discriminate loading of the patellar measurements in discriminating sex was as follows; patellar width was the highest discriminating parameter followed by patellar length then maximum axial perimeter and maximum axial area.

Table (3): Discriminant analysis for patellar measurements and Its Classifier Value

Variable	Standardized coefficient	Discriminate Loading	Univariate F ratio	Significance
Patellar length (cm)	0.512	0.834 (2)	28.164	<0.001
Patellar width (cm)	0.716	0.836 (1)	29.614	<0.001
Patellar thickness (cm)	-0.210	0.619 (6)	15.381	<0.001
Patellar angle (◦)	-0.020	-0.005 (11)	0.004	0.947
Maximum axial area	0.788	0.744 (4)	22.211	<0.001
Maximum axial perimeter	-0.584	0.793 (3)	26.301	<0.001
LF length (cm)	-0.078	0.684 (5)	20.056	<0.001
LF thickness (cm)	0.152	0.297 (8)	2.270	0.137
LF angle	-0.284	-0.250 (9)	2.164	0.147
MF length (cm)	-0.458	0.426 (7)	7.667	0.008
MF thickness (cm)	0.072	0.075 (10)	2.780	0.101
Unstandardized canonical discriminant functions:				
• Males		0.641		
• females		-1.106		
Canonical correlation		0.650		
Significance of Canonical correlation		0.002		

As regard the discriminant function of the discriminant analysis model of patellar measurements, **table 4** demonstrates that it was 89% sensitive and 78% specific in prediction of males. Regarding females, the sensitivity was found to be 78% and specificity as 89%. 85.2% of original grouped cases correctly classified.

Table 5 showed significant discriminant model of right side patellar measurements in discriminating sex (canonical correlation=0.897, p<0.001, accuracy 89.7%). The discriminate loading of measurements of the right patella in discriminating sex was as follows; patellar thickness was the highest discriminating parameter followed by maximum axial perimeter then maximum axial area.

Table (4): Predicted classification results for the discriminant analysis model of patellar measurements**.**

	Sex	Predicted Group Membership		
		male	female	Total
Original Count	male	73	9	82
	female	10	36	46
%	male	89.0	11.0	100.0
	female	21.7	78.3	100.0

Table (5): Discriminant analysis for right side patellar measurements and Its Classifier Value

Variable	Standardized coefficient	Discriminate Loading	Univariate F ratio	significance
Patellar length (cm)	0.144	0.438 (6)	33.140	<0.001
Patellar width (cm)	-0.006	0.462 (4)	36.983	<0.001
Patellar thickness (cm)	0.971	0.740 (1)	94.695	<0.001
Patellar angle (◦)	0.450	0.092 (10)	1.454	0.235
Maximum axial area	-0.180	0.513 (3)	45.589	<0.001
Maximum axial perimeter	-0.229	0.517 (2)	46.270	<0.001
LF length (cm)	0.262	0.441 (5)	33.669	<0.001
LF thickness (cm)	0.070	0.263 (9)	11.965	0.001
LF angle	-0.718	0.312 (7)	16.871	<0.001
MF length (cm)	0.116	0.286 (8)	14.145	0.001
MF thickness (cm)	0.007	0.011 (11)	0.020	0.889
Unstandardized canonical discriminant functions:				
• Males		1.215		
• females		-3.239		
Canonical correlation (accuracy)		0.897		
Significance of Canonical correlation		<0.001		

Concerning sensitivity and specificity; **table 6** revealed that the discriminant function of the discriminant analysis model of right side patellar measurements was 100% sensitive and 85.7%

specific for females. Concerning males, the sensitivity was calculated as 85.7% and specificity as 100% in prediction of males of original grouped cases correctly classified.

In regarding to left side, **table7** showed significant discriminant model of left side patellar measurements in discriminating sex (canonical correlation=0.620, p < 0.001, accuracy (62%).

The discriminate loading of the left side patellar measurements in discriminating sex was as follows; patellar length comes first as a highly discriminating parameter followed by patellar width, maximum axial perimeter then maximum axial area.

Table (6): Predicted classification results for the discriminant analysis model of right side patellar measurements.

	Sex	Predicted Group Membership		
		Male	**female**	**Total**
Original Count	male	32	2	34
	female	0	12	12
%	male	100.0	0	100.0
	female	0	85.7	100.0

Table (7): Discriminant analysis for left side patellar measurements and Its Classifier Value:

Variable	Standardized coefficient	Discriminate Loading	Univariate F ratio	significance
Patellar length (cm)	0.660	0.768 (1)	28.177	<0.001
Patellar width (cm)	1.051	0.750 (2)	29.491	<0.001
Patellar thickness (cm)	-0.472	0.444 (6)	9.858	0.002
Patellar angle (◦)	-0.299	0.078 (10)	0.307	0.581
Maximum axial area	0.842	0.586 (4)	17.186	<0.001
Maximum axial Perimeter	-0.615	0.637 (3)	20.300	<0.001
LF length (cm)	-0.055	0.555 (5)	15.420	<0.001
LF thickness (cm)	0.262	0.216 (8)	2.334	0.130
LF angle	0.170	0.048 (11)	0.113	0.737
MF length (cm)	-0.793	0.328 (7)	0.937	0.023
MF thickness (cm)	0.153	0.097 (9)	0.469	0.495
Unstandardized canonical discriminant functions:				
• Males		0.658		
• females		-0.928		
Canonical correlation (accuracy)		0.620		
Significance of Canonical correlation		<0.001		

Table 8 The discriminant function of the discriminant analysis model of left side patellar measurements was 85.4% sensitive and 76.5% specific in prediction of males, for females the sensitivity was 76.5% and specificity was 85.4% of original grouped cases correctly classified.

Table (8): Predicted classification results for the discriminant analysis model of left side patellar measurements.

	Sex	Predicted Group Membership		
		male	female	Total
Original Count	male	41	7	48
	female	8	26	34
%	male	85.4	14.6	100.0
	female	23.5	76.5	100.0

DISCUSSION

Plenty of literature is available about sex estimation from the skull, pelvis, long bones, and sternum. Because the majority of these bones that are typically used for sex determination are frequently retrieved either in a fragmented or incomplete state, it has been recently required to employ denser bones, such as the patella, calcaneus, and talus **(Yasar et al., 2018)**.

Little research is done to determine the availability of gender estimation based on patellar measurements in the Egyptian population. The current work utilized MR imaging of patella because it is non-invasive and more accurate.

The present study was carried out on 128 participants (82 males and 46 females), whose mean age was 39.9 and 44.63 years, respectively, ranging from 20 to 70 years.

In the current study, mean length, width and thickness of patella in males were 4.38±0.34, 4.55±0.31, and 2.09±0.22 cm respectively. Values for females were 3.90±0.31, 4.10±0.29, and 1.85±0.23 cm respectively. The mean of the abovementioned measurements was similar to the findings of other studies: **Oladrin et al., 2013, Peng et al., 2014, Vohra, 2017 and Ahmed et al., 2022.**

Lower values of patellar mean length; width and thickness were reported from other studies; difference can be due to different population characteristics as which were reported by **Al-Imam et al., 2016** on the Japanese ethnicity. Difference in results can be also attributed to using different measuring methods as which were reported by **Murugan et al., 2017** and **Baisakh et al., 2021,** who used sliding digital caliper on dry patellae of the Indian population. Patella is involved in several manners of sitting and squatting; as a result, cultural and ethnic factors can affect it **(Al-Imam et al., 2016).**

As regards difference in measurements between both sexes, the current results revealed that males had higher means for all patellar measurements than females. The difference was significant in 9 out of 11 indices, where patellar length and width demonstrated far greater sexual dimorphism (AUC was 0.849 and 0.847, respectively). Patellar angle and MF thickness were insignificant ($p > 0.05$).

As regards similar samples of the Egyptian population, our findings agreed with those of **Abdel Moneim et al., 2008** who studied two measurements of patella (minimum height and maximum width) and stated that there were highly significant values between males and females. Also, **Ahmed et al., 2022** revealed that the morphometric patellar measures showed significant gender difference in 5 out of 9 measurements.

As regard other populations**, Tomaszewska et al., 2022** in Poland stated similar results and found that the patella's highest height proved to be the most effective characteristic for discriminatory assessment, allowing the sex to be classified in 46.5% of cases. In Turkey, **Yasar et al., 2018** found it is possible to determine gender with an accuracy rate of 91% for females and 87% for males through three measurements of patella (transverse length, craniocaudal length and anteroposterior length). Several studies utilizing imaging techniques on patella among different populations addressed similar results: **Akhlaghi et al., 2010** and **Rahmani et al., 2020** on Iranian population **Zhan et al., 2020** on Chinese population. **Kemkes-Grottenthaler, 2005** in Germany analyzed patellar measurements from skeletal samples and declared similar results.

It is observed that our study revealed less accuracy of patellar measurements in discriminating sex (canonical correlation =65%) compared with other studies: **Michiue et al., 2018, Peckmann et al., 2016, Yasar et al., 2018, and Zhan et al., 2020.** This can be attributed to the fact the fact that the current study used 11 morphometric parameters compared to other studies that used a smaller number, and the larger number of parameters included items that are less accurate than others. Generally speaking, population variations, variations in measuring techniques, and variations in the measurements used can all be blamed for the variations in the accuracy of the patellar measurements in sex estimation between studies.

From a different point of view, we consider the larger number of parameters used to be a point of strength. It allowed us to discriminate between significant and non-significant parameters to exclude the latter in further future research.

According to discriminate loading of the patellar measurements in discriminating sex, the highest and most significant parameters were as follows: patellar width followed by patellar length, then maximum axial perimeter and maximum axial area. This coincided with **Abdel Moneim et al., 2008** and **Yasar et al., 2018**.

Slightly different results were obtained by **Dayal and Bidmos, 2005; Peckmann et al., 2016** and **Dorado-Fern´andez et al., 2020** who stated patellar height was more significant. **Zhan et al., 2020** and **Michiue et al., 2018** reported that patellar volume was the most accurate variable for sex estimation in their study.

As regard discriminant analysis for right side patellar measurements, the current results showed significant discriminant model of right side patellar measurements in discriminating sex with accuracy 89.7%, which was high compared to left side (62%). The discriminant function of the discriminant analysis model of right side patellar measurements was 100% sensitive and 85.7% specific for females. The sensitivity could be found as 85.7% and specificity as 100% in prediction of males of original grouped cases correctly classified. While as regard left side, the discriminant function of the discriminant analysis model of left side patellar measurements was 76.5% sensitive and 85% specific for females, and 85% sensitive and 76.5% specific in prediction of males.

These results coincided with **Singh et al., 2023** who found that the accuracy for classifying males and females based on right and left sides' measurements was 80% and 78.3% respectively.

Other studies addressed different results: **Chhaparwala et al., 2018 and Peckmann et al., 2016** didn't find statistically significant differences between left and right-side bones measurements. **Baisakh et al., 2021** found that the thickness of left side patella is significantly higher than right side with no significant difference found between height and width of both sides.

CONCLUSION AND RECOMMENDATION

The results of the current study indicate that patellar measurements are sexually dimorphic and can be used as a diagnostic tool for sex estimation, with the patellar width followed by patellar length, then maximum axial perimeter, and the maximum axial area having the highest discriminant loading. As regard each side solely, it was found that right side patellar measurements yielded higher accuracy in classifying males and females than left side measurements. Left side measurements yielded lower sensitivity and specificity values.

It is recommended to perform the study with a larger sample of the population from different Egyptian districts.

STRENGTHS AND LIMITATIONS OF THE STUDY:

The current study used a set of 11 metric patellar parameters, allowing full assessment of patella measurements and enabling discrimination between more, less, and non-significant ones. At the same time, the use of a larger number of parameters led to less accuracy of patellar measurements in discriminating gender in comparison to other studies.

Usage of convenient non random sample restricted to 6 months duration didn't allow having equal numbers of males and females in the sample. We included participants who fulfilled inclusion criteria regardless of their gender.

CONFLICT OF INTEREST: All authors declare that there are no conflicts of interest.

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دراسة مورفومترية للرضفة ودورها في تحديد الجنس بين عينة من السكان بمحافظة المنوفية

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المقدمة: يعتبر تحديد الفرد كذكر أو أنثى أحد الأهداف الرئيسية لأنثروبولوجيا الطب الشرعي في عملية تحديد الهوية. إذا كان الهيكل العظمي بأكمله متاحًا للفحص ، فسيكون تقدير الجنس أكثر دقة. في حالات الوفيات الجماعية مثل إصابات الانفجار أو حوادث الطائرات ،غالبًا ما تكون الجمجمه و الحوض والعظام الطويلة غائبة أو مجزأة ،لذا يجب محاولة التنبؤ بالجنس من أجزاء أخرى من الهيكل العظمي تغتبر الرضفة في جسم الإنسان هي أكبر عظم سمسماني يتطور في وتر العضلة الرباعية الفخذية. نظرًا لأن شكل وحجم الرضفة يعتمدان على قوة الكتلة العضلية ،فيوجد هناك اختلاف في القياسات بين الرجال و الاناث حيث انه من المحتمل أن تكون الكتله العضليه في الرجال اقوى من لإناث. لم تحظ الرضفة باهتمام كبيرفي تحديد الجنس. لذلك ، تركز هذه الدراسة على استخدام قياسات الرضفة في لتحديد الجنس.

الهدف من العمل: استنباط معادلات دالة تمييزية لتقدير الجنس من القياسات الشكلية الرضفي باستخدام التصوير بالرنين المغناطيسي (MRI) لعينة من السكان المصريين.

طرق البحث: اشتملت الدراسة الحالية صور MRI لمفاصل ركبة الأشخاص (يمينًا أو يسارًا) ، تم الحصول عليها من المرضى الوافدين لعمل فحوصات مختلفة فى قسم الاشعة بكلية الطب جامعة المنوفية.

• معايير الشمول: ستشمل الدراسة صور MRI لمفصل الركبة تم اختيارها في قسم الأشعة من أشخاص معروفين جنسهم وأعمارهم تتراوح بين 20 – 70 سنة.

• معايير الاستبعاد: الأشخاص الذين لديهم تاريخ من التشوهات الخلقية في الركبة ، والجراحة ، والصدمات الشديدة ، والرضفة المريضة أو الرضفة المشوهة ، وكسر الرضفة مع أو بدون ورم مفصل الركبة ، والخلع الرضفي الحاد ، والتهاب المفاصل الروماتويدي ، وأي مرض سيتم استبعاد التغييرات من الدراسة. سيتم أيضًا استبعاد تآكل العظام الشديد وفقدان كثافة العظام.

النتائج : كان متوسط عمر الحالات 39.9 و44.63 سنة للذكور والإناث على التوالي. كان متوسط طول وعرض وسمك الرضفة عند الذكور 4.38 ± 0.34 و 4.55 ± 0.31 و 2.09 ± 0.22 سم على التوالي. كانت القيم للإناث 3.90 ± 0.31 و 4.10 ± 0.29 و 1.85 ± 0.23 سم على التوالي. كان الفرق بين الذكور والإناث كبيرًا في 9 من أصل 11 مؤشرًا، حيث أظهر طول الرضفة وعرضها ازدواج الشكل الجنسي أكبر بكثير. وفيما يتعلق بكل جانب فقط، فقد وجد أن قياسات الجانب الأيمن الرضفي أعطت دقة أعلى في تصنيف الذكور والإناث من قياسات الجانب الأيسر (89.7% و62% على التوالي). أسفرت قياسات الجانب الأيسر عن قيم حساسية وخصوصية أقل.

الاستنتاج:

تشير نتائج الدراسة الحالية إلى أن قياسات الرضفة يمكن استخدامها كأداة تشخيصية لتحديد الجنس، مع عرض الرضفة متبوعًا بطول الرضفة، ثم الحد الأقصى للمحيط المحوري، والحد الأقصى للمنطقة المحورية التي لها أعلى تحميل تمييزي. أسفرت قياسات الرضفة في الجانب الأيمن عن دقة أعلى في تصنيف الذكور والإناث مقارنة بقياسات الجانب الأيسر.