Morphometric Study of Patella and Its Role in Sex Determination among Egyptians Using Magnetic Resonance Imaging

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ABSTRACT

In the morphometry of the patella, there are several naturally occurring variations. Few studies have focused on these anatomical differences among the Egyptian population. The present work aimed to evaluate age and gender variations in different morphometric patellar measurements using magnetic resonance imaging (MRI) in the Egyptian population. Nine patellar parameters were measured on 200 individuals "100 males and 100 females", aged from 20 to 70 years old using knee joint MRI obtained retrospectively from the picture archiving and communication system (PACS) of Radiology Department, Mansoura University. The mean values revealed statistically significant differences across gender for 5 out of 9 patellar measurements and 4 out of 9 across age, denoting sex and age differentiation in patellar morphology among the Egyptian population. Patellar height (PH), width (PW), thickness (PT), lateral facet width (PLFW), and facet thickness (PFT) showed statistically significant sexual dimorphism ($p \leq 0.05$) in all age groups. On the other hand, patellar angle (PA) showed the highest statistically significant difference ($p \leq 0.001$) for age estimation in all age groups. PH, PW, and PLFW showed a statistically significant negative correlation with age. Moreover, patellar measurements showed high accuracy rates for sex determination among the Egyptian population (84.3-93.6%) in different age groups. Morphometric patellar measurements obtained by non-invasive MRI examination were shown to be useful for sex determination and age prediction in the Egyptian population.

Introduction

The determination of gender is one of the main goals of forensic anthropology in the identification process (Perret et al., 2008). Classification of an individual as either male or female is considered gender determination (Afrianty et al., 2013). If the entire skeleton is available for examination, sex estimation will be more accurate, but in forensic situations, human skeletal remains are often incomplete or destroyed due to taphonomic history, animal behaviour, preservation conditions, or recovery proficiency (Krishan et al., 2016).

Since the skull, pelvis, and long bones are often missing or fractured, sex prediction must depend on other parts of the skeleton. However, the accuracy of sex determination from other skeletal remains depends on the degree of sexual dimorphism shown by the skeleton. Observation of morphological features is generally done on unfragmented skeletal remains (Gonzalez et al., 2009; Amores-Ampuero, 2017), while the metric method or statistical quantitative analysis is more objective, repeatable, and can be applied even on fragmented skeletal remains (Krishan et al., 2016).

In previous studies, other skeletal elements have been used for sex assessment such as long bones (Boldsen et al., 2015; Hishmat et al., 2015), sternum (Yonguc et al.,

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2015; Zhang et al., 2016b), scapula (Zhang et al., 2016a; El Morsi et al., 2017), clavicle (Atterton et al., 2016; Torimitsu et al., 2018), ribs (Kubicka and Piontek, 2016), fingers (Karn et al., 2019) and talus (Mahakkanukrauh et al., 2014). The patella which is the largest sesamoid bone that develops in the muscle-tendon of the quadriceps femoris has great significance nowadays not only for surgical orthopedic operations and designing of patellar prosthesis but also in forensic evaluations, evolutionary biology, and morphometric analysis. It resists postmortem and taphonomic changes, therefore it is useful for sex determination when complete skeletal remains are not present (Vohra., 2017).

While most skeleton features have been subjected to discriminant function analysis for sex estimation, the patella has received little attention. More studies from different populations are needed to encourage the usage of patellar parameters "at least one patella" in forensic anthropology for sex determination from incomplete skeletons retaining (Peckmann and Fisher, 2018; Michiue et al., 2018).

By using non-ionizing radiation, magnetic resonance imaging (MRI) allows for fast, complete, and clear visualization of the entire patellofemoral joint. Diagnostic arthroscopy has been replaced as a primary diagnostic modality by MRI, which is now considered a standard procedure. Furthermore, anatomical variations that may lead to patellar dysfunction and other types of patellofemoral joint disorders can be assessed using MRI (Muhamed and Saralaya, 2017).

The present work aims to evaluate the gender and age differences in the patella's different morphometric parameters to the greatest possible accuracy using MRI to determine the percentage of accurate sex prediction based solely on patellar measurements among the Egyptian population aged 20–70 years.

Materials and Methods:

The materials needed for the current study include MR images of the subjects' knee joints (right or left), obtained retrospectively from the picture archiving and communication system (PACS), confirming the inclusion and exclusion requirements, collected from the Radiology Department, Faculty of Medicine, Mansoura University. The research protocol was approved by Institutional Research Board (IRB), Faculty of Medicine, Mansoura University (R. 21.01.1145.R1.R2).

Study Design: The current study is a retrospective study that was performed from January 2019 to December 2020 on 200 MR images of normal patellae (100 males and 100 females).

- **Inclusion Criteria:** The study included randomly selected knee joint MR photographs taken for different purposes in the Radiology Department from subjects with known sex and their age ranging from 20 - 70 years.
- **Exclusion Criteria:** Subjects with a history of congenital abnormalities in the knee, edema, surgery, severe trauma, knee joint tumor, acute patellar dislocation, rheumatoid arthritis, and any pathological changes were excluded from the study. Extensive bone erosions and loss of bone density were also excluded.

Materials Used (MRI Protocol):

The patellar parameters in the study were measured from MR images taken from the PACS of the Radiology Department with the parameters mentioned below: (1) All studies were done using a 1.5 Tesla scanner (Philips Ingenia). (2) Every patient lies in a supine position with knee joint straightened and neutrally rotated at the time of imaging. (3) T2-weighted turbo spin-echo axial and sagittal

images of the knee joint with the following parameters (repetition time (TR) ≥2000, echo time (TE) 80-100, a field of view (FOV) 16-17, matrix 256 x 256, slice thickness 3 mm) were studied.

To determine the anatomical morphology of the patella., the following nine parameters were measured by an expert radiologist (15 years experience in musculoskeletal imaging) on the patellar mid axial and sagittal MR images, where the patellar maximal diameters were visible (Muhamed and Saralaya, 2017). The cartilage was not included in the measurements when the chondral surface was involved in any parameter measurement, due to age-based wear and tear variations in the measurements of the cartilage.

The parameters include: (1) **Patella Angle "PA":** It is the angle between medial and lateral patellar facets with the point of patellar central ridge as the zenith, (2) **Patella Width "PW":** It is the maximum distance between the most medial and the most lateral patellar points, (3) **Patella Height "PH":** It is the maximum distance between patellar apex tip and the base, (4) **Patella Thickness "PT":** It is the distance between the points of patellar central ridge to patellar anterior point, (5) **Patella Lateral Facet Width "PLFW":** It is the distance between the most lateral point of the patella and the patellar central point, (6) **Patella Facet Thickness "PFT":** It is the distance between patellar central point and patellar central ridge point, (7) **Patella Lateral Facet Ratio "PLFR=PLFW/PW":** It is patella lateral facet width : patella width, (8) **Patella Relative Thickness "PRT=PT/PW":** It is patella thickness : patella width and (9) **Patella Facet Thickness Ratio "PFTR=PFT/PT":** It is patella facet thickness : patella thickness.

All measurements were obtained using the secondary workstation provided by the vendor. To assess sex and age variations concerning patellar measurements; a total of 200 patellar MR images were divided into four groups based on their age., 20–30, 31–40, 41–50, and >50 years.

Statistical Analysis:

Data were fed to the computer and analyzed using "IBM SPSS Corp." released in 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp. Qualitative data were described using number and percent. Quantitative data were described using the mean, the standard deviation for parametric data after testing normality using the "Kolmogrov-Smirnov test". The significance of the obtained results was judged at the (0.05) level. "Student t-test" was used to compare 2 independent groups of parametric variables. Discriminant Analysis was used to predict membership in two or more mutually exclusive groups. "Pearson correlation" was used to correlate continuous parametric variables. One Way "ANOVA test" was used to compare more than 2 independent groups of parametric continuous variables with the "Post Hoc Tukey test" for within-group significance (Borror, 2009).

Results:

Two hundred knee MR images of patients; 100 (50%) were males and 100 (50%) were females; during the period (2019-2020) were included in this retrospective study. They were divided into four different age groups, "20-30", "31-40", "41-50", and ">50" years. The total number of subjects are 53 (26.5%), 45 (22.5%), 51 (25.5%), 51 (25.5%) subjects respectively in each group of age, as illustrated in table (1).

Table (1): Number and percentage of subjects in each group of age:

Age / years	Total number of subjects (%)
20-30	53 (26.5)%
31-40	45 (22.5)%
41-50	51 (25.5)%
>50	51 (25.5)%
Total	200 (100)%

The measurement values related to morphological parameters of the patella are shown in table (2). The results of the current study showed that the average size of the male patella is larger than that of the female, which was statistically significant (Figures 1, 2).

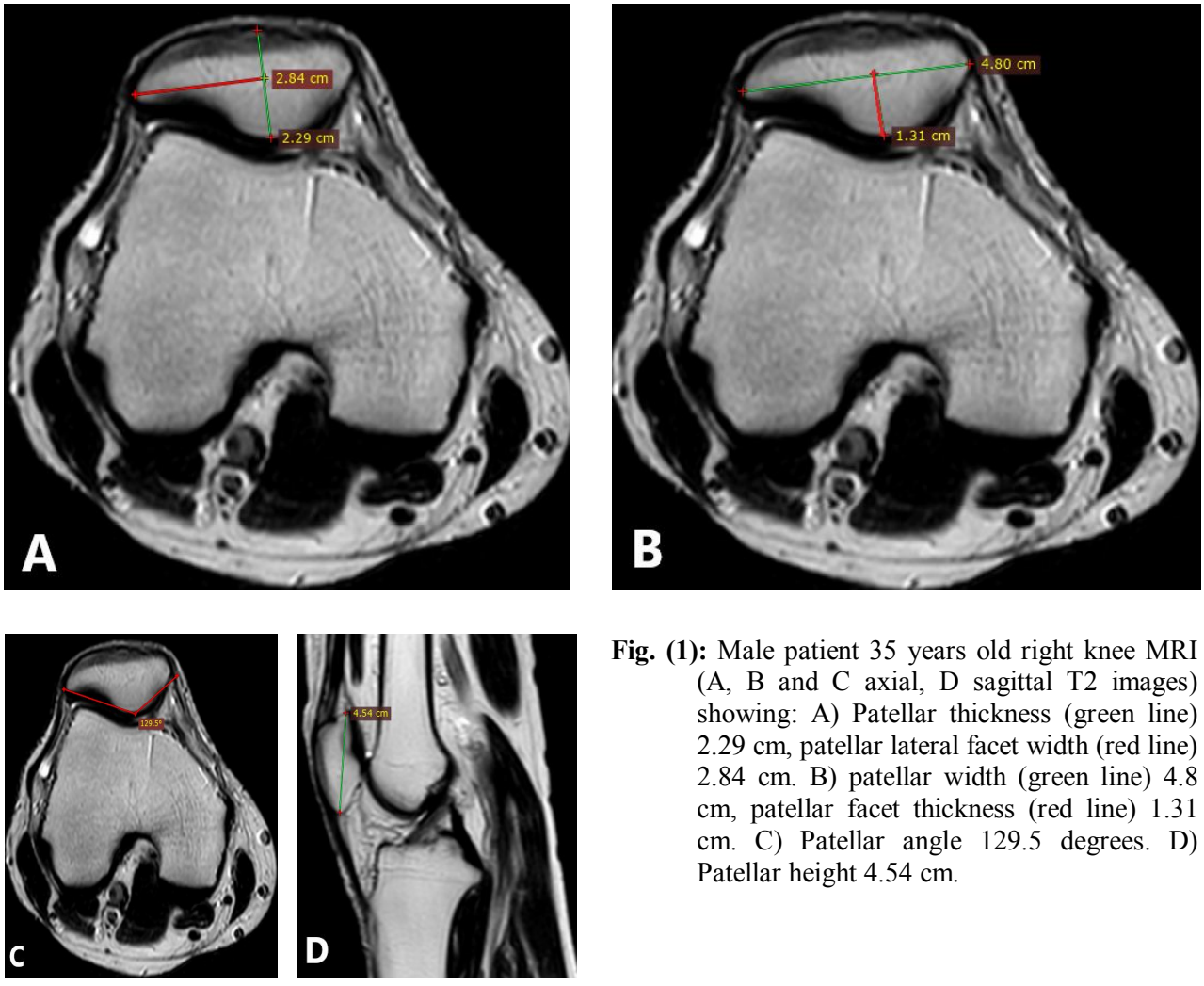

Fig. (1): Male patient 35 years old right knee MRI (A, B and C axial, D sagittal T2 images) showing: A) Patellar thickness (green line) 2.29 cm, patellar lateral facet width (red line) 2.84 cm. B) patellar width (green line) 4.8 cm, patellar facet thickness (red line) 1.31 cm. C) Patellar angle 129.5 degrees. D) Patellar height 4.54 cm.

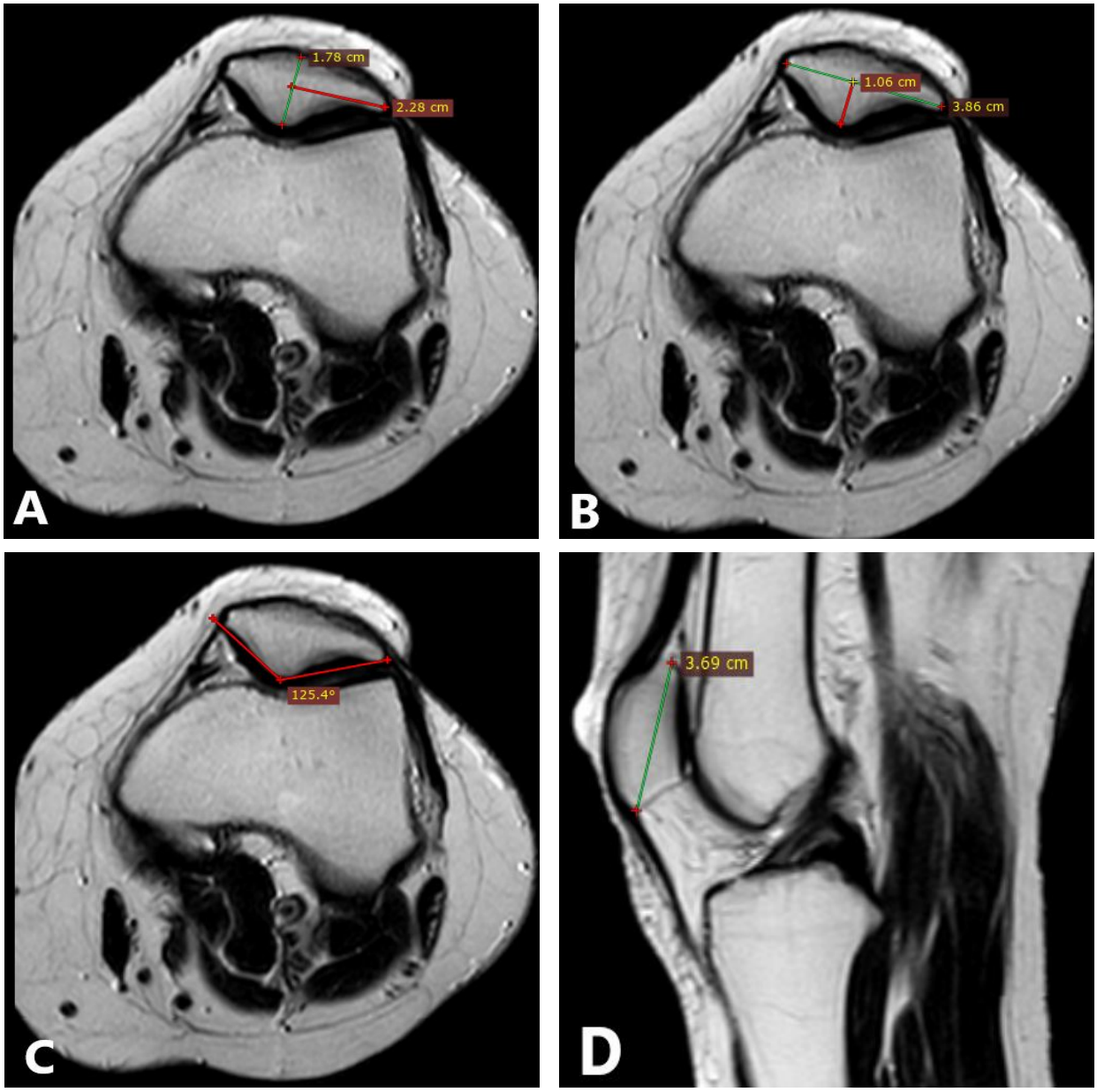

Fig. (2): Female patient 51 years old left knee MRI (A, B and C axial, D sagittal T2 images) showing: A) Patellar thickness (green line) 1.78 cm, patellar lateral facet width (red line) 2.28 cm. B) patellar width (green line) 3.86 cm, patellar facet thickness (red line) 1.06 cm. C) Patellar angle 125.4 degrees. D) patellar height 3.69 cm.

There was a gender-specific difference in patellar measurements. There was a statistically significant difference ($p \leq 0.05$) in the mean values of patellar parameters among gender in all age groups for 5 out of the 9 parameters indicating sex differences in the patellar measurements through the Egyptian population as shown in table (2).

Table (2): Mean patellar measurements distribution according to age and sex of the studied cases:

Age / years	Patellar parameters	Male	Female	t - test	p value
20-30	PH	4.54±0.322	3.81±0.22	8.02	<0.001*
	PA	134.51±4.99	130.06±4.17	3.05	0.004*
	PW	4.57±0.31	3.94±0.29	6.80	<0.001*
	PT	2.06±0.22	1.68±0.26	5.38	<0.001*
	PLFW	2.59±0.19	2.16±0.28	6.29	<0.0001*
	PFT	1.10±0.12	0.919±0.14	4.62	<0.001*
	PLFR	0.567±0.031	0.545±0.046	1.98	0.054
	PRT	0.449±0.039	0.422±0.054	2.05	0.045*
	PFTR	0.535±0.052	0.549±0.059	0.847	0.401
31-40	PH	4.52±0.45	3.85±0.22	6.98	<0.001*
	PA	133±4.20	126.95±4.95	4.54	<0.001*
	PW	4.59±0.31	3.96±0.25	8.07	<0.001*
	PT	2.12±0.20	1.79±0.25	4.98	<0.001*
	PLFW	2.48±0.29	2.20±0.17	4.22	<0.001*
	PFT	1.11±0.15	0.98±0.13	3.21	0.002*
	PLFR	0.539±0.052	0.537±0.106	0.120	0.905
	PRT	0.461±0.04	0.451±0.051	0.713	0.479
	PFTR	0.520±0.056	0.549±0.076	1.48	0.145
41-50	PH	4.56±0.28	3.83±0.26	9.28	<0.001*
	PA	133±3.45	132.25±5.12	0.59	0.555
	PW	4.56±0.32	4.07±0.29	5.46	<0.001*
	PT	2.07±0.17	1.77±0.19	5.69	<0.001*
	PLFW	2.62±0.19	2.23±0.23	6.26	<0.001*
	PFT	1.148±0.15	0.97±0.15	4.04	<0.001*
	PLFR	0.575±0.046	0.547±0.041	2.18	0.035*
	PRT	0.455±.032	0.433±0.042	1.97	0.055
	PFTR	0.554±0.068	0.546±0.056	0.411	0.683
>50	PH	4.36±0.26	3.89±0.25	6.51	<0.001*
	PA	132.84±4.93	128.95±5.47	2.54	0.014*
	PW	4.52±0.24	3.96±0.26	7.74	<0.001*
	PT	2.02±0.18	1.85±0.18	3.17	0.0003*
	PLFW	2.56±0.27	2.15±0.19	6.31	<0.001*
	PFT	1.12±0.12	1.01±0.129	2.93	0.005*
	PLFR	0.566±0.048	0.540±0.038	2.08	0.043*
	PRT	0.445±0.032	0.468±0.044	1.89	0.065
	PFTR	0.555±0.044	0.547±0.055	0.502	0.618

Parameters described as mean±SD, the test used: Student t-test, PH: "Patella Height"; PA: "Patella Angle"; PW: "Patella Width"; PT: "Patella Thickness"; PLFW: "Patella Lateral Facet Width"; PFT: "Patella Facet Thickness"; PLFR: "Patella Lateral Facet Ratio"; PRT: "Patella Relative Thickness"; PFTR: "Patella Facet Thickness Ratio". *statistically significant if p(≤0.05).

Through all patellar parameters, PH, PW, PT, PLFW, and PFT showed statistically significant sexual dimorphism ($p \leq 0.05$) in all age groups. In all age groups, the only patellar parameter which was not significant statistically was PFTR. Moreover, PA was insignificant in the (41-50) age group, PLFR was insignificant in (20-30) and (31-40) age groups and PRT was insignificant in (31-40), (41-50), and (>50) age groups.

Table (3) shows the discriminate loading of the patellar measurements in each age group. PH was a highly discriminating parameter in (20-30) and (41-50) age groups followed by PW in (20-30) age group and the PLFW in (41-50) age group. However, in (31-40) and (>50) age groups the PW was a highly discriminating parameter followed by the PH.

Table (3): Summary of interpretive measures for discriminant analysis:

Age/ years	Patellar parameters	Unstandardized	Standardized	Discriminate Loading	Univariate F ratio
20-30	PH	.070	.535	.757 (1)	64.238**
	PA	3.542	.333	0.288(6)	9.336**
	PW	-4.586	3.805	0.642(2)	46.293**
	PT	1.790	-3.453	0.508(4)	28.953**
	PLFW	59.041	-2.292	0.594(3)	39.654**
	PFT	-10.269	.459	0.436(5)	21.382**
	PLFR	64.462	2.133	0.187(8)	3.906
	PRT	-14.872	2.856	0.194(7)	4.214*
	PFTR	12.555	-.250	-0.08(9)	.718
	Group centroid low	0.914			
	Group centroid high	-2.316			
	Wilks Lambada (Canonical correlation)	0.312*			
31-40	PH	-.064	-.377	-0.708(2)	48.645**
	PA	-13.511	-.298	-0.460(4)	20.563**
	PW	27.198	1.303	-0.819(1)	65.071**
	PT	-1.135	-2.149	-0.505(3)	24.762**
	PLFW	-2.089	.209	-0.429(5)	17.828**
	PFT	.905	-1.871	-0.326(6)	10.284**
	PLFR	65.307	-.185	-0.012(9)	.014
	PRT	-9.287	3.148	-0.072(8)	.508
	PFTR	4.724	1.881	0.150(7)	2.19
	Group centroid low	-1.72			
	Group centroid high	1.108			
	Wilks Lambada (Canonical correlation)	0.336*			
41-50	PH	.011	.862	0.872(1)	86.053**
	PA	4.257	.047	0.056(8)	.354
	PW	-13.143	-.897	0.513(4)	29.782**
	PT	3.192	-.665	0.534(3)	32.215**
	PLFW	-23.200	1.713	0.589(2)	39.276**
	PFT	8.171	.631	0.380(5)	16.304**
	PLFR	7.622	-1.018	0.205(6)	4.739*
	PRT	-3.635	.286	0.185(7)	3.876
	PFTR	-2.916	-.835	0.039(9)	.169
	Group centroid low	1.455			
	Group centroid high	-1.654			
	Wilks Lambada (Canonical correlation)	0.285*			
>50	PH	.013	.503	0.713(2)	42.393**
	PA	-12.550	.068	0.279(6)	6.469*
	PW	22.357	-.800	0.848(1)	59.842**
	PT	2.009	4.714	0.347(4)	10.049**
	PLFW	23.561	-1.143	0.691(3)	39.775**
	PFT	-5.063	-1.568	0.321(5)	8.564**
	PLFR	-79.828	.996	0.228(7)	4.330*
	PRT	25.872	-3.214	-0.207(8)	3.568
	PFTR	-3.160	1.160	0.055(9)	.252
	Group centroid low	1.659			
	Group centroid high	-0.985			
	Wilks Lambada (Canonical correlation)	0.370*			

PH: "Patella Height"; PA: "Patella Angle"; PW: "Patella Width"; PT: "Patella Thickness"; PLFW: "Patella Lateral Facet Width"; PFT: "Patella Facet Thickness"; PLFR: "Patella Lateral Facet Ratio"; PRT: "Patella Relative Thickness"; PFTR: "Patella Facet Thickness Ratio". *Statistically significant if p(≤0.05).

On evaluating the mean values of various morphometric patellar measurements along with the four age groups, a statistically significant difference ($p \leq 0.05$) was detected in some patellar parameters as shown in table (4). Among all patellar parameters, there was a statistically significant difference ($p \leq 0.05$) in the following measurements; PH, PA, PW, and PLFW among the four age groups. PA showed the highest statistically significant difference ($p \leq 0.001$) for age differentiation in all age groups, but no statistically significant difference for PT, PFT, PLFR, PRT, and PFTR among the four age groups.

Table (4): Comparison of patellar measurements among different age groups:

Patellar parameters	Age group / years (Mean±SD)				p value
	20-30	31-40	41-50	>50	
PH	4.33±0.44^{AB}	4.11±0.46^{A}	4.22±0.46	4.07±0.34^{B}	0.012*
PA	133.25±5.48^{AB}	129.33±5.48^{AC}	132.65±4.28^{CD}	130.39±5.56^{BD}	<0.001*
PW	4.39±0.41^{AB}	4.21±0.42^{A}	4.33±0.39^{C}	4.17±0.37^{BC}	0.016*
PT	1.95±0.29	1.92±0.28	1.93±0.24	1.91±0.19	0.89
PLFW	2.47±0.29^{AB}	2.31±0.27^{AD}	2.44±0.28^{CD}	2.30±0.30^{BC}	0.004*
PFT	1.05±0.15	1.03±0.15	1.07±0.17	1.052±0.13	0.714
PLFR	0.561±0.037	0.538±0.087	0.562±0.04	0.549±0.04	0.114
PRT	0.442±0.045	0.455±0.047	0.444±0.038	0.459±0.04	0.140
PFTR	0.539±0.054	0.538±0.069	0.550±0.062	0.550±0.05	0.591

Used test: One Way ANOVA test, similar superscripted letters denote significant difference between groups having the same letters in the same row by Post Hoc Tukey test. PH: "Patella Height"; PA: "Patella Angle"; PW: "Patella Width"; PT: "Patella Thickness"; PLFW: "Patella Lateral Facet Width"; PFT: "Patella Facet Thickness"; PLFR: "Patella Lateral Facet Ratio"; PRT: "Patella Relative Thickness"; PFTR: "Patella Facet Thickness Ratio". *Statistically significant if p (≤0.05).

Moreover, PH, PW, and PLFW were found to be decreasing with age with statistically significant negative correlation (r = -0.216, -0.154, and -0.164, respectively) when the patellar measurements were analyzed using "Karl Pearson correlation". The remaining patellar parameters had no statistically significant correlation with age as shown in table (5).

Table (5): Correlation between age and patellar measurements among studied cases:

Patellar parameters	Pearson correlation coefficient	Age/years
PH	R	-.216**
	P	.002
PA	R	-.090
	P	.204
PW	R	-.154*
	P	.029
PT	R	-.062
	P	.379
PLFW	R	-.164*
	P	.020
PFT	R	.014
	P	.843
PLFR	R	-.030
	P	.668
PRT	R	.092
	P	.191
PFTR	R	.082
	P	.245

r: Pearson correlation coefficient, PH: "Patella Height"; PA: "Patella Angle"; PW: "Patella Width"; PT: "Patella Thickness"; PLFW: "Patella Lateral Facet Width"; PFT: "Patella Facet Thickness"; PLFR: "Patella Lateral Facet Ratio"; PRT: "Patella Relative Thickness"; PFTR: "Patella Facet Thickness Ratio". *Significant p-value "≤0.05". **Highly significant p-value "≤ 0.001".

Table (6) shows that the highest average accuracy of patellar measurements in differentiating sex was in the (41-50) age group with 93.6% accuracy followed by (20-30) age group with 90.6 % accuracy.

Table (6): Average accuracy of patellar measurements in differentiating sex at different age groups:

Age/ years	Patellar parameters	Classification function coefficient (Sex)		Corrected classification (%)	Average accuracy (%)
		Male	Female		
20-30	PA	18.768	18.543	92.5%	90.6%
	PFT	-6772.858	-6784.301		
	PFTR	12860.121	12874.937		
	PH	-171.349	-177.130		
	PLFR	24632.336	24441.609		
	PLFW	-5353.847	-5320.673		
	PRT	15935.088	15726.852		
	PT	289.797	337.838		
	PW	4655.639	4615.080		
	(Constant)	-15148.897	-14891.637		
31-40	PA	2.208	2.026	94.1%	88.2%
	PFT	-4869.765	-4907.940		
	PFTR	9081.527	9158.371		
	PH	24.455	21.247		
	PLFR	216.679	210.779		
	PLFW	-185.576	-183.018		
	PRT	18615.725	18800.242		
	PT	-1982.994	-2009.233		
	PW	2080.257	2093.604		
	(Constant)	-6655.560	-6711.923		
41-50	PA	7.534	7.500	97.9%	93.6%
	PFT	-847.348	-860.586		
	PFTR	605.424	646.291		
	PH	102.471	92.545		
	PLFR	22583.750	22655.889		
	PLFW	-5315.860	-5341.266		
	PRT	31804.369	31780.668		
	PT	-7162.360	-7151.057		
	PW	6060.868	6069.936		
	(Constant)	-13577.058	-13568.610		
>50	PA	-8.864	-8.898	90.2%	84.3%
	PFT	-9052.919	-9019.742		
	PFTR	16443.648	16384.545		
	PH	-88.994	-94.305		
	PLFR	13245.004	13182.719		
	PLFW	-3200.557	-3187.173		
	PRT	18066.735	18277.762		
	PT	732.887	664.494		
	PW	3879.062	3887.416		
	(Constant)	-11904.490	-11876.974		

PH: "Patella Height"; PA: "Patella Angle"; PW: "Patella Width"; PT: "Patella Thickness"; PLFW: "Patella Lateral Facet Width"; PFT: "Patella Facet Thickness"; PLFR: "Patella Lateral Facet Ratio"; PRT: "Patella Relative Thickness"; PFTR: "Patella Facet Thickness Ratio".

Discussion:

In forensic anthropology, gender determination is considered an important issue, because it is the first step in the identification process. The patella is made up of highly complex trabecular bone. There is a scarcity of data on gender and age-related anatomical comparisons of patellar measurements (Afrianty et al., 2013).

Direct and indirect measurements can be used to determine patella morphometry. The direct calculation is done with dried bone, skeletal remains, or intraoperative measurements taken with a caliper by the surgeon, which takes time and is subject to observer variability which might reduce the prediction accuracy (Akhlaghi et al., 2010; Muhamed et al., 2017). Indirect measurement is a method of measuring radiographic images that is simple, inexpensive, and noninvasive, as well as providing digital data for future study and reference. Several studies have adapted the use of X-ray, Computed Tomography, and MRI in the evaluation of patellar morphometry (Peng et al., 2014; Teke et al., 2018; Jain et al., 2019; Zhan et al., 2020).

The MR films are a non-invasive, fast, reliable, and inexpensive method to use (Ottow et al., 2017). MRI comes into consideration as a radiation-free imaging method to determine skeletal age, gender, and other forensic medicine applications, such as postmortem imaging (Daghighi et l., 2021). Furthermore, recent research has adapted the use of a fully automated and computer-driven approach for estimating age based on three-dimensional (3D) knee MRIs using machine learning (artificial intelligence) (Dallora et al., 2019; Mauer et al., 2020). Our study has observed several significant patellar anatomic differences concerning gender and age among the Egyptian population using MRI.

Regarding gender variation, most of the patellar parameters measured on MRI of the Egyptian population exhibited statistically significant variations between both males and females. The male patellae were found to have a greater geometrical dimension than the female patellae. In the present study, most of the patellar measurements' mean values were higher in males than females. These results suggest that the patella in this population is sexually dimorphic.

Similarly, it was found by Peckmann et al. (2016**)** in the Spanish population, Vohra (2017), Muhamed et al. (2017) and Jain et al. (2019) in the Indian population, Peng et al. (2014), Shang et al. (2014) and Zhan et al. (2020) in Chinese population, Peckmann and Fisher (2018) in African American, Teke et al. (2018) in Turkish population, Akhlaghi et al. (2010) and Rahmani et al. (2020) in Iranian population.

In this study, the patellar measurements were obtained from the MRI of 200 patients of the Egyptian Population, 5 out of the 9 measurements in all age groups were statistically significant, indicating sex differences in the patellar measurements ($p \leq 0.05$). These five patellar measurements were PH, PW, PT, PLFW, and PFT. On the other hand, the patellar measurement which was not significant statistically in all age groups was the PFTR. Moreover, PA was insignificant in the (41-50) age group, PLFR was insignificant in (20-30) and (31-40) age groups and PRT was insignificant in (31-40), (41-50), and (>50) age groups.

This is in agreement with Muhamed et al. (2017) who reported that PW, PT, PLFW, and PFT showed highly statistically significant sexual dimorphism ($p \leq 0.001$). However, PLFR was not statically significant.

The results of the current study demonstrated high accuracy rates for sex

determination in the Egyptian population from the patella (84.3%-93.6) in different age groups. The highest average accuracy of patellar measurements in differentiating sex was in the (41-50) age group with 93.6% accuracy followed by the (20-30) age group with 90.6 % accuracy.

Similarly, Zhan et al. (2020) reported 81.9%-91.6% sex estimation accuracy rates among the Chinese population using a combination of the patellar parameters. Also, Teke et al. (2018) reported 87-91% accuracy when estimating sex using morphological analysis of the patella in the Turkish population. Peckmann and Fisher (2018) study among African Americans and Rahmani et al. (2020) study among the Iranian population reported lower sex estimation accuracy rates when using patella metric indicators (80-85% and 83% respectively).

Regarding age variations, this study demonstrated differences in the anatomical profile of patellar measurements along with age groups. PH was a highly discriminating parameter in (20-30) and (41-50) age groups followed by PW in (20-30) age group and PLFW in (41-50) age group. However, in (31-40) and (>50) age groups, PW was a highly discriminating parameter followed by PH.

Through all the patellar measurements, significant age variations were observed in 4 out of the 9 parameters (PH, PA, PW, and PLFW). PA showed the highest statistically significant difference ($p \leq 0.001$) for age differentiation in all age groups, but no statistically significant difference for PT, PFT, PLFR, PRT, and PFTR. Moreover, PH, PW, and PLFW showed a negative correlation with the age but the remaining patellar parameters did not differ significantly with age. Also, Muhamed and Saralaya (2017) reported that a significant age variation was discovered in PW, PA, PFT, and PLFR, but not for PT, PLFW, PRT, and PFT.

Conclusion:

Patellar measurements obtained non-invasively from knee MR images revealed gender-specific differences with high accuracy for sex determination useful for forensic purposes. The results of the current MRI analysis on 200 Egyptian males and females revealed that 5 of the 9 morphometric patellar measurements showed substantial gender variance. Significant age variation was found in 4 out of the 9 parameters. This study can provide guidelines for sex and age prediction among Egyptians.

Recommendations:

Further studies in this field are recommended on a larger population in different governorates of Egypt.

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Conflict Of Interest :

All authors confirm that there is no organization support for the present work and there are not any financial connections with any organizations that may have an interest in the current work submitted.

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دراسة مورفومترية للرضفة ودورها في تحديد الجنس لدى المصريين باستخدام التصوير بالرنين المغناطيسي

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هناك العديد من التغيرات التي تحدث بشكل طبيعي في شكل الرضفة وقد ركزت القليل من الدراسات على هذه الاختلافات التشريحية بين سكان مصر. صممت الدراسة الحالية لتقييم الاختلافات العمرية والجنسية في القياسات الشكلية المختلفة للرضفة باستخدام التصوير بالرنين المغناطيسي (MRI) في عينة من المصريين . أجريت هذه الدراسة علي ٢٠٠ صورة باستخدام التصوير بالرنين المغناطيسي لمفصل الركبة تم الحصول عليها بأثر رجعي من أرشفة الصور ونظام الاتصالات (PACS) بقسم الأشعة التشخيصية بجامعة المنصورة لعدد من المرضى (١٠٠ من الذكور و ١٠٠ من الاناث) من سن ٢٠ إلى ٧٠ عامًا. حيث تم قياس تسعة معايير للرضفة وتحليل النتائج إحصائيا والمقارنة بينهم. كشفت القيم المتوسطة عن فروق ذات دلالة إحصائية في تمييز الجنس لـ ٥ من ٩ قياسات رضفية وفي تحديد الأعمار المختلفة ل ٤ من ٩ قياسات رضفية ، مما يدل على تمايز الجنس والعمر في التشكل الرضفي بين السكان المصريين. لقد أظهر ارتفاع الرضفة (PH) ،عرضها (PW) ، سماكتها (PT) ، عرض الوجه الجانبي لها (PLFW) وسمك الوجه (PFT) تمايزا جنسيا ذو دلالة إحصائية ($P \leq 0.05$) في جميع الفئات العمرية. ومن ناحية أخرى ، أظهرت زاوية الرضفة (PA) أعلى فرق ذو دلالة إحصائية ($P \leq 0.001$) لتقدير العمر في جميع الفئات العمرية. وقد أظهر كل من ارتفاع الرضفة و عرضها و عرض الوجه الجانبي لها علاقة سلبية ذات دلالة إحصائية مع العمر. علاوة على ذلك ، لقد أظهرت قياسات الرضفة معدلات ذات دقة عالية في تحديد الجنس بين السكان المصريين بنسبة (84.3-93.6%) في مختلف الفئات العمرية. القياسات المورفومترية للرضفة بإستخدام الرنين المغناطيسي علي مفصل الركبة تعد من أفضل القياسات في تحديد الجنس والتنبؤ بالعمر لدي السكان المصريين.