Original article

Prediction of Sex from Patellar Parameters Obtained by Magnetic Resonance Imaging in a Sample of Adult Egyptian

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ABSTRACT

Background: Patella resists taphonomic conditions and is commonly found as a complete bone after death. Thus, it gained attention as an identification tool, particularly with the advent of modern radiological modalities. **Objectives**: verifying the accuracy of using patellar parameters obtained by Magnetic resonance imaging (MRI) as sex predictors in a sample of adult Egyptians. **Methodology:** The study was conducted on 120 right knee MRI scans of Egyptians aged 18-60 years old (60 males and 60 females) obtained from Radiodiagnosis department, Alexandria Main University Hospital. Six patellar measurements were taken (craniocaudal length "CCL", patellar width "PW", patellar thickness "PT", patellar lateral facet width "PLFW", patellar facet thickness "PFT", and patellar angle "PA") then three ratios were calculated (Patellar lateral facet ratio "PLFR", Patellar relative thickness "PRT", Patellar facet thickness ratio "PFTR"). **Results:** All measurements were significantly higher in males than females whereas, none of the calculated ratios were significantly different between males and females. Both logistic regression models and Receiver operating characteristics (ROC) curve analyses denoted that the highest accuracy for sex prediction was achieved using CCL (accuracy 86.7%, area under curve 'AUC'=0.911) followed by PW (accuracy 85%, AUC=0.898) then PLFW (accuracy 79.2%, AUC= 0.855). The best result for sex identification was obtained when significant parameters were included in the same analyses (accuracy 88.4%, AUC= 0.942). **Conclusion:** patellar parameters obtained from MRI scans could be used as a reliable sex predictor among adult Egyptians.

KEYWORDS

Identification; Sex prediction; Patella; Magnetic Resonance Imaging; Egyptians.

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Submit Date: April 2024:
Revise date: May, 2024
Accept Date: May 2024

I. INTRODUCTION:

Mass disasters have been frequently occurring throughout the last few years. Such incidents are considered challenging for forensic anthropologists to identify victims. Sex identification is the most significant and critical element to be first ruled out in the biological profile of unknown remains. Determining sex allows the elimination of nearly half the matches of the suspected individuals (Saukko and Knight, 2016).

The presence of a full skeleton gives a chance for nearly perfect (100%) accuracy of sex estimation. Unfortunately, this is not the case in mass disasters. Incomplete, even single bones are found, highly damaged or fragmented. There are two methods of sex determination from skeletal remains: morphological and metric methods. Morphological methods are subjective, and observer-dependent, so found to be inaccurate. On the other hand, anthropometric methods can be statistically analyzed, they are objective and exhibit higher accuracy (Olateju et al., 2013; Aly et al., 2016; Welson and Abd El Basset, 2019; Indra et al., 2021).

In human beings, most sex differences in the skeleton become evident after puberty where sexual dimorphism is fully developed. Sexual dimorphism has proved to be variable between populations. Thus, population-specific discriminant analyses were adopted (Dawson et al., 2011; Mostafa et al., 2012; Aly et al., 2016; Peckmann and Fisher, 2018; Rahmani et al., 2020).

Skull and Pelvis show eminent sexual dimorphism with high accuracy. Regrettably in mass disasters and cases of long postmortem intervals, these bones could be missing. Studies nowadays are directed to analyze other skeletal remains for sex determination. Patella is one of the bones drawing attention lately (Guyomarc'h and Bruzek, 2011; Saukko and Knight, 2016; Klales, 2020).

The patella is located within the quadriceps femoris tendon. Its main function is to give more strength to the quadriceps femoris muscle providing better knee extension and flexion movement. The patella, which means in Latin "small plate," is the biggest sesamoid bone in the human body, triangular with a base upward & apex directed downward. Patellofemoral articulation together with femorotibial articulation forms the knee joint(Standring et al., 2008).

Magnetic resonance imaging (MRI) became a primary diagnostic modality for knee lesions, trauma, and disorders. In comparison to plain radiography and computed tomography (CT), MRI shows clear, accurate, and detailed examination of the knee joint. In addition, MRI has limited exposure risk compared with X-ray and CT (Aly et al., 2016; Muhamed and Saralaya, 2017; Tummala et al., 2018).

Recent forensic anthropological research studied patellar measurements obtained from MRI in different populations (Muhamed et al., 2017; Teke et al., 2018; Rahmani et al., 2020; Choi et al., 2021). However, to date, the usefulness of the patella visualized by MRI in sex identification among Egyptians has not been adequately investigated. Therefore, the present research aimed to verify the accuracy of using patellar parameters obtained by MRI as sex predictors in a sample of adult Egyptians.

II. SUBJECTS AND METHODS

Study design

The current research is a cross-sectional retrospective study.

Eligibility criteria

The study enrolled 120 Egyptians (≥18 years old) who performed MR imaging evaluation of their right knee in the Radiodiagnosis department, Alexandria Main University Hospital. The included patients were equally divided between both sexes. Patients with congenital anomalies, patellar fracture and/or dislocation, patellar osteoarthritis, knee tumors, and findings of infections were excluded.

Sampling

G-power software was used to calculate the sample size (Faul et al., 2007). The confidence level was adjusted at 95% and the power was adjusted at 80%. According to the results of (Ahmed et al., 2022), the effect size was 2.64, based on the mean patellar height=4.54± 0.32 in males vs. 3.81 ±0.22 in females The minimum sample size is 60 participants: 30 participants per group. We increased our sample to 60 participants per group to strengthen the power of the research.

MRI of the patella

The MR studies were conducted on 1.5-T and 3-T MR systems (Ingenia, Philips, Healthcare, Best, the Netherlands) using a dedicated knee coil. MR imaging protocol consists of three orthogonal imaging planes (sagittal, coronal, and axial), with a combination of fluid-sensitive sequences, either T2 weighted fat-suppressed or proton density-weighted (PDW) fat-suppressed sequences, and T1weighted non-fat-suppressed imaging however, only axial, and sagittal planes were used in the present study. Regarding the axial MRIs, the patellar metric parameters were assessed at the mid-axial images, which allowed the visualization of maximum transverse diameters.

The participants attained a supine position with full extension of their knees, the axial images were obtained parallel to the knee joint: axial T2 weighted image (T2WI) [Time of repetition/ Time of echo (TR/TE) 5000/100 ms, Field of view (FOV) 180 mm, slice thickness 4 mm], axial PDWI (TR/TE 2700/30 ms, FOV 180 mm, slice thickness 4 mm), sagittal T2 (TR/TE 4000/100 ms, FOV 180 mm, slice thickness 4 mm), sagittal PDWI (TR/TE 1400/30 ms, FOV 180, slice thickness 4 mm), all are multishot Turbo spin echo (TSE) sequences.

Patellar parameters

A- patellar measurements:

six patellar measurements were obtained as follows: (Bidmos et al., 2005; Muhamed et al., 2017)

1. **Patellar craniocaudal length (CCL);** measured at the midsagittal images that showed the maximum longitudinal length of the patella; it is measured from the most proximal to the most distal ends of the patella **(Figure 1).**

2. **Patellar width (PW);** measured at the mid-axial images that showed the maximum width of the patella; it is measured from the most medial to the most lateral ends of the patella **(Figure 2A).**
3. **Patellar thickness (PT);** measured from central ridge point of the patella along its posterior cortex (a) to its mid-anterior point (b), perpendicular to the patellar width **(Figure 2A).**
4. **Patellar lateral facet width (PLFW);** measured from maximum lateral end of the patella to its central point (the point of intersection of the patellar width and patellar thickness) **(Figure 2B).**
5. **Patellar facet thickness (PFT);** measured from central point to central ridge point of patella **(Figure 2B).**
6. **Patellar angle (PA);** angle between lateral facet and medial facet where zenith is patellar central ridge point **(Figure 2C).**

B- patellar ratios: (Muhamed and Saralaya, 2017)

Three patellar ratios were calculated as follows

a. **Patellar lateral facet ratio** (PLFR) = PLFW/PW.
b. **Patellar relative thickness** (PRT) =PT/PW.
c. **Patellar facet thickness ratio** (PFTR) =PFT/PT.]

Ethical considerations

An ethical approval was obtained from the Research Ethics Committee of the Faculty of Medicine, Alexandria University (Protocol Number: 0304818, IRB: 00012098, FWA: 00018699,). Confidentiality of case records was maintained, and all patient data was anonymized prior to analysis.

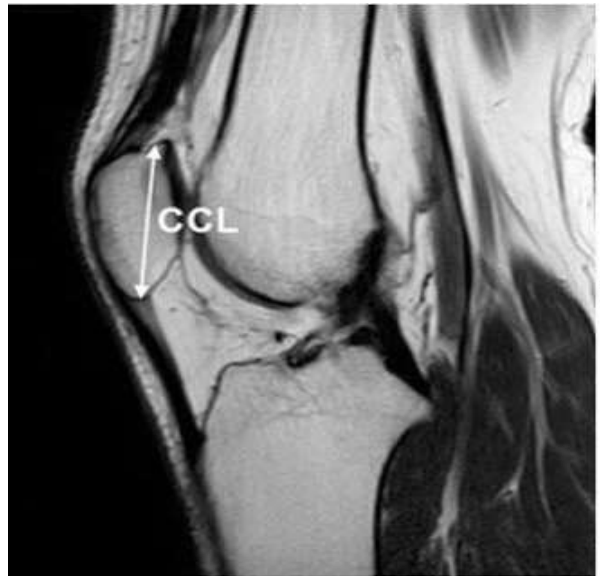

Figure (1): Mid-sagittal image shows the patellar craniocaudal length (CCL) from the most proximal to the most distal ends of the patella

Statistical analysis:

IBM SPSS software package (version 23.0) was used to analyze the obtained data. Kolmogrov-Smirnov test was applied to test the normality of variables' distribution. The student t-test compared normally distributed quantitative variables between both sexes. Multivariate analysis Regression was assessed to predict males from females. The receiver operating characteristics (ROC) curve was done. Acceptable performance was defined as an area under the curve (AUC) of more than 50%, and the best performance was defined as an area of 100%. The statistical significance was judged at the level of 5%.

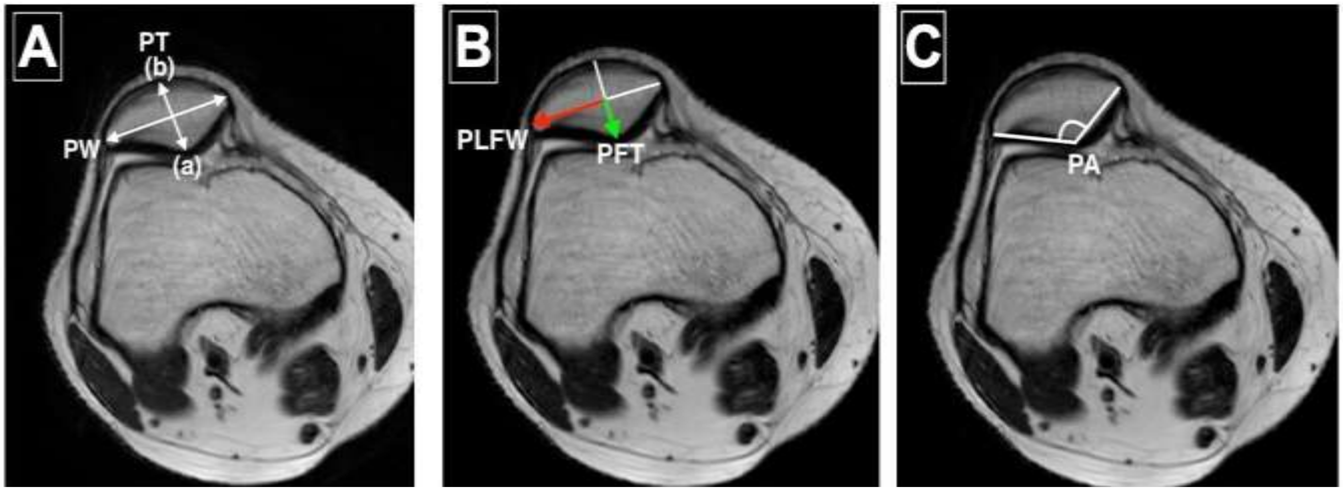

Figure (2): Axial images show: (A) the patellar width **(PW)** and patellar thickness **(PT)** from the patellar central ridge point (a) to the mid-anterior point of the patella (b); (B) shows patellar lateral facet width **(PLFW)** (red arrow) and patellar facet thickness **(PFT)** (green arrow); (C) shows patellar angle **(PA)** between the medial and lateral patellar facets.

III. RESULTS

In the present research, we analyzed nine patellar anthropometric parameters obtained from 120 right knee MRI scans (60 males and 60 females). The patients' ages ranged from 18 to 60 years old. The mean age of males was 31.77± 10.36 (range 22- 60 years old) while in females it was 35.05 ±11.75 (range 18- 58 years old) with no statistically significant difference between both sexes (t= 1.624 and p=0.107) (**Table 1**)

Assessment of sexual dimorphism using different patellar parameters

Out of the nine patellar parameters examined in the present study; six measurements exhibited statistically significant sexual dimorphism in which male patellar dimensions were found to be greater than that of females. These significant measurements were CCL (p <0.001), PW (p <0.001), PT (p< 0.001), PLFW (p< 0.001), PFT (p< 0.001) and PA (p= 0.019).

On the contrary, patellar parameters that showed non-significant statistical differences were the three calculated ratios: PLFR (p= 0.979), PRT (p= 0.361), and PFTR (p= 0.195) (**Table 2**)

Logistic regression analysis

Regression equations were adopted for each patellar parameter that exhibited significant sexual dimorphism and were found to be all significant (p ≤0.05). The equation based on CCL yielded the highest accuracy of 86.7% and a cut-off value of 39.9 mm, following it closely was the PW with an accuracy of 85% and a cut-off value of 43.8 mm, then PLFW with an accuracy of 79.2% and a cut-off value of 24.3 mm. Sex was identified to be male if the results were greater than the cut-off values determined. When the six significant patellar parameters were included in a single logistic regression model, the best accuracy for sex determination was achieved (88.4%). Males

Table (1): Distribution of subjects according to their sex and age (n=120)

Age (Years)	Males (n = 60)	Females (n = 60)	T	p
Min. – Max.	22.0- 60.0	18.0 - 58.0	1.624	0.107
Mean ± SD	31.77±10.36	35.05±11.75		

n: number of subjects, Test of significance (t): Student t-test , MR scans of studied subjects were obtained from Radiodiagnosis Department, Alexandria Main University Hospital

Table (2): Analysis of patellar parameters obtained by MRI in a sample of Egyptians by Student's t-test

Patellar parameters		Males (n = 60)	Females (n = 60)	T (p)
		Mean ± SD	Mean ± SD	
Measurements	CCL	42.04±2.88	37.21±2.56	9.717* (<0.001*)
	PW	46.17±3.53	40.49±2.56	10.080* (<0.001*)
	PT	20.19±1.68	18.01±1.71	7.037* (<0.001*)
	PLFW	25.86±2.29	22.70±2.02	8.017*(<0.001*)
	PFT	11.37±1.37	10.44±1.02	4.242* (<0.001*)
	PA	130.11±4.16	128.17±4.77	2.372* (0.019*)
Ratios	PLFR	0.56±0.03	0.56±0.04	0.026 (0.979)
	PRT	0.44±0.04	0.45± 0.04	0.918 (0.361)
	PFTR	0.57± 0.07	0.58± 0.04	1.303 (0.195)

n: number of subjects

Test of significance (t): Student t-test, *p*: *p* value

*: Statistically significant at $p \leq 0.05$

CCL: Craniocaudal length, PW: Patellar width, PT: Patellar thickness, PLFW: Patellar lateral facet width, PFT: Patellar facet thickness, PA: Patellar angle, PLFR: Patellar lateral facet ratio, PRT: Patellar relative thickness, PFTR: Patellar facet thickness ratio

MRI: Magnetic Resonance scans of studied subjects were obtained from Radiodiagnosis Department, Alexandria Main University.

could be identified at cut-off values >0.36 (**Table 3**).

ROC analysis

ROC analysis referred the highest performance for sex identification to the CCL (AUC= 0.911, sensitivity 90.0, specificity 83.3, P<0.001) followed by PW (AUC= 0.898, sensitivity 93.3, specificity 76.7, P<0.001) then PLFW (AUC= 0.855, sensitivity 86.7, specificity 71.7, P<0.001) (**Table 4**). It also showed that the best results were obtained with the inclusion of all six significant parameters in the ROC curve (AUC= 0.942, sensitivity 95, specificity 81.7, P<0.001) **Figure (3).**

Table (3): Logistic regression analysis of patellar parameters for sex identification in a sample of Egyptians

Parameters	Regression Equation	Cut off	Accuracy	P	R^2
CCL	29.978+ (-0.758*CC length)	39.9	86.7%	<0.001*	0.614
PW	26.339+ (-0.612*Patellar width)	43.8	85.0%	<0.001*	0.609
PT	14.013+ (-0.733*Patellar thickness)	19.0	75.9%	<0.001*	0.384
PLFW	16.274+ (-0.673*Patellar lateral facet width)	24.3	79.2%	<0.001*	0.461
PFT	8.335+ (-0.768*Patellar facet thickness)	10.5	66.7%	<0.001*	0.193
PA	12.820+ (-0.099*Patellar angle)	128.2	60.0%	0.023*	0.061
All significant	32.984+ (-0.569*CC length) + (-0.301*Patellar width) + (-0.251*Patellar thickness) + (0.066*Patellar angle) + (-0.273*Patellar lateral facet width) +(0.483*Patellar facet thickness)	0.360	88.4%	<0.001*	0.723

n: number of subjects, If value >Cut off = Male, *: Statistically significant at P ≤ 0.05

CCL: Craniocaudal length, PW: Patellar width, PT: Patellar thickness, PLFW: Patellar lateral facet width, PFT: Patellar facet thickness, PA: Patellar angle

Table (4): ROC Curve analysis of patellar parameters' performance for sex identification in a sample of Egyptians

Measurements	Sensitivity	Specificity	P	AUC	Cut off
CCL	90.0	83.3	<0.001*	0.911	39.9
PW	93.3	76.7	<0.001*	0.898	43.8
PT	71.7	80.0	<0.001*	0.820	19.0
PLFW	86.7	71.7	<0.001*	0.855	24.3
PFT	56.7	76.7	<0.001*	0.722	10.5
PA	53.3	66.7	0.078	0.592	128.2
All significant	95.0	81.7	<0.001*	0.942	0.360

If value > Cut off = Male *: Statistically significant at p ≤ 0.05; CCL: Craniocaudal length, PW: Patellar width, PT: Patellar thickness, PLFW: Patellar lateral; facet width, PFT: Patellar facet thickness, PA: Patellar angle.

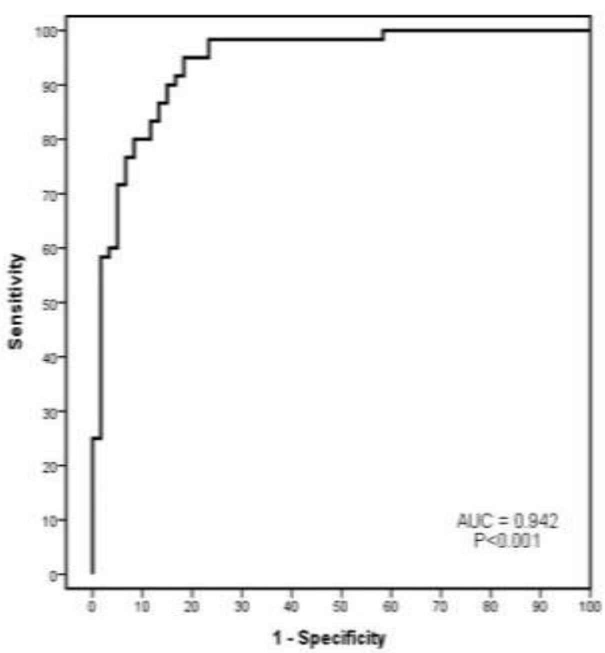

Figure (3): ROC curve for the performance of significant patellar parameters (CCL, PW, PT, PLFW, PFT, and PA) in sex identification in a sample of Egyptians.

IV. DISCUSSION

Sex determination is one of the most important steps in creating a biological profile of an individual in forensic anthropological casework (Krishan et al., 2016). The patella is a very dense sesamoid bone, subcutaneously located, and well known to resist taphonomic changes. Furthermore, it is a single small compact bone that can be easily found as a complete bone after death. Being in the quadriceps tendon gives it another advantage of being preserved when the body is mutilated or burnt for any reason. All the above-mentioned criteria encouraged anthropologists to use patella for sex identification (Neumann, 2010; Kayalvizhi et al., 2015; Welson and Abd El Basset, 2019; Zhan et al., 2020). Therefore, this study investigated the patellar parameters obtained by MRI for the prediction of sex among Egyptians.

In the present work, six parameters were significantly greater in males than females (CCL, PW, PT, PLFW, PFT, and PA). In contrast, the three patellar ratios (PLFR, PRT, and PFTR) showed insignificant differences between both sexes. The present study was consistent with other studies' results on the Egyptian population. (Abdel Moneim et al., 2008) using X-ray and (Abdelaleem et al., 2016) using 3D CT found that mean male patellar measurements were significantly greater than female ones. In addition, (Ahmed et al., 2022) used MRI to obtain patellar parameters and their results denoted that PL, PW, PT, PLFW, and PFT could be used for sex identification in Egyptians.

Nevertheless, another Egyptian study revealed larger patellar length, depth, and breadth in males compared to females, however, the differences were not statistically significant (Welson and Abd El Basset, 2019). Variation in the results could be attributed to the inclusion of the juvenile age group in their study where patellar size was still not fully attained (Howale and Patel, 2013).

Similar results to the current study were demonstrated in different populations. Iranian studies conducted by (Akhlaghi et al., 2010) on adult corpses and (Rahmani et al., 2020) on living adult subjects found similar results of significantly larger patellar parameters in males than females using sliding caliper and MRI respectively. (Teke et al., 2018) MRI research on the Turkish population also demonstrated the same results.

Many studies were carried out in Asian populations to assess the possibility of using patella as a sex indicator. Studies performed on the Chinese population using CT scans conducted by (Shang et al., 2014) and (Zhan et al., 2020) and knee X-rays conducted by (Aly et al., 2016) revealed almost indistinguishable results from that of the current work. They all concluded that male patellar dimensions were significantly greater than those of females despite that Aly et al., (2016) study was on minor Chinese.

Similarly, Indian patellar dimensions were studied by (Kayalvizhi et al., 2015) and (Vohra, 2017) using vernier caliper on corpses. Whereas (Jain et al., 2019) used knee X-rays of North Indians, and (Muhamed and Saralaya, 2017) used MRI scans of South Indians for sex identification. All of them came to the finding of significantly higher patellar measurements among males than females. It is noteworthy that in contrast to our study, the PRT and PFTR showed statistically significant sexual dimorphism in the (Muhamed and Saralaya, 2017) study. The slight differences between the current study & Muhamed and Saralaya results might be attributed to population differences.

Comparable results were found by (Sakaue, 2008) and (Michiue et al., 2018) in Japanese using dry bones & postmortem CT scans respectively, (Phoophalee et al., 2012) in North Thai using dry bones and (Yoo et al., 2007) in Korean population using MRI knee scans.

Western research as (Introna et al., 1998), (Baldwin and House, 2005), (Kemkes-Grottenthaler, 2005), and (Peckmann et al., 2016) studied patellar dimensions on dry bones of adult dead bodies using vernier caliper. They concluded that the patella is sexually dimorphic in Southern

Italy, Germany, the USA, and Spain, respectively, in which male patellar dimensions were greater.

Research has been conducted also on Africans where (Bidmos et al., 2005) study on White South Africans, (Olateju et al., 2013) study on South Africans of European ancestry, and (Peckmann and Fisher, 2018) study on African Americans proved the sexual dimorphism of the patella. It is noteworthy that they all performed their study on dry bones using calipers.

In the current study, logistic regression and ROC curve analyses were adopted to allow the practical applicability of patellar parameters for sex identification. The accuracies of logistic regression equations for sex determination ranged from 60% to 86.7%. The CCL was the best sexually dimorphic parameter with an accuracy of 86.7% and AUC = 0.911 followed by PW (accuracy 85.0%, AUC = 0.898) then PLFW (accuracy 79.2%, AUC = 0.855). However, the best accuracy was obtained when incorporating all the sexually dimorphic parameters in a single statistical analysis where it reached 88.4% with AUC = 0.942

These accuracies are near to that of other studies in various populations. An Egyptian study showed that the accuracy for patellar sex determination by univariate discriminant functional analysis ranged from 64.6% to 85.9%. and when applying multiple discriminant functional analysis, the accuracy was 85.9%. In contrast to the present findings, patellar thickness was found to be the highest sexually dimorphic parameter (Abdelaleem et al., 2016). The observed variation could be explained by the implementation of a different radiological modality as they used CT scans.

Studies on Iranians by (Akhlaghi et al., 2010) and (Rahmani et al., 2020) found that the accuracy of sex determination ranged from 74.3% to 91.2% and 65.8% to 84.5% respectively using univariate discriminant analysis. By multivariate analysis in Akhlaghi et al., (2010), the accuracy reached 92.9% and by stepwise discriminant analysis in Rahmani et al., (2020) it reached 85.7%. However, unlike the present study, both Akhlaghi et al., (2010) and Rahmani et al., (2020) revealed that the highest accuracy was obtained from patellar width. This difference could be due to population and ethnic variations. Moreover, in the Turkish population, (Teke et al., 2018) study revealed 87.91% overall accuracy for sex determination using discriminant function analysis.

Among Chinese, (Zhan et al., 2020) study reported sex classification accuracy rates of 73.1% to 85.7% by univariate analysis of each patellar parameter and 81.9% to 91.6% by combining parameters. However, (Aly et al., 2016) who conducted their study on the juvenile age group mentioned that the best accuracy for sex classification in Chinese was 73% which denoted limited reliability of patella for sex identification in minors.

Considering the Western population, (Kemkes-Grottenthaler, 2005) study in Germany and (Introna et al., 1998) in Italy predicted sex from patellar parameters with accuracies of 84% and 83.8% respectively.

Regarding the Africans, both (Peckmann and Fisher, 2018) study on African Americans and (Bidmos et al., 2005) study on White South Africans figured out that the highest overall accuracy for sex estimation reached 85% from the combined patellar variables using discriminant function equations.

The current study provided regression and ROC analyses using the virtual patellar parameters that could be applied as a convenient tool for sex prediction with accuracy reaching 88.4%. Taking into consideration that sex could be correctly identified with accuracy 80% using long bones (Saukko and Knight, 2016).

V. CONCLUSION AND RECOMMENDATIONS

The present study pointed to the patella as a tool for sex prediction among adult Egyptians. MRI scan is a convenient, non-invasive, and accurate modality to obtain anthropometric measurements. The current research elucidated that CCL, PW, PT, PLFW, PFT, and PA exhibited sexual dimorphism that was statistically significant. Among all studied parameters, the CCL yielded the best accuracy of 86.7%. The highest accuracy (88.4%) was achieved when the six significant parameters were included in a single regression model. It is recommended to conduct a national Egyptian study that includes a larger sample size for further validation of the current results. In addition, similar future studies among different populations are recommended. Moreover, future research using patellar parameters is recommended to predict other anthropological variables such as age, stature, and race.

Availability of Data

The data used during the present research are available from the corresponding author upon reasonable request.

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التنبؤ بالجنس من خلال معلمات الرضفة التي تم الحصول عليها بواسطة التصوير بالرنين المغناطيسي في عينة من المصريين البالغين

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تقاوم الرضفة الظروف البيئية وعادة ما يمكن العثور عليها كعظمة كاملة بعد الموت. ولذلك فقد حظيت بالاهتمام لكونها أداة استعراف في الطب الشرعي وخاصة مع ظهور طرق التصوير الإشعاعي الحديثة. لذلك هدفت الدراسة الحالية إلى التحقق من دقة استخدام المعلمات الرضفية التي تم الحصول عليها بواسطة التصوير بالرنين المغناطيسي من قسم الأشعة التشخيصية بالمستشفى الجامعي الرئيسي بالإسكندرية كمتنبئات للجنس في عينة من المصريين البالغين. وقد أجريت الدراسة على 120 فحص بالرنين المغناطيسي للركبة اليمنى للمصريين الذين تراوحت أعمارهم بين 18و60 عاما (60 ذكرًا و60 أنثى). تم أخذ ست قياسات للرضفة على النحو التالي: الطول القحفي الذيلي (CCL)، العرض (PW)، السمك (PT)، عرض الوجه الجانبي (PLFW)، سمك الوجه (PFT)، وزاوية الرضفة (PA)، ثم تم حساب نسبة الوجه الجانبي للرضفة (PLFR)، السمك النسبي للرضفة (PRT)، ونسبة سمك الوجه الرضفي (PFTR). وقد أوضحت هذه الدراسة أن القياسات الرضفية الستة كانت أعلى في الذكور عن الإناث بفارق ذو دلالة إحصائية. في حين لم يكن هناك ذو فارق دلالة إحصائية بين الجنسين فيما يخص النسب الثلاثة التي تم حسابها. وقد أشارت كل من نماذج الانحدار اللوجستي وتحليلات منحنى ROC إلى أنه تم تحقيق أعلى دقة للتنبؤ بالجنس باستخدام (CCL) حيث بلغت دقته 86.7٪ والمنطقة الواقعة تحت المنحنى 0.911 يليه PW بدقة 85% والمنطقة الواقعة تحت المنحنى 0.898 ثم PLFW بدقة 79.2% والمنطقة الواقعة تحت المنحنى 0.855. وعندما استخدمت جميع المعلمات ذات الدلالة الإحصائية معاً فإن الدقة بلغت 88.4% والمنطقة الواقعة تحت المنحنى أصبحت 0.942. وقد خلصت الدراسة الحالية إلى أنه يمكن استخدام المعلمات الرضفية التي تم الحصول عليها من فحوصات التصوير بالرنين المغناطيسي كمؤشر موثوق للجنس بين المصريين البالغين.