Original Article

The Morphometric Analysis of the Patella from the Male Cadaveric Native Knees of the Ethnic Igbos of Southeast Nigeria and Its Implications in Total Knee Replacement

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Abstract

Background: In forensic study, the importance of the patellar morphometry for human identification has been widely accepted, and it also plays a role in the biomechanics of the knee. **Aim:** The aim of this study is to analyse the morphometric parameters of patella from the cadaver of the Igbo population of South-east Nigeria. **Materials and Methods:** Parameters from 60 patellae from 30 male cadavers at the museum of the Department of Anatomy University of Nigeria were measured using the Vernier calipers. **Results:** The determined values of the parameters of the cadaveric knees in centimetres are as follows: PH: M =4.6, SD = 0.47, PW: M =4.69, SD = 0.29, PT: M =2.66, SD = 0.15, PLH: M = 6.67, SD = 0.67, PLW: M = 2.86, SD = 0.27, WMAF: M = 2.55, SD = 0.18, WLAF: M =2.77, SD = 0.18. The results of the independent sample t-tests indicated that there were no statistically significant differences in the mean values of the parameters of interest between the left and right patella. The result of the Pearson correlations between PH and other parameters indicated there was a very strong positive significant correlation with PW: (r[60] =0.924, P < 0.01), the PW had a strong positive significant correlation with PT (r[60] = 701, P < 0.001), WMAF (r[60] = 763, P < 0.01), and WLAF (r[60] = 700, P < 0.001). The PT had a weak significant positive correlation with PLW (r[60] = 0.338, P = 0.008) and WMAF (r[60] =0.479, P < 0.001). The PLW was weakly significantly positive correlated with WMAF (r[60] = 0.486, P < 0.001) and WLAF (r[60] = 0.403, P = 0.001). The WLAF was strongly significantly positive correlated with WMAF (r[60] = 0.975, P = 0.001). The PH among the Igbo population (M = 4.61, SD = 4.7) was significantly higher than that of Koreans (t[59] = 2.543, P = 0.014) with a small effect size (Cohen's d = 0.33). The PT among the Igbo population (M = 2.66, SD = 0.15) was significantly higher than Korea (t[59] = 22.278, P < 0.01) with a large effect size (Cohen's d = 2.88). **Conclusion:** This study has established that there are differences with the parameters of interest Igbo ethnic group with that of other populations of interest. The determined values will serve as a guide in the selection of patella component sizes among the studied population.

Keywords: Patella morphometry ethnic Igbos, South East Nigeria, Total knee replacement

Introduction

The patella is a seasamoid bone which is an important component of the extensor apparatus mechanism of the knee. It increases the lever arm of the extensor apparatus, thereby contributing a 50% increase on the quadriceps strength.[1] The study of the patella parameters is on the increase taken into consideration the fact that it expands the knowledge of knee biomechanics and the physiopathology of knee ailments and their respective treatments.[2]

In forensic study, the importance of the patellar morphometry for human identification has been widely accepted, and it also plays a role in the mechanical design of the knee. In implant design and certain surgical procedures such as patella resurfacing for total knee arthroplasty measurements of the patella and patellar ligament are often used. The harvesting technique of patellar ligament grafts during the reconstruction of the anterior cruciate ligament/posterior cruciate ligament depends on the morphometry of the donor patella.[3-5]

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The patella plays an important role in the stability of the native knee joint. The medial border of the most distal part of vastus medialis has transverse fibres that are directly attached to the patella. The natural tendency to lateral displacement is counteracted by the pull of these transverse fibres medially.

Therefore, the patella is of great clinical importance from the anatomical and surgical point of view. Consequently, any deviation in the morphometry of the patella bone in respect to femoral and tibial shafts may change the biomechanics of the patellofemoral joint. Many studies[6-8] have confirmed ethnic and racial variations of the patella morphometry. Radiographic technique has been used to calculate the Insall–Salvati index which is defined as the ratio of the length of the patellar ligament to the greatest length of the patella by Philips *et al*.[9-11] The limitations of using the Insall–Salvati Index include a lack of sensitivity to patella morphology and abnormalities. In addition, approximated measurements are derived from the lateral radiographs of the knee.[12,13] The authors[13,14] have made attempts to reduce the errors from the measurement on radiographs, but the approximation and assumptions which are used affect the accuracy of this radiographic technique. Consequently, measurements carried out in cadavers are likely to be more accurate because they do not involve approximation and assumptions. There is no documented study on the indices of patella morphometry of the Igbos of the South-east Nigeria. What are the parameters of these indices? Is there any laterality in these parameters? Are there any differences in the parameters of the patella geometry of the ethnic Igbos and that of other known populations? Do these parameters correlate among themselves? This study has hypothesised that there are no differences with the parameters interest with that of other populations of interest, no correlations and no laterality among these parameters.

Therefore, the aim of this study is to determine the morphometric indices and laterality of patella from the cadaver of the Igbo population, correlate them among themselves and compare them with that of other selected populations.

Materials and Methods

A 15-cm incision on the medial sides of both knees of the cadaver [Figure 1] after which the skin and fascia lata covering both knees were carefully dissected to expose the quadriceps tendon, the patella and the patellar ligament. The tendon of quadriceps femoris and the patellar ligament were carefully freed from the underlying structures without causing any damage or alteration to the desired structures. With the knee flexed as much as possible but not in excess of 45 degrees, using a Vernier calipers the following measurements were taken from these end points:

1. Patella height (PH) – Linear distance between the superior border and the apex [Figure 2]
2. Patella width (PW) – Linear distance between the medial and the lateral border [Figure 3]
3. Patella thickness (PT) – Linear distance between the anterior surface and the median ridge on the posterior surface [Figure 4]
4. Patellar ligament height (PLH) – Linear distance between the apex of the patella and the tibial tuberosity [Figure 5]
5. Patellar ligament width (proximal end) (PLW) – Maximum width of the patella at approximately 1 cm from the apex of the patella [Figure 6]

Figure 1: Knee incision that provided access to the patella after dissection

Figure 2: Measurement of patella height

Figure 3: Measurement of patella width

6. Width of medial articular facet (WMAF) – Maximum width from the medial border to the median ridge [Figure 7]
7. Width of lateral articular facet (WLAF) – Maximum width from the lateral border to the median ridge [Figure 8].

Statistical analysis

We used the IBM SPSS package (IBM Corp., IBM SPSS Statistics for Windows, Version 25.0, Armonk, NY, USA) developed by International Business Machines Corporation (IBM) was used to analyse our data. Descriptive statistics were calculated for all the variables of interest. Continuous measures were summarised as means and standard deviations. The *P* values for comparing the means of continuous variables were determined after selecting a level of significance ($\alpha = 0.05$). A one sample *t*-test was used for the comparison with of other selected populations. The Pearson correlation coefficient was used to determine the correlation between the knee parameters.

Results

Descriptive statistics

The determined values of the parameters of the cadaveric knees in centimetres are as follows: PH: $M = 4.6$, $SD = 0.47$, PW: $M = 4.69$, $SD = 0.29$, PT: $M = 2.66$, $SD = 0.15$, PLH: $M = 6.67$, $SD = 0.67$, PLW: $M = 2.86$, $SD = 0.27$, WMAF: $M = 2.55$, $SD = 0.18$, WLAF: $M = 2.77$, $SD = 0.18$ [Table 1].

Independent *samples* t-test for side comparison for the patella parameters

An independent *t*-test was carried out to compare the parameters on both sides. The results of the independent sample *t*-tests indicated that there were not significant differences in parameters between the left and right patella for the following parameters PH: ($t[58] = 0.110$, $P = 0.913$), PW: ($t[58] = 0.178$, $P = 0.859$), PT: ($t[58] = 0.170$, $P = 0.866$), PLH: ($t[58] = 0.000$, $P = 0.1.000$), PLW: ($t[58] = 0.096$, $P = 0.924$), WMAF: ($t[58] = 0.288$, $P = 0.774$), WLAF: ($t[58] = 0.284$, $P = 0.777$) [Table 2]. The test provided evidence to fail to reject the null hypothesis which stated that the means of the parameters were equal.

Correlations among the patella parameters

The result of the Pearson correlations between PH and other parameters [Table 3] indicated there was a very strong positive significant correlation with PW: ($r[60] = 0.924$, $P < 0.01$), strong positive significant correlations with PT ($r[60] = 0.797$, $P < 0.01$) and WMAF ($r[60] = 0.713$, $P < 0.01$) and a moderate positive significant correlation with WLAF ($r[60] = 0.653$, $P < 0.01$). It had a weak positive correlation with PLW ($r[60] = 0.432$, $P = 0.001$). It had a negative weak correlation with PLH ($r[60] = -0.321$, $P = 0.012$).

The PW had a strong positive significant correlation with PT ($r[60] = 701$, $P < 0.001$), WMAF ($r[60] = 763$, $P < 0.01$), and WLAF ($r[60] = 700$, $P < 0.001$). It had a negative weak significant correlation with PLH ($r[60] = -0.398$, $P = 0.002$), and a weak positive significant correlation with PLW ($r[60] = 335$, $P = 0.009$). The PT had a weak significant positive correlation with PLW ($r[60] = 0.338$, $P = 0.008$), WMAF ($r[60] = 0.479$, $P < 0.001$), and WLAF ($r[60] = 0.425$, $P = 0.001$). The PLH was weakly significantly positive correlated to WMAF ($r[60] = 0.491$, $P < 0.001$), and WLAF ($r[60] = 0.482$, $P < 0.001$).

Figure 4: Measurement of patella thickness

Figure 5: Measurement of patella ligament height

Figure 6: Measurement of patella ligament width

Figure 7: Measurement of width of medial articular facet

Figure 8: Measurement of width of lateral articular facet

Table 1: Descriptive statistics for mean parameters of the cadaveric patella from the knees of ethnic Igbos

Parameters	*n*	Minimum	Maximum	Mean	SD
PH	60	3.60	5.40	4.61	0.47
PW	60	4.40	5.30	4.69	0.29
PT	60	2.30	3.00	2.66	0.15
PLH	60	5.80	8.30	6.67	0.67
PLW	60	2.50	3.40	2.86	0.27
WMAF	60	2.20	2.80	2.55	0.18
WLAF	60	2.50	3.10	2.77	0.18

PH: Patella height, PW: Patella width, PT: Patella thickness, PLH: Patella ligament height, PLW: Patella length weight, WMAF: Width of medial articular facet, WLAF: Width of lateral articular facet, SD: Standard deviation

The PLW was weakly significantly positive correlated with WMAF ($r[60] = 0.486$, $P < 0.001$), and WLAF ($r[60] = 0.403$, $P = 0.001$).

The WLAF was strongly significantly positive correlated with WMAF ($r[60] = 0.975$, $P = 0.001$).

One-sample *t*-test for the mean comparison of the mean parameters of the cadaveric patella from the knees of ethnic Igbos with the mean parameters of other ethnic groups for patella height dimensions

The PH among the Igbo population (M = 4.61, SD = 4.7) was significantly higher than Korea ($t[59] = 2.543$, $P = 0.014$) with a small effect size (Cohen's d = 0.33), London ($t[59] = 19.626$, $P < 0.01$) with a large effect size (Cohen's d = 2.53), and South African populations ($t[59] = 4.036$, $P < 0.01$) with a medium effect size (Cohen's d = 0.52). It was significantly lower when compared with the Finland population $t[59] = -13.711$, $P < 0.01$) with a large effect size (Cohen's d = 1.77) [Table 4].

One-sample *t*-test for the mean comparison of the mean parameters of the cadaveric patella from the knees of ethnic Igbos with the mean parameters of other ethnic groups for patella height dimensions

The PT among the Igbo population (M = 2.66, SD = 0.15) was significantly higher than Korea ($t[59] = 22.278$, $P < 0.01$) with a large effect size (Cohen's d = 2.88), London t (59) = 21.764, $P < 0.01$) with a large effect size (Cohen's d = 2.80) and USA populations t (59) = 20.736, $P < 0.01$) with a large effect size (Cohen's d = 1.81) [Table 5].

Discussion

There has been an attempt by the researchers in previous studies to obtain the parameters of the patella, the articular facets of the patella and the patellar ligaments during total knee arthroplasty[14,15] as well as the use of radiographs.[16,17] Unlike the measurements from total knee replacements and radiographs, this cadaveric study had an advantage of allowing several measurements to be taken on each cadaver *in situ* though some authors[18] had argued that shrinkage of soft tissue in embalmed samples could be a disadvantage of this method. However, some studies have demonstrated that in the contrary that the extent of shrinkage in a formalin-fixed soft tissue is minimal and therefore constitutes no disadvantage.[19,20]

This study was carried out to determine the morphometric indices and laterality of patella from the cadaver of the Igbo population correlate them among themselves and compare them with that of other selected populations.

These determined parameters no doubt will be of immense benefit to the manufactures of prosthesis who had based their sizes on the Western parameters[21,22] which may not be suitable for the Igbo population.

There was no statistically significant difference in parameters between the left and right patella.

This is in consonant with other previous studies.[23-25]

The PH among the Igbo population was significantly higher than that of Koreans with a small effect size. This is in consonance with the findings of Kim *et al*. who found in their study of Korean population a smaller patella when compared with that of the Western population. However, in comparison with that of the London and South African populations with a

Table 2: Independent samples test for laterality comparison of the patella parameters

Parameters homogeneity of variance	Levene's test for equality of variances		*t*-test for equality of means						
	F	Significant	*t*	df	Significant (two-tailed)	Mean difference	SE difference	95% CI of the difference	
								Lower	Upper
PH									
Equal variances assumed	0.019	0.892	0.110	58	0.913	0.01333	0.12161	−0.23010	0.25676
PW									
Equal variances assumed	0.013	0.910	0.178	58	0.859	0.01333	0.07479	−0.13638	0.16305
PT									
Equal variances assumed	0.010	0.922	0.170	58	0.866	0.00667	0.03923	−0.07185	0.08519
PLH									
Equal variances assumed	0.010	1.000	0.000	58	10.000	0.00000	0.17332	−0.34693	0.34693
PLW									
Equal variances assumed	0.024	0.877	0.096	58	0.924	0.00667	0.06930	−0.13206	0.14539
WMAF									
Equal variances assumed	0.012	0.912	0.288	58	0.774	0.01333	0.04632	−0.07939	0.10605
WLAF									
Equal variances assumed	0.430	0.515	0.284	58	0.777	0.01333	0.04691	−0.08057	0.10724

PH: Patella height, PW: Patella width, PT: Patella thickness, PLH: Patella ligament height, PLW: Patella length weight, WMAF: Width of medial articular facet, WLAF: Width of lateral articular facet, SD: Standard deviation, CI: Confidence interval

Table 3: Correlations among patella parameters

	PH	PW	PT	PLH	PLW	WMAF	WLAF
PH							
Pearson correlation		0.924**	0.797**	−0.321*	0.432**	0.713**	0.653**
Significant (two-tailed)		0.000	0.000	0.012	0.001	0.000	0.000
n	60	60	60	60	60	60	60
PW							
Pearson correlation	0.924**		0.701**	−0.398**	0.335**	0.763**	0.700**
Significant (two-tailed)	0.000		0.000	0.002	0.009	0.000	0.000
n	60	60	60	60	60	60	60
PT							
Pearson correlation	0.797**	0.701**		−0.175	0.338**	0.479**	0.425**
Significant (two-tailed)	0.000	0.000		0.182	0.008	0.000	0.001
n	60	60	60	60	60	60	60
PLH							
Pearson Correlation	−0.321*	−0.398**	−0.175		−0.202	−0.491**	−0.482**
Significant (two-tailed)	0.012	0.002	0.182		0.121	0.000	0.000
n	60	60	60	60	60	60	60
PLW							
Pearson Correlation	0.432**	0.335**	0.338**	−0.202		0.486**	0.403**
Significant (two-tailed)	0.001	0.009	0.008	0.121		0.000	0.001
n	60	60	60	60	60	60	60
WMAF							
Pearson Correlation	0.713**	0.763**	0.479**	−0.491**	0.486**		0.975**
Significant (two-tailed)	0.000	0.000	0.000	0.000	0.000		0.000
n	60	60	60	60	60	60	60
WLAF							
Pearson Correlation	0.653**	0.700**	0.425**	−0.482**	0.403**	0.975**	
Significant (two-tailed)	0.000	0.000	0.001	0.000	0.001	0.000	
n	60	60	60	60	60	60	60

**Correlation is significant at the 0.01 level (two-tailed), *Correlation is significant at the 0.05 level (two-tailed). PH: Patella height, PW: Patella width, PT: Patella thickness, PLH: Patella ligament height, PLW: Patella length weight, WMAF: Width of medial articular facet, WLAF: Width of lateral articular facet

Table 4: One-sample test mean comparison of mean parameters of the cadaveric patella from the knees of ethnic Igbos with other ethnic groups for patella height dimensions (patella height)

Population	Population mean	*t*	df	Significant (two-tailed)	Mean difference	95% CI of the difference		*Cohen's d*
						Lower	Upper	
Korea	4.46	20.543	59	0.014	0.15333	0.0327	0.2740	00.33
Finland	5.44	−130.711	59	0.000	−0.82667	−0.9473	−0.7060	10.77
London	3.43	190.626	59	0.000	10.18333	10.0627	10.3040	20.53
South African	4.37	40.036	59	0.000	0.24333	0.1227	0.3640	00.52

CI: Confidence interval

Table 5: One-sample *t*-test for mean comparison of the mean parameters of the cadaveric patella from the knees of ethnic igbos with the mean parameters of other ethnic groups for patella height dimensions (patella thickness)

Population	Population mean	*t*	df	Significant (two-tailed)	Mean difference	95% CI of the difference		*Cohen's d*
						Lower	Upper	
Korea	2.23	22.278	59	0.000	0.43333	0.3944	0.4723	2.88
London	2.24	21.764	59	0.0000	0.42333	0.3844	0.4623	2.80
USA	2.39	20.736	59	0.000	0.40333	0.3644	0.4423	1.81

CI: Confidence interval

large and medium effect sizes, respectively. This is at variance with the findings of Hoaglund and Low[26] who had postulated that generally that Caucasian knees are generally larger than Asian knees. It was significantly lower when compared with the Finland population with a large effect size. The patellar height is taken into consideration and it is of fundamental importance when evaluating patella femoral complaints, operations involving knee arthroplasty, anterior cruciate ligament, or proximal tibial osteotomy.[27]

Most of these parameters correlated strongly with themselves. During TKR, the decision whether to resurface a patella or not rests with the surgeon. Apart from surgical training and experience, a preoperative analysis of patellofemoral tracking, and an intraoperative analysis of the patella femoral articular surface and articulation are also critical to the final decision. These correlations established in this study will be of immense benefits when dealing with patients of Igbo ethnic group. However, these immense benefits as stated earlier is limited by the inability of the study to provide enough information to answer all the research questions taken the sample size and sex distribution (male only) into consideration.

Conclusion

This study has established that there are differences with the parameters of interest Igbo ethnic group with that of other selected populations of interest. The study established correlations that would be taken into consideration during the resurfacing of patella in TKR. There was no laterality among these parameters.

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Conflicts of interest

There are no conflicts of interest.

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