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Fermoral Intercondylar Notch Geometry Of Nigerians

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ABSTRACT

Ninety-four cadeveric femoral bones consisting of 60 males and 34 females type were collected and treated for preservation through standard procedures. Using the caliper method, the intercondylar notch width, Notch depth and diameter of distal end of femur were measured. The notch shape index and notch width index were also calculated.

The mean notch depth was found to be 3.30 ± 0.14 for the 94 femur bones. It was found to be 3.23 ± 0.14 for male and 3.37 ± 0.20 for females. The sex differences in notch depth were statistically insignificant (P>0.05). The diameter of the distal end of femur was 7.98 ± 0.60 for male bones and 7.85± 0.55 for female bones and the difference between male and female proved statistically significant (P<0.05). The Notch width as measured was 2.31 ± 0.21 for males and 2.21 ± 0.24 for females and sex difference in value proved insignificant (P>0.05).

The notch shape index (NSI) was calculated by dividing the notch width with notch depth. The Notch width index (NWI) was calculated by dividing the notch width with the diameter of the distal end of femur and the difference in value between male and female (NWI) proved statistically significant (P<0.05). The notch geometry had been implicated in anterior cruciate ligament (ACL) injuries and from this study we presume that the difference in incidence of ACL injuries between males and females is as a result of differences in intercondylar notch width index and the diameter of distal end of femur in both sexes.

KEY WORDS: Intercondylar Notch Width Index, Notch Shape Index, Notch Depth, Notch Geometry, Anterior Cruciate Ligament (ACL).

Physical anthropometrical measurements of bone and other body organs have become relatively important in medicine. The proportions obtained are linked to age, sex, and race and sometimes implicated as possible risk factor related to injuries. Intercondylar notch geometry is one of the intrinsic factors implicated in predisposing individuals to anterior cruciate ligament (ACL) injury(s)

The distal extremity of the femur is expanded to produce two prominent bone masses, the lateral and medial condyles. At the anterior aspect these two condyles are united to a great extent, and are continuous with the shaft of the bone, while posteriorly they are separated by a deep gap, the intercondylar notch (ICN), and they project backwards considerably beyond the plane of the poplitial surface of the shaft. Our work focuses on the geometry of the ICN because of the implication of any abnormality of its geometry to the all-important knee joint.

Mark et al (1999) had measured the ICN geometry of one hundred male and one hundred female bones housed at the National museum of National history, Smithsonian Institution in Washington D.C and determined the differences between males and females. They specifically calculated the three indices of notch width index (NWI), notch area index (NAI) and notch shape index (NSI) and concluded that no differences existed between males and females concerning notch width or the two dimensional area that the cruciate ligaments pass through in males and females, they

only differed when compared with a general measure of NSI.

Djordal et al (1997) measured the NWI radiographically and suggested that a small femoral intercondylar notch may represent a smaller anterior cruciate ligament and therefore indicate a knee with less stability.

Teitz et al (1997) in their investigation showed that the range of index in male and female overlapped, and most important, there was no difference in the NWI between patient with and without ACL tear. They therefore suggested that difference in notch geometry might be a factor, yet it cannot account for the differences in ACL tear pattern between male and female.

Didia et al (2002), measured the intercondylar notch (ICN) width in Nigerians and related it to the fermoral length. They found the width to range from 1.81cm (18.1mm) to 2.81cm (28.1mm), but found no significant relationship between notch width and fermoral length ($P>0.05$). They concluded that since stenosed notch individuals are at high risk of ACL injuries the normal value they have established could be used for practical and accurate screening of individuals who are predisposed to ACL ruptures.

John Orchard (2001), in a prospective four-year correlation of radiographic indices and ACL injuries in an athletic college age population, measured the NWI and eminence width index (EWI) and the notch width and eminence width ratio (NW/EW) on 956 graduating class (828 males and 128 females) with or without injury. The NWI averaged 0.206 $\pm$ 036 for males and 0.208 $\pm$ .034 for females. The NWI for those sustaining ACL injures was 0.178 $\pm$ .024 for males and 0.172 $\pm$ .040 for females. The difference in NWI between injured and non-injured group was statistically significant for both male and the females ($P<0.05$). These results suggest that the risk for ACL injuries be related to the relative size of the intercondylar notch.

The relevance of this study is derived from the fact that in spite of the frequency of ACL and menisal tears especially as sports related injuries, not much has been done in Nigeria to determine the geometry of the notch area of distal end of femur, which has been predicted as a predisposing factor.

MATERIALS AND METHOD

Materials used for measurements in this study included a vernier sliding caliper, a calibrated rule, a pair of dividers from a mathematical set, a sharp pointed marker pen and ninety –four (60 male and 34 female) femur bones collected over a period of four years from the Anatomy dissecting rooms of University of Port-Harcourt, University of Calabar, University of Nigeria, Enugu Campus, and Nnamdi Azikiwe University, Nnewi campus. The bones were normally cleaned and properly treated for preservation through standard procedures. All bones were free from orthopaedic disorders that could alter measured values.

Measurements:

All measurements including notch width, depth and diameter were made directly from bones, using the caliper technique as described previously by Didia et al (2002) and shown in Fig. 1.

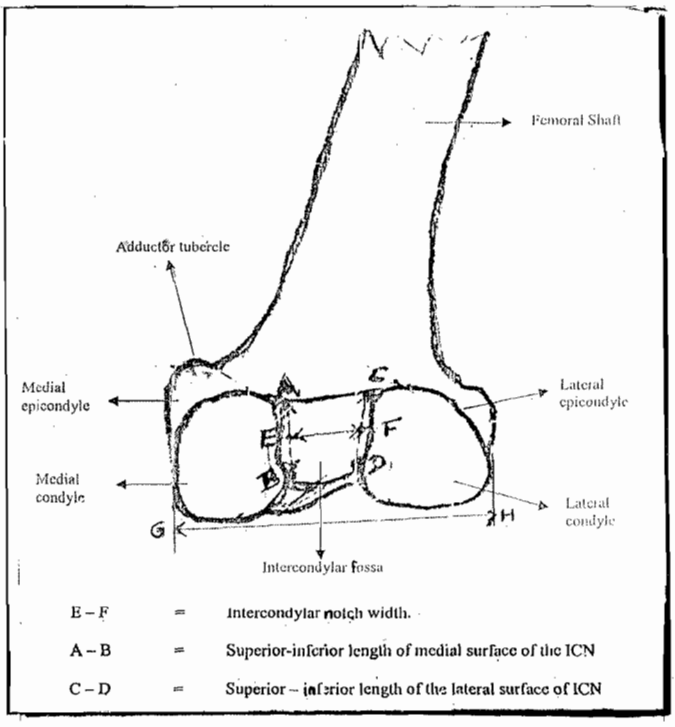

Fig. 1: The Posterior View of lower end of Femur showing how measurements of ICM width were made.

The diameter of the distal end of fermur was measured as line GH drawn from the lateral border of the lateral condyle to the medial border of the medial condyle passing through the line of measurement of the notch width. The notch depth was measured from the midpoint of line EF to the floor of the intercondylar fossa.

The NWI was calculated by dividing the notch width with the diameter of the distal end of femur and the NSI was calculated by dividing the notch width with the notch depth. Descriptive statistical values (mean and standard deviations) were calculated and recorded.

In the case of intercondylar notch width (ICN width), NWI, NSI the actual ranges were noted from where also we have worked out the calculated ranges which enabled us work out identification points and demarking points for the bones using the method of Singh et al (1972). The different values gotten for the calculated parameters are recorded in Tables1-14.

RESULTS

The data obtained in this investigation are presented in Table 1-14, and Figures 2-3.

TABLE 1: Analysis Of Significant Variation In Inter-Condylar Notch (INC) Width In 94 Femora

Detail of Measurement	Male Right	Fem. Right	Male Left	Fem. Left
No	34	18	26	16
Mean	2.35	2.21	2.26	2.20
Actual	1.8-2.8	1.8-2.7	1.8-2.8	1.8-2.5
Identification Point	>2.7	NIL	>2.5	NIL
%beyond D.P	17%	NIL	7.6%	NIL

Table 2: Statistical Calculation From Measurement Of Intercondylar Notch Width In 94 Femora

Detail of Measurement	Male Right	Fem Right	Male Left	Fem. Left
Mean	2.35	2.21	2.26	2.20
Standard Deviation	0.28	0.25	0.35	0.22
Standard error	0.05	0.06	0.07	0.06
Calculated Range	1.51-3.19	1.46-2.96	1.21-3.31	1.54.2.36
Demarking Point	>2.96	<1.51	>2.86	NIL
%beyond D.P	NIL	NIL	NIL	NIL

Table 3: Frequency Of Notch Width In 94 Femora

NW	Male Right	Fem. Right	Male Left	Fem. Left	Total
1.8	2	3	3	2	10
1.9	1	0	1	1	3
2.0	0	1	1	0	2
2.1	5	3	2	3	13
2.2	5	2	3	4	16
2.3	6	4	2	2	14
2.4	5	2	1	0	8
2.5	1	2	2	4	9
2.6	3	0	2	0	5
2.7	1	1	4	0	6
2.8	5	0	4	0	9

TABLE 4: Frequency Of The Diameter of The Distal End of Femura In 94 Female Femora

Length	X-mark	Right	Left	Total Freq.(F)	EFX
6.5-6.9	6.7	0	3	3	20.1
7.0-7.4	7.2	3	0	3	21.6
7.5-7.4	7.7	6	8	14	107.8
8.0-8.4	8.2	5	4	9	73.8
8.5-8.9	8.7	4	1	5	43.5

TABLE 5: Frequency Of Diameter Of The Distal End Of Femur In 60 Male Fermora

Length	X-Mark	Male Left	Male Right	Total Freq.(F)	EFX
6.5-6.9	6.7	3	5	8	53.6
7.0-7.4	7.2	0	0	0	0
7.5-7.9	7.7	9	6	15	115.5
8.0-8.4	8.2	15	9	24	196.8
8.5-8.9	8.7	7	6	13	113.1

Table 6: Frequency Of Notch Depth In 94 Femora

Notch Depth	Male Right	Female Right	Male Left	Female Left	Total
2.7	1	0	1	0	2
2.8	0	0	4	0	4
2.9	1	0	1	2	4
3.0	4	3	2	1	10
3.1	1	1	1	0	3
3.2	2	0	2	1	5
3.3	9	3	3	2	17
3.4	6	4	2	2	14
3.5	7	4	6	0	17
3.6	3	3	4	8	18

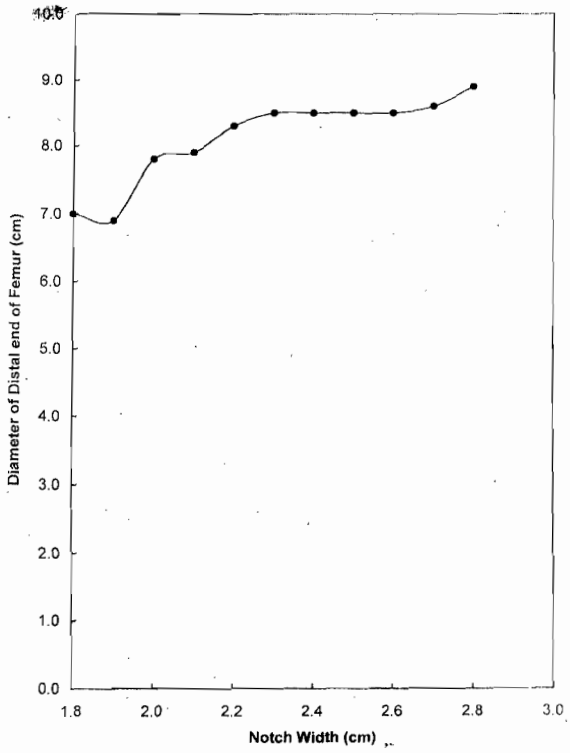

Fig.2: Graph of Diameter of Distal End of Femur Against Notch Width.

Table 7: Showing The Relationship Between Notch Depth And Notch Width In 94 Femora

z	Range Of Notch Dept	
	Male	Female
1.8	1.8-3.0	2.9-3.4
1.9	2.8-2.9	-3.4
2.0	2.8-3.3	-
2.1	3.0-3.3	3.0-3.6
2.2	2.9-3.4	2.9-3.6
2.3	3.2-3.4	3.3-3.5
2.4	3.3-3.5	3.5-3.6
2.5	3.3-3.6	3.5-3.6
2.6	3.3-3.6	3.5-3.6
2.7	3.3-3.6	3.6
2.8	3.6	3.6

Table 8: Comparing Notch width and Diameter of distal end of femur

Notch Width	Range of diameter of distal end of femur
1.8	6.5-7.0
1.9	6.7-6.9
2.0	6.9-7.8
2.1	7.6-7.9
2.2	7.6-8.3
2.3	7.9-8.5
2.4	7.8-8.5
2.5	7.9-8.5
2.6	8.0-8.5
2.7	8.3-8.6
2.8	8.3-8.9

The intercondylar notch width (ICN-width) is recorded Tables 1-3. The values have been presented for the both sexes and different sides of the limb (right or left). The actual range for right male femora is 1.8-2.8cm (mean of 2.21 ± 0.25) for right female femora, 1.8-2.8(mean of 2.26 ± 0.35) for left male femora and 1.8-2.5(mean of 2.20 ± 0.22) for left female femora Table 1 &2.

Using the student t-test the sex differences is found not be significant P>0.05.

The diameter of distal end of femur is presented in Table 4-5. The mean diameter for female is 7.85 ± 0.55 and 7.98 ± 0.61 for males. The sex difference is found to be significant P<0.05. The values obtained for Notch depth are shown in Tables 6-7.The range for Notch depth is 2.7-3.6. When compared to notch width (Table 8) in the male femora it was observed that notch depth increases with increase in notch width. This is not true for female femora as confirmed in Chart 2. The sex differences in notch depth is insignificant P>0.05).

Notch width, Notch depth and Notch diameter were only measured to assist in the calculation of intercondylar NWI and NSI.

Notch Width Index (NWI):

The NWI of the male right femora varied from 0.260-0.339 with a mean of 0.291 + 0.22 (Tables 9 & 10). In the female the NWI ranged from 0.250 to 0.329 with a mean of 0.278 + 0.018. For the male left and female left femora it ranged as 0.260 –0.349 (mean 0.299 + 0.026) and 0.269-0.319 (mean 0.285 + 0.014) respectively. The mean NWI for combined male femora is 0.295-0.024 and 0.282 ± 0.016 for the combined female femora.

The difference between male and female NWI is found to be statistically significant P<0.05. The frequency of occurrence of NWI in the 94 femora is shown in table II and it shows that more Nigerian femur will have NWI of between 0.260-0.299.

Notch Shape Index (NSI):

The values of intercondylar notch shape index (NSI) obtained in this study are recorded in tables 12-14. The range of NSI for males is 0.60-0.84 with a mean 0.705 ± 0.06. For females NSI ranged from 0.50-0.79 with a mean of 0.637 ± 0.04, the frequency of occurrence of NSI is tabulated in table 14 and it shows that more female femurs will have NSI falling within the range of 0.06 to 079. The sex difference is insignificant P>0.05.

Table 9: Analysis of Significant variable of Intercondylar Notch Width Index (NWI) in 94 males and 34 females

Details of Measurement	Male Right	Female Right	Male Left	Female Left
No	34	18	26	16
Mean	0.291	0.278	0.299	0.285
Actual Range	0,260-0.339	0.250-0.329	0.260-0.349	0.269-0.319
Identification Point	>0.329	<0.260	>0.319	NIL
%Beyond I.D	2.9%	22.2%	30.8%	NIL

TABLE 10: Showing Statistical Calculation From The Measurement Of Intercondylar Notch Width Index (Nwi) In 94 Femora

Detail Of Measurement	Male Right	Fem. Right	Male left	Fem. Left
Mean	0.291	0.278	0.299	0.285
Standard Deviation	0.022	0.018	0.026	\0.014
Standard Error	0.004	0.004	0.005	0.004
Calculated Range	0.225-0.357	0.224-0.332	0.221-0.377	0.2453-0.327
Demarking Point	>0.332	<0.225	>0.327	<0.221
% BEYOND D.P	2.0%	NIL	30.8%	NIL

Table 11: Frequency Of Intercondylar Notch Width Index Nwi) In 94 Femora

Nwi	Male right	Fem. right	Male left	Fem. left	Total
0.250-0.259	0	4	0	0	4
0.260-0.269	5	1	4	2	12
0.270-0.276	9	5	5	4	23
0.280-0.289	6	3	3	5	17
0.290-0.299	3	4	2	2	11
0.300-0.309	3	0	2	2	7
0.310-0.319	2	0	2	1	5
0.320-0.329	5	1	3	0	9
0.330-0.339	1	0	4	0	5
0.340-0.349	0	0	1	0	1

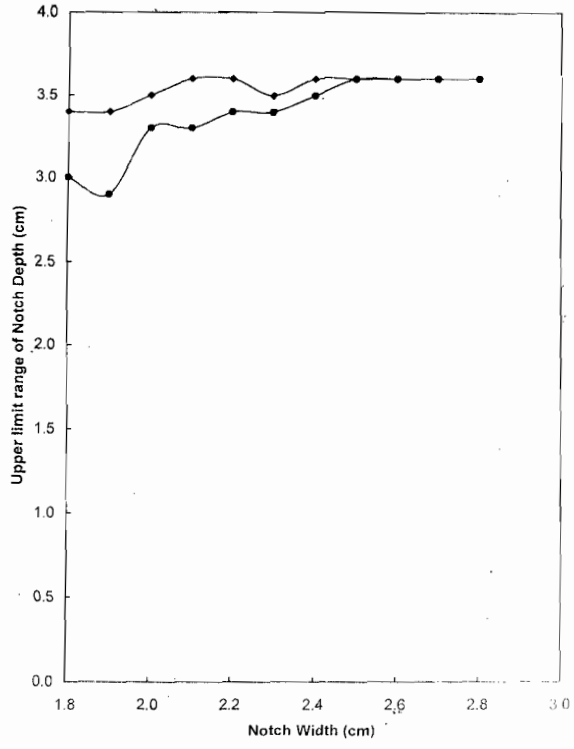

Fig. 3: Graph of the upper limit of Notch Depth Against Notch Width.

TABLE 12: Analysis Of Significant Variable Of NSI In 94 Femora

Details Of Measurement	Male Right	Fem. Right	Male Left	Fem. Left
No	34	18	26	16
Mean	0.705	0.637	0.726	0.648
Actual Range	0.60-0.84	0.50-0.79	0.60-0.84	0.50-0.0.79
Identification Point	>0.79	<0.60	>0.79	<0.60
% Beyond I.D	11.8%	5.6%	11.5%	6.3%

Male Mean 0.716 ± 0.06 Female Mean 0.643 ± 0.04 P>0.05

TABLE 13: Statistical Calculation From Measurement Of NSI In 94 Femora

Detail Of Measurement	Male Right	Fem. Right	Male Left	Female Left
Mean	0.705	0.637	0.726	0.648
S.D	0.06	0.04	0.06	0.04
S.E	0.01	0.01	0.01	0.01
Calculated Range	0.525-0.885	0.517-0.757	0.546-0.906	0.528-0.768
Demarking Pont	>0.757	<0.525	>0.768	<0.546
% Beyond D.P	23.5%	NIL	30.8%	6.3%

Table 14: Frequency Of NSI in 94 Femora

NSI	Male Right	Female Right	Male Left	Female Left	Total
0.55-0.54	0	1	0	1	2
0.55-0.59	0	1	0	2	3
0.60-0.64	5	9	3	3	20
0.65-0.69	13	6	6	8	33
0.70-0.74	7	0	5	1	13
0.75-0.79	5	1	9	1	17
0.80-0.84	4	0	3	0	7

DISCUSSION

The diameters of the intercondylar notch width, the notch depth, and diameter of distal end of femur measured using the caliper technique are presented in the results of this study. The choice of caliper technique is based on the fact that measurements from radiographs have been criticized as being unreliable, (Schickendatz 1993) and both CT scan and computer graphic techniques are not available to us. The NWI and NSI have been quantified as shown in materials and methods and this is the first time that this will be done on Nigerian cadaveric bones.

Our data shows that no differences exist between male and female bones in terms of Notch width, NSI, and Depth of intercondylar notch but the difference between male and female in NWI is significant ($P<0.05$), and diameter of distal end of femur ($P<0.05$). The result shows that males may have a proportionately wider intercondylar notch when normalized by anterior/posterior height of the notch.

The intercondylar notch is normally described as normal, stenosed or narrow especially by sports medicine practitioners (Anderson et al 1987, Houseworth et al 1987, Laprade et al 1994), and athletes with stenosed intercondylar notch are at high risk of ACL injury (Laprade et al 1994). From our study it is obvious that NWI will lead to differences in incidence of ACL injuries between males and females.

Apart from the present study, the authors are working on other aspects of the skeletal alignment and how they affect the mechanics of the knee joint. Majority of ACL injuries are non-contact in nature (Arendth et al, 1995) and the injuries occurred more often on landing from a jump. More of the ACL injuries affect women more than men (Arendth et al 1995). The explanation for this discrepancy may well lie in the geometry of the knee joint and so further quantification of the area and shape of the articular area is recommended.

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