Innovations

Morphometric Analysis of Femoral Condyles in Dry Human Femur – A Cross Sectional Observational Study

[1] Dr. B. Narayana Rao; [2]Dr. V. Vinila
[1] Professor and Head, [2] Assistant Professor
[1,2] Department of Anatomy Konaseema Institute of Medical Sciences and Research Foundation, Amalpuram, India

Corresponding Author: **Dr. B. Narayana Rao**

Abstract:

Introduction: *The human knee is a complex synovial joint involving the distal end of the femur and the proximal end of the tibia and patella. Common knee joint surgeries for osteoarthritis typically include replacement surgeries, osteotomies to address degenerative changes, and implant fixations for trauma. So for designing various prostheses and implants, morphometric data and cross-sectional analysis of femoral condyles are very important.* ***Aim:*** *To analyze morphometric data of various dimensions of femoral condyles by direct method to measure variations between the right femur and the left femur.* ***Materials and methods:*** *One hundred two dry adult femurs of unknown sex are selected with respect to femoral condyles measured for bicondylar width, anteroposterior diameter of both medial femoral condyles and lateral femoral condyles, the transverse diameter of both medial femoral and lateral femoral condyles, and intercondylar notch width index. All the dimensions of the right femur and left femurs are measured by digital vernier caliper, and statistical analysis of data has been done by mean, SD, and P-value using an independent T-test.* ***Results:*** *Average bicondylar width is 72.1 ± 4.52; average anteroposterior distance of both medial and lateral condyles is 56.5 ± 4.50 and 57.25 ± 3.77; average transverse distance of both medial and lateral condyles is 24.75 ± 3.01 and 25.05 ± 2.93; and average intercondylar notch width is 16.3 ± 3.96. In the study there were no much observable differences between right-side and left-side measurements.* ***Conclusion:*** *The data was collected using a direct method and analyzed. This data will throw light on the knowledge of various femoral condyles, which will help in designing the prostheses and implants for better results of total knee replacement surgeries and osteotomies.*

Key words: *Femur, Implants, Prosthesis, Knee joint, Osteoarthritis.*

Introduction:

The bony components of the knee joint are the femoral condyles, the tibia, and the patellar articular surface. It is a compound, complex, and condylar type of modified hinge joint, and there will be forward movements of the transverse axis in extension and moving backward during flexion. As well as there is conjunct rotation of the femur over the tibia and the tibia over the femur around a vertical axis.

The medial femoral condyle is more massive, having a larger articular surface and being more curved anteroposteriorly, which plays a key role in locking movement of the knee. 1 Both femoral condyles are convex in the coronal and sagittal planes.

The coordination and integrity of the fibrous capsule, semilunar cartilages, ligaments, and muscles, as well as the configuration of the femoro-tibial articulation, provide stability and mobility to the knee joint. The flexion can be active or passive and depends on the position of the hip. In active flexion the range is 120°-140° in the flexed hip and passively up to 160°. The mobility of the knee joint is regulated by the formation and integrity of the articular surfaces and ligaments of the knee.The last 30° of full extension is completed by conjunct rotation, which is called "screw home movement."[1]

Usually bicondylar width and anterior and posterior diameter of medial femoral condylar and lateral femoral condyles are essential for morphometric analysis, which is useful in designing prostheses for TKR.[2]The objective of the TKR is twofold: a) functional dynamics should be almost equal to the normal knee; b) long-term viability of the implant.[3]

In dealing with the cases of osteoarthritis and trauma, data of various measurements of distal femoral condyles is important for designing the replacement prostheses and other implants, in order to maintain the normal functional range of the knee. It is important to select the appropriate size of femoral component. A key factor for the success of total knee replacements is good matching between the prosthesis and the respective surface of the joint.

Therefore, a cross-sectional observational study of morphometric analysis of femoral condyles in dry human femurs was done, which is useful in selecting the proper size of prosthesis for a better prognosis after surgery.

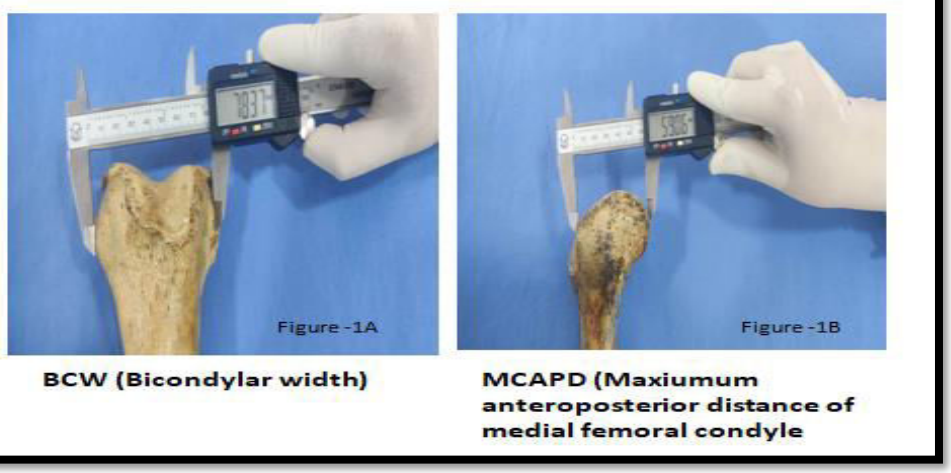
Materials and Methods:

This is a descriptive cross-sectional study in the Department of Anatomy, Konaseema Institute of Medical Sciences & RF, Amalapuram, Andhra Pradesh, India. One hundred two dry adult femurs of age and sex not known, selected from the department, were studied. Only complete and fully ossified bones that are not damaged were included, and damaged, deformed bones showing arthritic changes were excluded in the study.

Procedure:

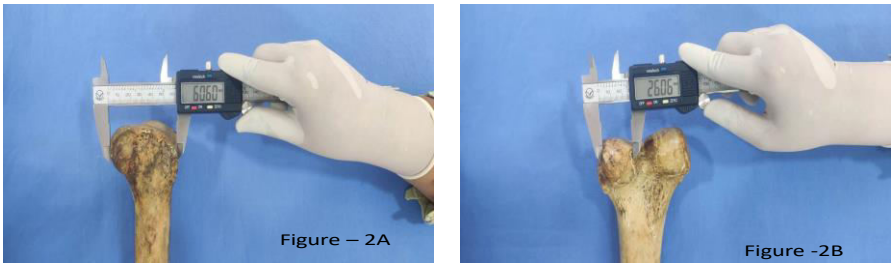
The side of the femoral bones has been decided by standard anatomical description. A sliding digital vernier caliper had been used for measuring the parameters. Values measured in millimeters. The following measurements were taken as follows.

- BCW: Bicondylar width. Maximum measurement between medial and lateral epicondylesof femurin transverse plane. (Fig.1A)
- MCAPD: Maximum anteroposterior diameter of medial femoral condyle.Maximum measurement between anterior and posterior surfaces of medial femoralcondyle.(Fig.1B)
- LCAPD: Lateral condylar anteroposterior diameter. Maximum measurement between anterior and posterior surfaces of lateral femoralcondyle (Fig.2A)
- MCTD: Medial condylar transverse diameter. Maximum transverse distance between medial and lateral surfaces of medial femoralcondyle. (Fig.2B)
- LCTD: Lateral condylar transverse diameter. Maximum transverse distance between medial and lateral surfaces of lateral femoral condyle.(Fig.3A)
- ICNW: Intercondylar Notch Width. Maximum distance between medial and lateral surfaces of intercondylar notch posteriorly. (Fig.3B)



BCW (Bicondylar width)

MCAPD (Maxiumum anteroposterior distance of medial femoral condyle



LCAP (Lateral condylar anteroposterior diameter)

MCTD (Medial condylar transverse diameter)

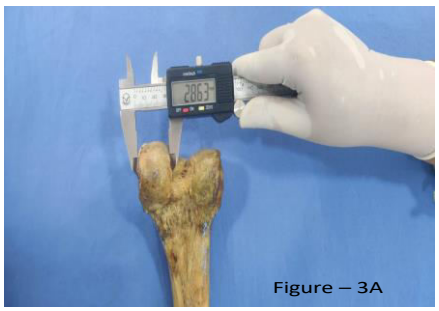


Figure – 3A

LCTD (Lateral condylar transverse diameter)

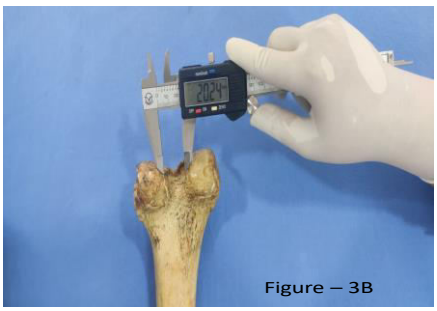


Figure – 3B

ICNW (Intercondylar notch width)

Statistical analysis: The qualitative data was prepared as percentages and dimensions. Qualitative data was prepared as mean and standarddeviation.

Results:

Table 1: Measurement of various parameters of femoral condyles on the right side

S.NO	Parameter	N	RANGE		Mean	Standard Deviation
			Minimum	Maximum		
1	BCW	54	61.86	80.51	72.20	4.31
2	MCAP	54	32.28	63.57	56.28	5.08
3	LCAP	54	43.76	63.81	57.06	3.71
4	MCT	54	19.83	34.43	24.78	2.96
5	LCT	54	18.66	32.89	25.37	3.14
6	ICNW	54	7.49	23.09	16.27	3.93

Table 2: Measurement of various parameters of femoral condyles on the left side

S.NO	Parameter	N	RANGE		Mean	Standard Deviation
			Minimum	Maximum		
1	BCW	48	58.82	79.48	72.00	4.74
2	MCAP	48	47.2	65.54	56.88	3.93
3	LCAP	48	47.96	66.9	57.47	3.84
4	MCT	48	20.41	34.4	24.83	3.07
5	LCT	48	19.54	33.07	24.88	2.73
6	ICNW	48	8.95	24.78	16.46	3.99

Table 3: Measurement of various parameters of femoral condyles on the right and left side

S.NO	Parameter	Side of the femur (Mean ± SD) mm		Average	P-Value (2 tailed students T-test)
		Right(n=54)	Left (n=48)		
1	BCW	72 .2 ± 4.31	72 .0 ± 4.74	72.10 ± 4.52	0.823
2	MCAP	56.2 ± 5.08	56.8 ± 3.93	56.50 ± 4.50	0.502
3	LCAP	57.1 ± 3.71	57.4 ± 3.84	57.25 ± 3.77	0.589
4	MCT	24.7 ± 2.96	24.8 ± 3.07	24.75 ± 3.01	0.934
5	LCT	25.3 ± 3.14	24.8 ± 2.73	25.05 ± 2.93	0.399
6	ICNW	16.2 ± 3.93	16.4 ± 3.99	16.30 ± 3.96	0.801

Out of 102 adult femur bones 54 are right bones and 48 are left bones there is no muchdifference in various measurements observed in right femur and left femur (P > 0.05). Mean BCW on right and left sides are 72.20 and 72.00 respectively as there is no significant difference (P>0.05). Anterior and posterior diameters of medial and lateral condyles on right side are 56.28 and 57.06 andAnterior and posterior diameters of medial and lateral condyles on left are 56.88 and 57.47 respectively showing no disparity. The MCTD and LCTD on right side are 24.78 and 25.37 and on left side are 24.83 and 24.88 which are also nearly similar .ICNW on right and left sides are 16.27 and 16.46 all most same.(Tables: 1& 2).

The p-value observed between the parameters of the right and left sides is>0.05. Hence, it is not statistically significant. (Table: 3)

Discussion:

The knee joint is the largest complex joint. As the total knee replacement became popular for the treatment of chronic osteoarthritis of the knee, a comprehensive assessment of morphometric data of the dimensions of the condyles of the femur became very important for the design and alignment of properly fitting prostheses. A morphometric study of the condyles of the femur and the intercondylar notch width is very important in deciding the stability of the knee joint. In this study morphometric data was measured by vernier caliper directly, and data is categorized in tables 1, 2 & 3. All the measurements of femoral condyles are put together for comparison with other studies.

In our study, the mean bicondylar width is 72.1 ± 4.52; the right side is 72.2 ± 4.31, and the left side is 72.0 ± 4.74, which is similar to Anil Kumar Dwivedi[4] 72.5 ± 5.3 and 73.3 ± 5.3 for both right and left sides and Attada PVK[5] 72.8 ± 10.2 and 74.7 ± 10.2, respectively, on the right and left sides, and Ameet et al.[6] 72.5 ± 5.3 and 73.3 ± 5.3 for the right and left sides. But it is a little higher than Chawre HK[7], 16.80 and 66.23 on the right and left sides, and Lakati KC[8] et al., 68.39 and 68.49 on both the right and left sides, and a little lower than Ravichandran D et al.[9], 74.58 ± 0.57 and 73.97 ± 0.61 on the right and left sides, but in the study by Terzidis et al., Greek[10], the values are much higher, 88.6 ± 0.42. In this study statistically not much difference between the right bone and the left bone was observed. Only the study by Terzidiset al.[10], Greek, showed higher values than ourpresent study, because the values belong to the European race.

The mean medial condyle anteroposterior diameter of the present study is 56.5 ± 4.50; Ameet (6) et al. got similar results of 55.9 ± 0.29, and Mahalakshmi Rajanet al.[11], also got similar results of 56.6 ± 4.19, which is also similar to so many other Indian studies but less than Terzidis et al.'s Greek[10] 61.1 ± 0.34.

The mean lateral condylar anteoposterior diameter of the present study is 57.25 ± 3.77, which is similar to Mahalakshmi Rajan et al.[11], 58.52 ± 3.44 and 56.92 ± 4.41 on both right and left sides, and Neelimaet al.[12], 58.0 ± 0.51, but more than

Santhosh Kumar Sahuet al.[13], 54.80 ± 5.00 and 55.84 ± 4.16, and less than Terzidis et al. (Greek)[10], 61.1 ± 0.33.

Statistically no observable difference was observed in either MCAPD or LCAPD in our study. If the implant is too large in the anterior-posterior measurements, which may lead to limitation of flexion. Undersized anterior-posterior dimensions may result in loosening of the prosthesis.

In the study, the mean medial condyle transverse distance is 24.75 ± 3.01. Similar observations of 24.62 ± 1.9 were seen in the CT study of Moghtadeviet al.[14], Iran and 24.45 ± 2.05 and 27.28 ± 2.29 on the right and left sides, respectively, by Biswas et al.[15], are nearly similar, whereas the findings by Neelima et al.[12], 21.33 ± 0.43, are comparatively lesser; otherwise, most are almost similar to most of the findings from other authors from India.

The average mean lateral condyles transverse distance observed in our study is 25.05 ± 2.93. The findings by Biswaset al.[15], are 27.80 ± 2.91 and 28.03 ± 2.56 on the right and left sides, which are slightly higher, and Chavdaet al.[16], found 30.3 ± 3.05 and 29.6 ± 2.03 on the right and left sides, which are also higher.

The mean intercondylar notch width in our observation is 16.3 ± 3.96, which is less than other authors findings. Santhosh Kumar Sahuet al.[13], 19.98 ± 3.24 on the right and 19.82 ± 3.14 on the left, and Ameetet al.[6], findings are 18.0 ± 3.0 on the right and 17.9 ± 2.5 on the left, and Ravichandranet al.[9], 18.89 ± 0.29 and 18.65 ± 0.27 on the right and left sides, respectively.

Morphometric measurements of the right and left sides did not show any statistically significant differences between each other. The build and stature of the persons will reflect on the bony measurements, and we should take into account the race and lifestyle of the individual also.

Restraints of the study:

Our study was done on 102 dry femur bones, though it consists of a small sample size, as the sex is not known, and also the right and left femurs do not belong to the same individuals.

Conclusion:

After collecting and analysing the various measurements of condyles of the femur directly, this morphometric analysis enlightens the understanding of the knowledge of femoral condyles that helps in the designing of prostheses and implants for better results of total knee replacement surgeries.

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