RESEARCH ARTICLE

MORPHOMETRIC STUDY OF THE MENISCI OF KNEE JOINTS OF HUMAN FOETUSES

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ABSTRACT

Background: It is well established that there are marked differences in contour and the insertion of the medial and lateral menisci in adult knee joints. Variations in form of thickness and width of menisci have determined the different injury mechanisms. However, this data is scarce in human foetuses.

Aims & Objective: To evaluate and analyze the morphometric aspects of the menisci of the knee joints such as the external circumference thickness, the width, peripheral and inner border lengths, and the distance between anterior & posterior horns of the fetal menisci.

Material and Methods: This study was done on 54 knee joints from 27 formalin fixed human fetal cadavers that were without any gross musculoskeletal system anomalies and available at Department of Anatomy, Index Medical College Hospital and Research Centre, Indore. The thickness and width were evaluated at three different points: anterior 1/3rd, middle 1/3rd and posterior 1/3rd parts and values were compared between medial and lateral menisci, between right and left joints and also between male and female foetuses. A non-elastic wet cotton thread and a digital Vernier Calliper of 0.01 mm accuracy were used for the measurement.

Results: The study shows statistically significant morphological differences between medial and lateral menisci, right and left joint and also between joints of male and female foetuses. The results reported here further validate the earlier morphometric findings of studies on human foetuses.

Conclusion: Comparative analysis with adults' menisci historical data suggests that the main morphological features like thickness at middle 1/3rd and width at posterior 1/3rd for both menisci and distance between the horns of medial Vs. lateral meniscus are same with adults explaining the common mechanism of injuries. Some reported differences could be due to the mesenchymal differentiation or variability of the vasculature early in embryonic life.

Key-Words: Morphometry; Knee joint; Menisci; Foetuses; Horn

Introduction

The menisci are composed of fibro-cartilage and project from the fibrous capsule as incomplete partition between condyles of the femur and the tibia. The menisci are important functional unit, able to improve joint congruence and load distribution, thereby reducing the stress of the knee joint.[1] Since the menisci performing important mechanical functions, such as supporting body weight, shock absorption, stabilization and rotational facilitation.[2] The function of stabilization in every plan, but mainly, the rotational is one of the most important and is directly related to the meniscal trauma.[3] There are marked differences in the contour and insertion between the medial and the lateral menisci which are important in relation to the injury mechanism.[4] Also, variation of form and in particular of thickness and width of menisci can determine the possibility and kind of injury.[5]

However, the morphometric parameters related to the fetal menisci are scarce in available literature. Therefore in this study, we evaluated the differences in various parameters of fetal lateral and medial menisci like thickness of outer circumference, the peripheral and inner border lengths, the width of menisci and distance between anterior and posterior horns and also analyzed the differences in male and female fetal menisci.

Materials and Methods

This study was done at Department of Anatomy, Index Medical College Hospital and Research Centre, Indore, on 54 knee joints (27 right and 27 left sides), of 27 human fetal cadavers from Malwa region of the Madhya Pradesh. The male and female ratio was approximately 1:1 and the gestational age was ranging from 21 to 37 weeks. All the fetuses were preserved in 10 % formalin solution and had no gross musculoskeletal anomalies. After removing the skin and muscles, the menisci were approached anteriorly by a longitudinal incision on each side of the joint capsule, cutting the collateral and patellar ligaments transversely. To expose the menisci clearly, the intra-articular ligaments were cut and the femurs were separated. Data were recorded on a standardized collection table.

The peripheral and inner border lengths were measured

with the help of non-elastic cotton thread of 0.30 mm diameter. The wet thread was placed along the periphery of the meniscus from the apex of the anterior horn to the apex of posterior horn. The length of the thread was measured with digital Vernier Calliper (Aerospace) with accuracy 0.01 mm; the length of thread was called "peripheral length." In the same way, the inner border length was measured by placing the thread at the inner free edge of the meniscus (Figure 1).

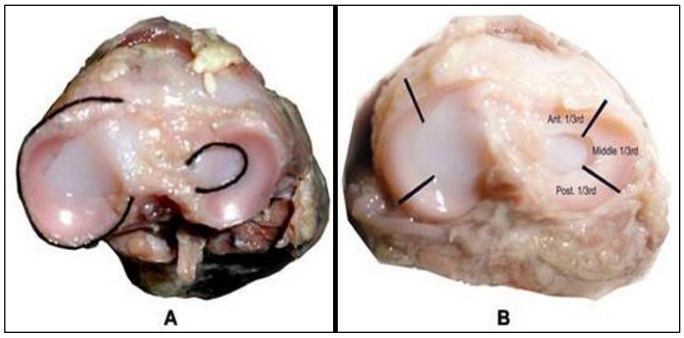

Figure-1: A. Showing the method of measurements of the peripheral & inner border lengths of the meniscus with non-elastic blade cotton thread. **B.** Showing the three parts of the meniscus (anterior, middle & posterior thirds) for measurements of thickness of outer circumference & width

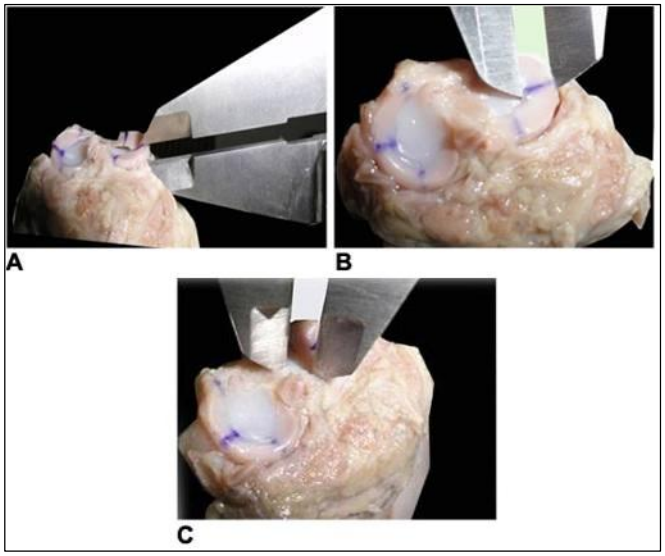

Figure-2: A. Showing the method of measurements of the thickness of outer circumference of the meniscus. **B.** Showing the method of measurements of the width of the meniscus. **C.** Showing the method of measurements of the distance between anterior and posterior horn of the meniscus.

The menisci were divided into three equal parts using the thread and the parts are called as anterior, middle and posterior thirds. The width was measured at midpoint of these three parts; from each point, the Vernier Calliper was positioned from the outer edge to the inner edge of each meniscus. The thickness of outer circumference of the meniscus was measured using the same width points, and then the Vernier Calliper was placed between the top and bottom edge on the outer circumference. The distances between anterior and posterior horns were determined using the internal face of Vernier Calliper which was placed between the apex of the anterior horn and the apex of the posterior horn (Figure 2).

The data were analyzed statistically using student's t-test and paired t-test. Two tailed p-values <0.05 were considered significant. The SPSS 10.0 software was used for statistically analysis. The data were presented as mean ± SD.

Results

The study shows statistically significant morphological differences between medial and lateral menisci. The peripheral and inner border lengths of medial meniscus (26.92 ± 4.7 mm and 16.36 ± 3.31 mm) were significantly more than the peripheral and inner border lengths of lateral meniscus (23.59 ± 3.57 mm and 12.90 ± 1.9 mm) ($p<0.05$ and $p<0.05$) (Table 1).

Table-1: Comparison of peripheral and inner free border lengths of fetal menisci (n=54)

Length	Medial Meniscus (mm)	Lateral Meniscus (mm)
Peripheral length	26.92 ± 4.7	23.59 ± 3.57
Inner border length	16.36 ± 3.31	12.90 ± 1.9

(Values are mean ± SD, statistical significance p<0.05)

Table-2: Comparison of peripheral thickness of fetal menisci at different region (n=54)

Length	Medial Meniscus (mm)	Lateral Meniscus (mm)
Anterior 1/3rd	2.04 ± 0.47	1.80 ± 0.42
Middle 1/3rd	2.19 ± 0.49	2.00 ± 0.45
Posterior 1/3rd	2.05 ± 0.56	1.76 ± 0.41
Average thickness	2.10 ± 0.51	1.85 ± 0.43

(Values are mean ± SD, statistical significance p<0.05)

Table-3: Comparison of width of fetal menisci at different region (n=54)

Length	Medial Meniscus (mm)	Lateral Meniscus (mm)
Anterior 1/3rd	3.06 ± 0.61	3.22 ± 0.50
Middle 1/3rd	2.94 ± 0.53	3.49 ± 0.70
Posterior 1/3rd	3.51 ± 0.74	3.63 ± 0.63
Average thickness	3.17 ± 0.86	3.45 ± 0.63

(Values are mean ± SD, statistical significance p<0.05)

Table-4: Comparison of distance between anterior and posterior horns (n=54)

	Medial Meniscus (mm)	Lateral Meniscus (mm)
Distance between anterior and posterior horns	5.59 ± 1.1	3.07 ± 0.68

(Values are mean ± SD, statistical significance p<0.05)

Table-5: Comparison of right and left menisci of knee joints

Parameters	Meniscus (mm)			
	Right Medial	Left Medial	Right Lateral	Left Lateral
Peripheral length	27.44 ± 4.62*	26.40 ± 4.80*	23.63 ± 3.46	23.55 ± 3.74
Inner border length	16.20 ± 2.73	16.51 ± 3.53	12.89 ± 1.69	12.92 ± 2.13
Avg. thickness of outer circumference	2.10 ± 0.53	2.09 ± 0.50	1.89 ± 0.42	1.82 ± 0.45
Average width	3.18 ± 0.69	3.17 ± 0.67	3.47 ± 0.65	3.43 ± 0.61
Distance between anterior & posterior horns	4.71 ± 0.70	4.78 ± 0.68	2.39 ± 0.41	2.33 ± 0.33

(Values are mean ± SD, statistical significance p<0.05,*statistically significant)

Table-6: Comparison of male and female menisci of knee joints

Parameters	Meniscus (mm)			
	Right Medial	Left Medial	Right Lateral	Left Lateral
Peripheral length	27.03 ± 5.08	26.80 ± 3.24	23.18 ± 4.12	24.04 ± 2.89
Inner border length	16.41 ± 3.90	16.30 ± 2.09	12.28 ± 1.92*	13.58 ± 1.68*
Avg. thickness of outer circumference	2.15 ± 0.58	2.04 ± 0.43	1.82 ± 0.49	1.90 ± 0.38
Average width	3.28 ± 0.80	3.06 ± 0.51	3.56 ± 0.73*	3.33 ± 0.49*
Distance between anterior & posterior horns	4.95 ± 0.74*	4.52 ± 0.56*	2.48 ± 0.45*	2.23 ± 0.20*

(Values are mean ± SD, statistical significance p<0.05, *statistically significant)

The thickness of outer circumference the medial meniscus at the anterior one third, middle one third and posterior one third (2.04 ± 0.47 mm, 2.19 ± 0.49 mm and 2.05 ± 0.56 mm) was significantly more than the thickness of outer circumference at anterior one third, middle one third and posterior one third lateral meniscus (1.80 ± 0.42 mm, 2.00 ± 0.45 mm and 1.76 ± 0.41mm) (p<0.05, p<0.05 and p<0.05). The average thickness of outer circumference of medial meniscus (2.10 ± 0.51 mm) was also significantly more than the average the thickness of outer circumference of lateral meniscus (1.85 ± 0.43) (p<0.05) (Table 2).

The width of the medial meniscus at the anterior one third, middle one third and posterior on third (3.06 ± 0.61 mm, 2.94 ± 0.53 mm and 3.51 ± 0.74 mm) were significantly less than the width of the lateral meniscus at the anterior one third, middle one third and posterior one third (3.22 ± 0.50 mm, 3.49 ± 0.70 mm and 3.63 ± 0.63 mm (p<0.05, p<0.05 and p< 0.05)) and average width of the medial meniscus (3.17 ± 0.68 mm) also significantly less than the average width of the lateral meniscus (3.45 ± 0.63 mm) (p<0.05) (Table 3).

The distance between the anterior and posterior horns of the medial meniscus (5.59 ± 1.1 mm) was significantly more than the lateral meniscus (3.07 ± 0.68 mm) (p<0.05) (Table 4). There was no statistically significant difference in the dimensions of right and left menisci except between the peripheral length* (p = 0.017) of right and left medial menisci (Table 5). There were no statistically significant difference found in various dimensions of medial and lateral menisci of males and females such as peripheral length, average thickness, inner border length and average width of medial menisci. While we have observed the statistically significant difference in some dimensions of menisci between males and females such as distance between anterior and posterior horns of medial and lateral menisci* (p = 0.007 and p = 0.023), inner free border length* (p = 0.005) and average width* (p = 0.032) of lateral meniscus (Table 6).

Discussion

The morphometric data related to the fetal menisci are scarce; therefore the main aim of this work was to analyze the morphometric variations present in the human fatal meniscus, enriching the literature on this subject. The morphometric data related to the menisci of the human foetuses have been reported by Kale A, et al[13] and Murlimanju BV et al[14]. Although the Morphometric data related to the menisci of the adults is a well-established as reported by authors like Testut, L and Laterjet A et al[2],Calliet RMD et al[3], Hayashi LK et al[4], Motta Filho LA et al[9], Kapandji AI[6] and Braz, PRP, Silva WG et al[15].

In present study we observed that there were statistically significant differences found between medial and lateral, right and left sides and male and female fetal menisci. The various parameters of the present study slightly greater than findings of Murlimanju, BV et al. Significant difference of peripheral & Inner border lengths was seen; medial vs. lateral menisci, in line with Murlimanju et al peripheral and inner border lengths of the medial meniscus (26.66 ± 4.69 mm and 14.72 ± 2.63 mm) were significantly greater than lateral meniscus (25.14 ± 4.05 mm and 12.59 ± 3.22 mm) and in our study the values were (26.92 ± 4.7 mm and 16.36 ± 3.31 mm) for medial and (23.59 ± 3.57 mm and 12.90 ± 1.9 mm) for lateral meniscus. Braz et al found significant difference in anterior 1/3rd; medial vs. lateral menisci and no significant difference in peripheral border length in adults.

In contrast to Murlimanju et al, thickness of outer circumference of anterior, middle, posterior one thirds & average thickness of outer circumference were significantly different; medial Vs lateral menisci. Almeida et al reported significant difference in anterior 1/3rd & posterior 1/3rd , medial Vs lateral menisci and the middle 1/3rd has been the thickest portion both medial & lateral meniscus same as reported by both Braz et al & Almeida et al.

In agreement with Braz et al, we also found significant difference in width of anterior 1/3rd, middle 1/3rd, posterior 1/3rd & average width, medial vs. lateral menisci while Murlimanju et al reported significant difference in average width, medial vs. lateral menisci and Almeida et al reported significant difference at anterior 1/3rd & posterior 1/3rd but no significant difference in middle 1/3rd, medial vs. lateral menisci. Also in line with Braz et al as in adults we also found posterior 1/3rd was the widest part in both medial & lateral meniscus, while Almeida reported posterior 1/3rd widest in medial meniscus &

middle 1/3rd widest in lateral meniscus in adults, same reported by Murlimanju et al in foetuses. According to Miller[11], the most common type of tear in the menisci is the longitudinal tear, usually involving the posterior segment of either the medial or the lateral meniscus, being the narrow anterior ends justify the rarity of injuries of the anterior third of medial menisci.

The distance between the anterior and posterior horns of the medial meniscus significantly more than the lateral was in agreement with Kapandji, Almeida, Muralimanju and Braz,et al, & this greater proximity of horns of lateral meniscus may explains why they are less prone to injury. Kapandji et al also reported that the horns of lateral meniscus are closer together than those of the medial meniscus. which showed that the distance between the anterior and posterior horns of the lateral meniscus is 12.55 mm and medial meniscus 25.88 mm, same was the case with Almeida, et al that the distance between the anterior and posterior horn of medial meniscus (29.70 ± 4.12 mm) was significantly higher than lateral meniscus (12.71 ± 1.84 mm), Due to the fact that the lateral meniscus has the form of an almost complete ring, whereas the medial is more like a half-moon.

Kale, et al studied fetal menisci and reported that the mean width of the midpoint of the anterior horn, posterior horn and the lateral side of the lateral menisci were recorded as 0.29, 0.34 and 0.37 cm respectively. The mean width of the midpoint of the anterior horn, posterior horn and the lateral side of the medial menisci were recorded as 0.28, 0.29 and 0.26 cm respectively. These measurements are nearly similar to our findings. Rico and Ayala et al[5] observed that the medial meniscus is more commonly affected and topographically lesions were more frequently at the middle 1/3rd (51%) followed by posterior 1/3rd (39%) and the anterior 1/3rd (10%). The middle 1/3rd of menisci more vulnerable to injury this may due to the anterior and posterior horns are fixed while remaining part (middle 1/3rd) is mobile and more prone to stress.

The statistically significant differences in parameters like average width, inner border length, and distances between anterior and posterior horns between male and female foetuses needs further validation in large sample size.

Conclusion

Our study further validates the findings earlier reported in fetal menisci. Comparative analysis with adults' menisci historical data suggests that the main morphological features like thickness at middle 1/3rd and width at posterior 1/3rd for both menisci and distance between the horns of medial vs. lateral meniscus are same with adults explaining the common mechanism of injuries. Some reported differences could be due to the mesenchymal differentiation or variability of the vasculature early in embryonic life. Our work was done with academic interest and we believe that the data not only authenticate but also adds value to the available literature on morphological features of human fetal menisci.

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