

Morphological Study of “Meniskos” in Human Foetuses of South Indian Population and its Clinical Significance

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ABSTRACT

Introduction: The shape of the menisci is crescentic. There are variations in the morphology of the menisci. The knowledge about these variants is necessary for the radiologists and orthopaedic surgeons to discriminate between the normal variants and meniscal injuries.

Aim: To analyse the morphology of menisci in foetuses in the South Indian Population.

Materials and Methods: An observational study was conducted on 30 knee joints of 15 foetuses of age between 20-37 weeks of gestation. The study was conducted between May 2015 to May 2017. The foetuses were fixed with formalin and dissected. The morphology of the menisci was noted macroscopically and tabulated.

Results: In the present study, among the 15 foetuses with 30 knee joints, the most common shape was crescent.

Among the 30 medial menisci and 30 lateral menisci, there were 33 crescentic-shaped (55%), 7 sickle-shaped (11.7%), 6 C-shaped (10%), five U-shaped (8.4%), 1 V-shaped (1.7%), and 1 ring-shaped menisci (1.7%). Out of 30 medial menisci there was only one incomplete discoid meniscus. Among the 30 lateral menisci there were three complete and three incomplete discoid menisci. In this study, the discoid menisci were observed mostly commonly in the lateral menisci. A rare variant, ring-shaped meniscus was present in one medial meniscus (1.7%).

Conclusion: Morphological variants of the menisci are often misinterpreted as tear. The knowledge about the morphology is especially important for the radiologist and orthopaedician to differentiate the tear and the variants in Magnetic Resonance Imaging (MRI).

Keywords: Discoid menisci, Meniscus, Meniscal injury, Menisci variants, Ring-shaped menisci

INTRODUCTION

Greek word “meniscus” meaning “little moon” which represents the crescent shape of the meniscus. It is made up of fibrocartilage. The meniscus divides the knee joint into menisco femoral compartment and menisco tibial compartment. The main function of the menisci is that it acts as a shock absorber, for the conduction of axial load and as well as for the stability of the knee joint while standing and while performing dynamic actions like flexion and extension. All these functions of the menisci in turn protect the articular cartilage from damage and prevent the osteoarthritis [1].

The phylogeny of meniscus traced back more than 300 million years reveals that the hominids and the humans exhibit similar morphological characteristics of the menisci. This reflects that both share a similar lineage of genetic material. Because of the emergence of bipedalism, the patellofemoral joint was formed. The permanent bipedalism of the humans resulted in formation of medial and lateral menisci. Each menisci had anterior and posterior horn which was inserted on the tibial plateau [2].

During development, the menisci appear about 9th-10th week during foetal period. During the embryological period, the medial tibial plateau is oval whereas the lateral tibial plateau is circular. Because of the difference in the surface area of the tibial plateau and asymmetric load transmission, there is a transformation in the morphology of the developing menisci [3].

As the age increases, the meniscus loses its elasticity, becomes stiffer and turns yellow. There is also formation of empty spaces in the meniscus. This cystic change leads to tear in the menisci during torsional movements. A tear in the menisci, in turn damages the articular cartilage of the knee joint [2].

In 1975, a ring-shaped meniscus was discovered for the first time by Noble during autopsy. Ring-shaped menisci can be symptomatic

as well as asymptomatic. The most common symptom is knee pain with no swelling of knee joint. It is misdiagnosed as bucket handle tear of the normal menisci or a central tear of the discoid lateral menisci [4]. Discoid meniscus, a variant in the morphology of the menisci causes tear in the menisci, degeneration, and instability in the knee joint [4,5]. Since there is rise in imaging procedure for knee joint for various diseases, insight about the morphology of the knee joint is necessary for the radiologist and orthopaedician [4]. Hence, the present study was conducted with an aim to analyse the morphology of menisci in foetuses in South Indian Population.

MATERIALS AND METHODS

It was an observational study conducted on 15 foetuses (seven male and eight female foetuses) in the Department of Anatomy, PSG Institute of Medical Sciences and Research, Coimbatore, Tamil Nadu, India. The Institutional Ethical Committee approval was obtained (Project no 15/127). This study was conducted during the year May 2015 to May 2017.

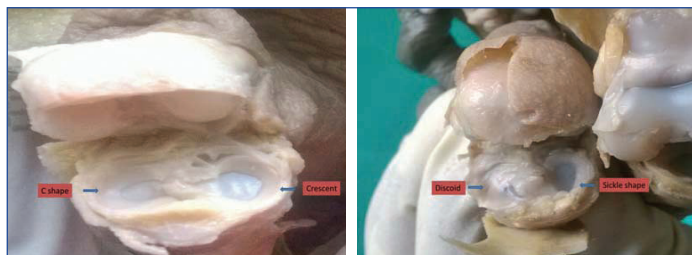
Inclusion criteria: All foetuses in the department with gestational age between 20-37 weeks were included in the study.

Exclusion criteria: The foetuses with musculoskeletal disorder, injuries to menisci, degenerated menisci were excluded from this study.

Study Procedure

Dissection of the skin and the muscles was done. The patellar ligament was cut, and longitudinal incision was made on each side of the joint capsule. The capsule, coronary ligaments, and the cruciate ligaments were cut to expose the menisci. The tibial condyles were detached from the soft tissue. After exposing the menisci, the morphology was observed macroscopically and classified [1,6].

Lateral and medial menisci are classified morphologically on the basis of classifications in previous literatures as V-shaped, U-shaped, C-shaped, crescentic-shaped, and sickle-shaped. If the anterior horn, posterior horn, and the body is thin then it is (semilunar) crescent shaped [Table/Fig-1]. If the anterior and the posterior horns are thin, but body is thick then it is sickle-shaped [Table/Fig-2]. If the shape of the menisci resembles U-shape, V-shape, C-shape then they were classified according to their shape [1,6,7]. The menisci covering the entire tibial plateau was classified as discoid type [Table/Fig-2,3]. The discoid type is classified by Watanabe as complete, incomplete and Wrisberg variant. In complete type the menisci occupies the entire tibial plateau whereas in incomplete type 80% of the tibial plateau is occupied by the menisci. In Wrisberg variant, the menisci are more normal than complete and incomplete type but there is no posterior meniscal attachment [8,9]. In ring-shaped meniscus the anterior and posterior horns are continuous [Table/Fig-3] [4,10].



[Table/Fig-1]: C-shaped menisci, Crescentic shape.

[Table/Fig-2]: Discoid menisci, Sickle-shaped menisci. (Images from left to right)



[Table/Fig-3]: Ring-shaped menisci, Discoid menisci.

STATISTICAL ANALYSIS

The data was noted in datasheet for statistical analysis. Statistical Package for the Social Sciences (SPSS) (version 26) was used to compute the percentage.

RESULTS

In this study, out of 60 menisci (30 medial and 30 lateral menisci) there were 33 crescentic shape menisci (55%), seven sickle-shaped (11.7%), six C-shaped (10%), five U-shaped (8.3%), one V-shaped (1.7%), four incomplete discoid (6.6%), three complete discoid (5%) and one ring-shaped menisci (1.7%) [Table/Fig-4]. Among all the shapes, the crescentic shape was the most common variety in both males and females and most common among the medial menisci. The percentage of crescentic-shaped medial menisci (85.71%) in males was higher than the females (56.25%) [Table/Fig-5]. In this study, there was a ring-shaped variant on the right side of

Shape of the menisci	Medial menisci (n=30)	Lateral menisci (n=30)	Total (n=60)
Crescent	21 (70%)	12 (40%)	33 (55%)
U-shaped	-	5 (16.7%)	5 (8.3%)
Complete discoid	-	3 (10%)	3 (5%)
Incomplete discoid	1 (3.3%)	3 (10%)	4 (6.6%)
C-shaped	2 (6.7%)	4 (13.3%)	6 (10%)
V-shaped	-	1 (3.33%)	1 (1.7%)
Sickle shape	5 (16.7%)	2 (6.7%)	7 (11.7%)
Ring shape	1 (3.3%)	-	1 (1.7%)

[Table/Fig-4]: Medial menisci and lateral menisci.

female medial meniscus [Table/Fig-6]. The discoid menisci were most commonly occurring in the lateral menisci than the medial menisci [Table/Fig-4]. In the above study among the 15 foetuses, six foetuses (two males and four females) had same morphology on both the right and left-side. The wrisberg variant was absent in this study.

Menisci morphology	Medial menisci males (n=14)	Medial menisci females (n=16)	Lateral menisci males (n=14)	Lateral menisci females (n=16)
Crescent	12 (85.71%)	9 (56.25%)	7 (50%)	5 (31.25%)
U-shaped	-	-	-	5 (31.25%)
Complete Discoid	-	-	3 (21.43%)	-
Incomplete discoid	-	1 (6.25%)	1 (7.14%)	2 (12.5%)
C-shaped	-	2 (12.5%)	3 (21.43%)	1 (6.25%)
V-shaped	-	-	-	1 (6.25%)
Sickle-shaped	2 (14.28%)	3 (18.75%)	-	2 (12.5%)
Ring-shaped	-	1 (6.25%)	-	-

[Table/Fig-5]: Comparison of menisci between male and female foetuses.

Menisci morphology	Medial menisci right (n=15)	Medial menisci left (n=15)	Lateral menisci right (n=15)	Lateral menisci left (n=15)
Crescent	11 (73.3%)	10 (66.67%)	5 (33.33%)	7 (46.67%)
U-shaped	-	-	2 (13.33%)	3 (20%)
Complete discoid	-	-	-	3 (20%)
Incomplete discoid	-	1 (6.67%)	3 (20%)	-
C-shaped	1 (6.67%)	1 (6.67%)	3 (20%)	1 (6.67%)
V-shaped	-	-	1 (6.67%)	-
Sickle-shaped	2 (13.33%)	3 (20%)	1 (6.67%)	1 (6.67%)
Ring-shaped	1 (6.67%)	-	-	-

[Table/Fig-6]: Comparison of morphology of menisci between right and left side.

DISCUSSION

Clinical significance: The menisci play a foremost role in absorption of shock and preventing damage to the articular cartilage and help in preventing osteoarthritis. The menisci are predisposed for injuries in both children and adolescents. The treatment of choice is arthroscopic meniscal repair. The snapping knee syndrome occurs more commonly in children and young adolescents [6]. After partial or total meniscectomy, meniscal tissue replacement can be done by autogenous graft (tendon, fat) or allogenic transplant (human donor menisci) or with artificial meniscus prosthesis. The autogenous or allogenic transplants provide a scaffold for stimulating remodelling process which results in the formation of new meniscal tissue [11]. In allograft meniscal transplantation, the exact shape and size of the menisci which matches the recipient knee must be selected and sent by the tissue bank. To provide the most agreeable allograft, it is necessary to learn about the morphology of the menisci [12].

According to Murlimanju BV et al., discoid meniscus occurs due to abnormal morphogenesis of menisci. In his study among the medial menisci, 46.2% were crescentic, 23.6% were V-shaped, 13.2%, U-shaped, 9.2% sickle-shaped and 7.5% C-shaped. According to his study 45.29% cases has similar shape on both sides. In the present study, 6 foetuses (40%) had similar morphology on both sides. In the previous study there was no discoid menisci. In the present study, there was 3.3% discoid medial menisci and 20% discoid lateral menisci. In the present study, apart from discoid menisci another infrequent variant, ring-shaped medial meniscus was found. The difference in the shape of the menisci was due to the differential growth of the mesenchyme and vasculature of the menisci in the embryonic life [6].

Discoid menisci are one of the congenital anomalies of the menisci, which are exceedingly rare and frequently seen in the lateral menisci. Discoid menisci are more commonly occurring than other anomalies such as ring-shaped menisci and double layered menisci. The incidence of discoid lateral menisci is higher in the Asian population [8,13]. The discoid lateral menisci incidence in South India was 17.9% [14]. In the present study, the incidence of discoid lateral menisci was 20% which is a tad higher than the previous study [14]. According to Le Minor JM, the discoid lateral menisci is usually unilateral [15]. According to Rao SK and Rao SP the discoid lateral menisci occur more in females. In the present study, the discoid menisci were found more commonly in the lateral menisci and in females than in males [16].

According to Kim JH et al., in Asian population the discoid lateral menisci occur at a higher rate. The discoid lateral meniscus has different ultrastructure as well as morphology when compared to the normal menisci which makes it prone to injury. The treatment for discoid menisci includes close follow-up for asymptomatic patients and partial meniscectomy for symptomatic patients [17]. According to Vinagre G et al., the microstructural anatomy of discoid menisci shows irregular orientation and decrease in the collagen fibres. Mucoïd degeneration also takes place in discoid menisci [18].

According to Kale A et al., the variations in shape were studied in 11 foetus cadaver and found that 77% of the lateral menisci were discoid. In the present study, 20% of the lateral menisci were discoid, which was lesser [19]. In another study, the morphology was studied in 219 adult subjects and found that 6.2% were complete discoid lateral, 31.8% of knees had incomplete discoid lateral, 0.9% knees had ring-shaped lateral menisci and 0.5% of knee had double layered menisci. All these rare subtypes were not found in the medial menisci [20]. In the present study, one ring-shaped menisci were present in the right medial menisci and there was a slightly higher rate of occurrence of complete type and less rate of incomplete discoid lateral menisci.

Esteves C et al., reported a case of ring-shaped lateral menisci with hypoplastic anterior cruciate ligament. In the present study, one ring-shaped medial meniscus was found. This can be mistaken for bucket handle tear of menisci, Anterior Cruciate Ligament (ACL) tear which leads to unnecessary surgical procedure [21]. This suggests that ring-shaped menisci may be associated with other deformities like hypoplastic ACL. The association between discoid lateral meniscus and inclination of proximal tibiofibular joint was studied. Discoid lateral menisci were associated with the horizontal type proximal tibiofibular joint and would retain the horizontal type of inclination after closure of epiphysis, whereas in the normal menisci, it shifts from horizontal to oblique type. Therefore, meniscal tear was common in discoid lateral menisci [22].

The morphological variant of foetal menisci in Population of Turkey was studied. Total 12% of lateral menisci were crescentic, 66% sickle-shaped, 2% disc shaped and 14% incomplete disc shaped 6% were C-shaped. In Turkish population, sickle-shaped lateral menisci were the commonest type [23]. In the present study, the most common type found in lateral menisci was crescentic shape.

The reason for the development of the discoid menisci which is more common in the lateral menisci was studied. The femoral condyles and the tibial condyles have asymmetrical morphology. Because of this asymmetrical morphology, there was asymmetrical load transmission. In accordance with this, there are different morphological variants of the menisci. Histologically perforating, circumferential and radially oriented fibres are present in the menisci. In the lateral meniscus, the layered structure is developed earlier than the medial meniscus. This earlier histogenesis and asymmetrical load transmission causes the morphological variations [3].

The menisci are highly cellular during development. Later the cellularity decreases, and the concentration of collagen fibres

increases. During developmental period, the vascular supply to the menisci is by blood vessels from periphery. As the foetus grows and reaches the adult period, the vascularity decreases, the blood vessels supply the 10-30% of the periphery of the menisci. The remaining part of the menisci is supplied by the synovial fluid. When the child walks, there is stress given by the load because of which, the orientation of collagen fibres changes [2].

A case series of ring-shaped lateral menisci was reported, where the anterior and posterior horns of the meniscus were continuous. The lateral menisci were more commonly involved [10]. In the present study, ring-shaped menisci was present in the medial menisci. The meniscal tear and the variants like discoid as well as ring-shaped menisci can be differentiated in MRI images. In coronal images the inner portion of the ring-shaped meniscus had tapering inner margins as that of normal meniscus. The anterior and posterior horns of the menisci appear as two homogenous triangular areas. These two are connected by a body segment which represents as "central bow tie sign". This sign is absent in bucket handle tear. The discoid and ring-shaped menisci show central bow tie sign. "The mirror sign" which is the reflection of the normal C shape menisci was also found in ring-shaped menisci [4].

Fujii M et al., reported the formation of ring-shaped menisci post ACL reconstruction [24] and Nagashima M et al., reported the formation of ring-shaped menisci after the partial meniscectomy. The reason for the formation of interhorn meniscal tissue between the anterior and posterior horn is not known [25]. The ring-shaped lateral meniscus can be added as the fourth variant in Watanabe's classification [4,26]. The correlation between the different morphology of the menisci and the incidence of osteoarthritis was not determined in this study. In future large scale studies can be done to determine which morphology causes higher incidence of osteoarthritis.

Limitation(s)

The study was limited by its small sample size. The comparison of the morphology of the menisci between the human foetus and the adult menisci by cadaveric and radiological study was not performed which could be done in future studies.

CONCLUSION(S)

The present study was conducted to reveal the different variants in the morphology of the menisci. In this study, there was considerable occurrence of discoid and ring-shaped menisci. Thus, knowledge of the morphological variant of the menisci is necessary to plan the surgery for repair as well as to distinguish the normal variant from injuries. The ring-shaped menisci can be included in the Watanabe's classification.

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