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Variation in the shape of the knee meniscus and incidence of the discoid shape in Myanmar's adult population: A cross-sectional study

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ABSTRACT

Background

A meniscal injury is one of the most common sports-related problems and the most frequent injury to the knee joint. The method for determining meniscus shape is used in designing therapies for treating various joint diseases.

Material and methods

Anatomy dissection was performed, and the shapes of knee menisci were studied in 160 menisci from 40 autopsy bodies (20 males and 20 females) from Medical Universities in Myanmar. The bodies were embalmed with 4% formaldehyde and then preserved in a weak formalin solution.

Results

The number of crescentic-shaped medial menisci was 5 (6.25%), horseshoe-shaped menisci were 6 (7.5%), sickle shapes were 48 (60%), U shapes were 8 (10%), V shapes were 12 (15%), and complete discoid shapes were only 1 in number (1.25%). There was no incomplete discoid, circular, or C shape at all. The commonest shape of the medial meniscus was a sickle. The number of C-shaped lateral menisci was 6 (7.5%), the complete discoid shape was 1 (1.25%), the incomplete discoid shapes were 13 (16.25%), and the circular shapes were 60 (75%). Crescentic, horseshoe, sickle, U, and V-shaped lateral menisci were absent. Circular was the commonest of all. Among 160 menisci, an incomplete discoid shape was found in 13 menisci, and a complete discoid shape was found in two: one meniscus as a primitive disc and a very rare infantile shape in another.

Conclusion

Our findings will help morphologists and orthopaedic surgeons with surgical procedures and knee joint arthroscopy. It will also help patients with effective rehabilitation after meniscal injuries and surgery.

Keywords

Discoid, human, knee meniscus, shape.

Background

The meniscus means "little moon" and is a C-shaped cartilage piece that cushions between the tibia and femur. It is a tissue comprising two wedge-shaped semilunar sections of fibrocartilaginous structures inside the knee joint. The menisci, which cover approximately 2/3 of the tibial surface, act like gaskets between the femur and tibia, deepening the flat upper end of the tibia. Meniscus plays a role in the complex biomechanics of the knee and is involved in the stability of the joint, shock absorption, sharing and transmission of the load, nutrition, and lubrication of the articular cartilage [1-3].

There are two types of menisci: lateral and medial [4]. According to the shapes, the menisci were grouped into discoid and undiscoid shapes. The discoid-shaped menisci were subgrouped into complete-shaped and incomplete discoid-shaped menisci. The undiscoid menisci were sub-grouped into crescentic-shaped, semilunar-shaped, sickle-shaped, C-shaped, sided U-shaped, and sided V-shaped. (Figure 1) The shape of the adult meniscus was the gradual resorption of the central portion of a complete plate in the early stages of the embryonic knee joint [5]. The discoid-shaped meniscus is the most common anatomic variant of the lateral meniscus, which is prone to tearing at a younger age. The morphological and structural characteristics lead to peripheral detachment, commonly developing symptoms such as pain, snapping, or limited extension. Patients with snapping knees without pain or locking symptoms will likely have an incomplete discoid meniscus [6]. Anatomical anomalies of the meniscus are an exciting subject because of their clinical significance in developing conditions limiting daily physical activities.

Additionally, it is noteworthy that various morphological anomalies are still being reported for the first time as incidental findings [7]. The frequency of variations can differ in different populations due to genetic variations. Since the knee is a weight-bearing joint and lacks the stability of the hip and ankle's congruent joints, it is more prone to injury. Meniscal injuries are common among school athletes [8], which may cause knee functional impairment. The average age for traumatic and degenerative meniscus lesions is 30 and 40 years, respectively [9], which declines with increasing age for both males and females [10]. Meniscal injuries are acute injuries with lasting consequences. It has been estimated that 66–70 meniscal injuries occur annually per 100,000 people [11-13]. Arthroscopic treatment for meniscal injuries is a pervasive orthopaedic operation [14]. Among sports physicians, a meniscus tear is a prevalent injury that often requires surgical intervention due to intense pain and dysfunction of the knee joint [15]. Meniscal injuries also have an enormous financial impact on the population, as more than 1.7 million patients are estimated to undergo meniscal surgery every year [16, 17].

This pioneering study aimed to examine the variation in the shape of knee menisci and determine the incidence of discoid-shaped menisci in adult human cadavers from Myanmar. Defining more comprehensive anatomical trends regarding the variations of the menisci will set the preliminary work for future prevention and treatment plans for knee injuries.

Material and methods

Study design

It was a cross-sectional descriptive-analytical study. Forty adult embalmed bodies of both genders (20 males and 20 females) aged 18 to 65 years were dissected. The study was performed at the Anatomy Departments, University of Medicine 1 and 2, Yangon, Myanmar. A simple random sampling method was adopted for this study.

Data collection

The dissection was done with the cadaver placed in a supine position. A horizontal incision below the knee and two vertical incisions at the sides of the knee were made, and the skin was reflected from the front of the knee. After removing the skin, quadriceps tendon, and medial and lateral collateral ligaments, the joint cavity of the knee was opened by making longitudinal incisions on each side of the joint capsule. The joint capsule and the intra-articular ligaments were cut, the menisci were exposed clearly, and the femur condyles were separated. Morphologic variations in the shape of the menisci were noted and classified. When the meniscus covered the tibial plateau circularly, the meniscus was said to be discoid type. The incomplete discoid type had an open area at the centre of the meniscus. The crescentic (semilunar) type had a thin anterior horn, posterior horn, and a thin body. The horse-shoe-shaped type had a thick anterior horn, a posterior horn, and a thick body. The sickle-shaped type had thin anterior and posterior horns and a thick body. Sided U, sided V, and C shape type resembled like sided U, sided V, and C shapes respectively. Data collection was done using the quantitative data collection technique of "observing." All dissections were performed systematically, and the data were recorded on a standardized collection sheet. After the procedure, the skin was stitched back thoroughly with minimal disfiguration [6].

Inclusion and exclusion criteria

All menisci from 40 cadavers from the Departments of Anatomy, University of Medicine 1, and University of Medicine 2, Yangon, Myanmar, were included in the study. Severely injured knee joints, meniscal injuries, meniscectomy, joint diseases such as osteoarthritis, rheumatic arthritis, rheumatoid arthritis, and musculoskeletal disorders related to cadavers were excluded. Cadavers with a single limb, amputations above the knee, and surgical interventions in the knee were also excluded to avoid bias.

Sample size calculation

The total sample size calculated for this study was 160 specimens (80 medial menisci and 80 lateral menisci) using $n=Z^2pq/ d^2$

[n=the desirable estimated sample size; Z=the standard normal deviation with 95% confidence interval; p=proportion of variants; q=0.5, d=degree of accuracy] [18].

Data interpretation and statistical analysis

Outcome variables were the number of menisci in various shapes such as crescent shape, horse-shoe shape, sickle shape, U shape, V shape, C shape, complete discoid shape, incomplete discoid shape, and circular shape. The explanatory variables were gender and laterality. For descriptive statistics, frequency distribution was done.

Ethical committee approval

The Ethical and Research Committee and Academic Committee of Anatomy, University of Medicine 2, Yangon, approved the research. Informed consent was obtained from the next of kin before the dissection of the cadaver.

Results

Among medial menisci, sickle shape (Figure 8) was the most common 48(60%), followed by V shape (Figure 3) 12(15%), U shape (Figure 7) at 8(10%), and Horse-shoe shape (Figure 6) 6(7.5%). A C shape, an incomplete discoid shape, and a circular shape were not found. Among lateral menisci, circular shape (Figures 4 and 7) was the most common 60 (75%), followed by incomplete discoid shape (Figures 3 and 5) 13(16.25%) and C shape (Figure 6) 6 (7.5%). Crescent, horse-shoe, sickle, U, and V-shaped meniscus were not found. (Table 1)

Table 1: Incidence of various shapes of menisci

	Medial meniscus		Lateral meniscus	
Shapes	Frequency	%	Frequency	%
Crescent shape	5	6.25	0	0
Horse-shoe shape	6	7.5	0	0
Sickle shape	48	60	0	0
U shape	8	10	0	0
V shape	12	15	0	0
C shape	0	0	6	7.5
Complete discoid shape	1	1.25	1	1.25
Incomplete discoid shape	0	0	13	16.25
Circular shape	0	0	60	75
Total	80	100	80	100

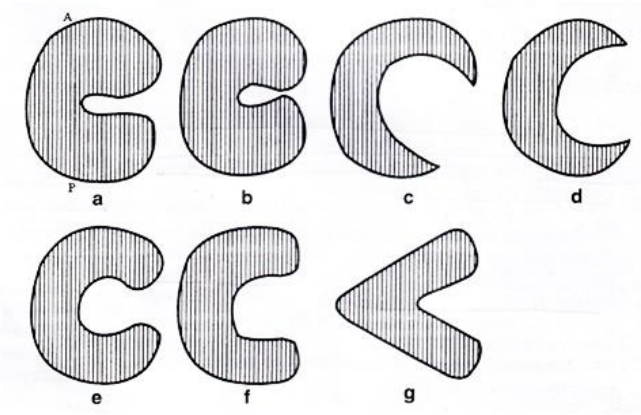

Figure 1: Various shapes of the menisci in newborns [4]
a - incomplete discoid meniscus, b - complete discoid meniscus, c - crescentic shaped meniscus, d - sickle shaped meniscus, e - C shaped meniscus, f - sided U shaped meniscus, g - sided V shaped meniscus

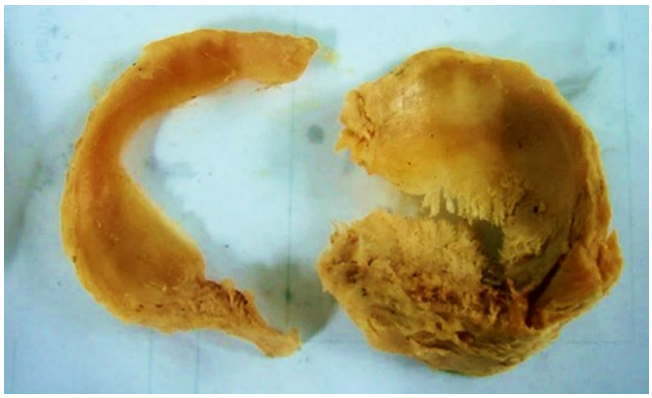

Figure 2: Photograph of right menisci showing V-shaped medial meniscus and complete discoid (primitive disc type) lateral meniscus (case 11)

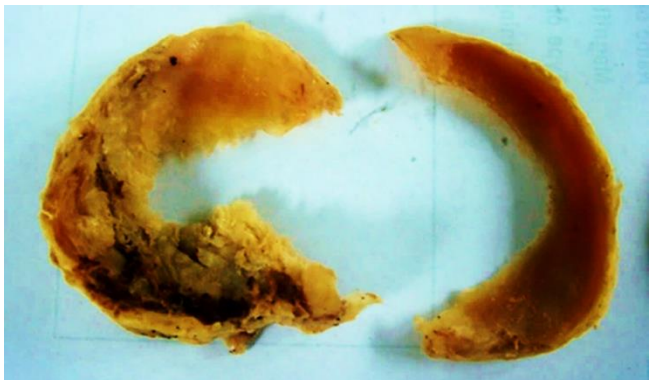

Figure 3: Photograph of left menisci resembling V-shaped medial meniscus and an incomplete discoid lateral meniscus (case 11)

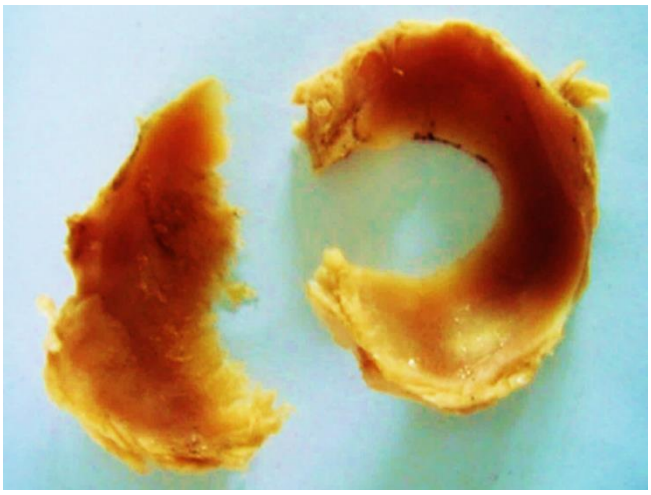

Figure 4: Photograph of right menisci showing complete discoid (infantile type) medial meniscus and circular shape lateral meniscus (case 8)

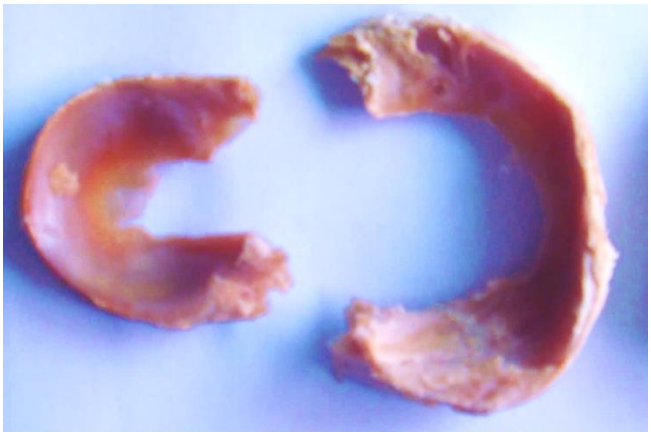

Figure 5: Photograph of left menisci showing horse shoe shape medial meniscus and incomplete discoid shape lateral meniscus (case 31)

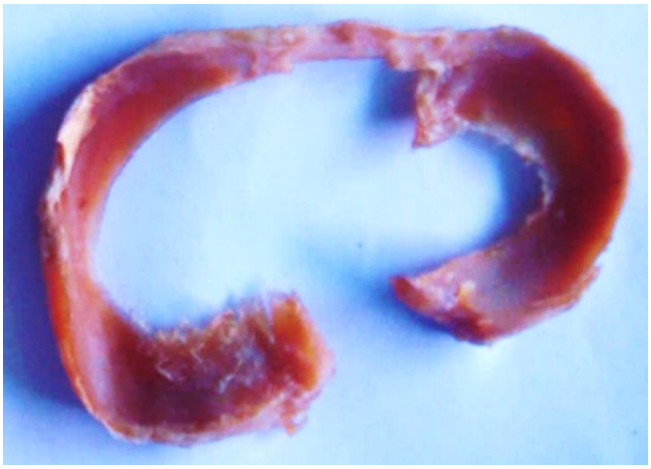

Figure 6: Photograph of right menisci showing horse shoe shape medial meniscus and C shape lateral meniscus (case 30)

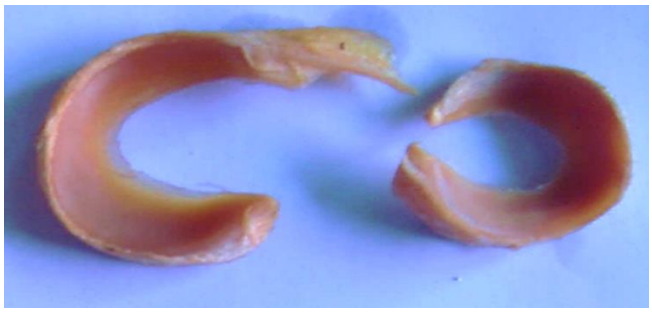

Figure 7: Photograph of right menisci showing U shape medial meniscus with transverse fibrous slip and circular shape lateral meniscus (case 17)

Figure 8: Photograph of left menisci showing sickle shape medial meniscus and circular shape lateral meniscus (case 29)

Table 2: Incidence of various shapes of menisci according to side

Shape	Medial meniscus			Lateral meniscus		
	Right	Left	Total	Right	Left	Total
Crescent shape	2 (2.5 %)	3 (3.75 %)	5 (6.25 %)	0	0	0
Horse-shoe shape	3 (3.75%)	3 (3.75 %)	6 (7.5%)	0	0	0
Sickle shape	24 (30%)	24 (30%)	48 (60%)	0	0	0
U shape	4 (5%)	4 (5%)	8 (10%)	0	0	0
V shape	6 (7.5%)	6 (7.5%)	12 (15%)	0	0	0
C shape	0	0	0	4 (5%)	2 (2.5%)	6 (7.5%)
Complete discoid	1 (1.25 %)	0	1 (1.25 %)	1 (1.25 %)	0	1 (1.25%)
Incomplete discoid	0	0	0	5 (6.25 %)	8 (10%)	13 (16.25 %)
Circular shape	0	0	0	30 (37.5 %)	30 (37.5 %)	60 (75%)

Compared to the side of the medial menisci, a sickle shape was found in 24 menisci (30%) on both sides, which was the most common shape. A complete discoid shape (Figure 4) was found only on the right side of one meniscus. In comparison to the side of lateral menisci, a complete discoid shape (Figure 2) was found only on the right side; an incomplete discoid shape was found in 5 menisci (6.25%) on the right side and 8 menisci (10%) on the left side, and a circular shape in 30 menisci (37.5%) on both sides. The majority of lateral menisci were circular. (Table 2)

Table 3: Incidence of various shapes of menisci according to gender

Shape	Medial meniscus			Lateral meniscus		
	Male	Female	Total	Male	Female	Total
Crescent shape	1 (1.25 %)	4 (5%)	5 (6.25 %)	0	0	0
Horse-shoe shape	2 (2.5%)	4 (5%)	6 (7.5%)	0	0	0
Sickle shape	32 (40%)	16 (20%)	48 (60%)	0	0	0
U shape	2 (2.5 %)	6 (7.5%)	8 (10%)	0	0	0
V shape	3 (3.75 %)	9 (11.25 %)	12 (15%)	0	0	0
C shape	0	0	0	4 (5%)	2 (2.5 %)	6 (7.5%)
Complet e discoid	0	1 (1.25%)	1 (1.25 %)	0	1 (1.25%)	1 (1.25%)
Incompl ete discoid	0	0	0	1 (1.25%)	12 (15%)	13 (16.25 %)
Circular shape	0	0	0	35 (43.75 %)	25 (31.25 %)	60 (75%)

When the medial menisci of both men and women were compared, they were found to have 32 menisci (40%) with a sickle shape in males, 16 menisci (20%) in females, and one meniscus (1.25%) with a complete discoid shape was found only in females. So, the most common shape of the medial meniscus was a sickle shape in both genders. In comparison of lateral menisci in both genders, there are 35 menisci (43.75%) of circular shape and 25 menisci (31.25%) in females; 1 meniscus (1.25%) of complete shape in females; 1 meniscus (1.25%) of incomplete shape in males; and 12 menisci (15%) in females. For the lateral meniscus, the most common shape was circular in both genders. (Table 3)

This study had 15 discoid-shaped menisci (9.4%) (2 complete discoids and 13 incomplete discoids). Among them, 14 discoid menisci were found in females and one meniscus in males; 14 discoid menisci were lateral menisci, and only one was a medial meniscus. Discoid menisci were seen on both sides in five cases and only on one side in five cases. (Table 4)

Table 4: Incidence of discoid shape of menisci

Case Number	genders	Side	Type (Complete/ Incomplete)	MM/ LM
Case No. 1	Female	Left	Incomplete	LM
Case No. 7	Female	Right	Incomplete	LM
Case No. 8	Female	Right	Complete	MM
Case No. 8	Female	Left	Incomplete	LM
Case No. 11	Female	Right	Complete	LM
Case No. 11	Female	Left	Incomplete	LM
Case No. 15	Female	Left	Incomplete	LM
Case No. 27	Female	Right	Incomplete	LM
Case No. 27	Female	Left	Incomplete	LM
Case No. 31	Male	Left	Incomplete	LM
Case No. 35	Female	Right	Incomplete	LM
Case No. 35	Female	Left	Incomplete	LM
Case No. 36	Female	Right	Incomplete	LM
Case No. 40	Female	Right	Incomplete	LM
Case No. 40	Female	Left	Incomplete	LM

Discussion

A previous study by Murlimanju *et al*. showed that 46.2% of the medial meniscus was crescentic-shaped, 23.6% of the medial meniscus was sided V-shaped, 13.2% of the medial meniscus had a sided U-shape, 9.4% of the medial meniscus was sickle-shaped, and 7.5% of the medial meniscus was C-shaped. In our study, in 54.71% of the cases, the medial meniscus shape differed on either side of the knees, and no discoid medial menisci were seen. The crescentic shape, U shape, V shape, and C shape of the medial meniscus were less compared to Murlimanju *et al*.'s study; however, the horseshoe shape sickle shape was more. We also observed that 1.25% of the meniscus was completely discoid. The result may be due to a geographical region, genetic variations, or race differences [4]. Another study focused on the foetus found that 18.8% of the medial menisci were crescentic-shaped, 22.72% were sided V-shaped, 9.09% were sided U-shaped, 36.36% were sickle-shaped, 13.63% were C-shaped. In the present study, the crescentic shape, V shape, and C shape were found less and higher in a horse-shoe shape, sickle shape, U shape, and complete discoid shape [6].

Shashidhar *et al*. found that 50% of medial menisci were crescent-shaped, 37% were sided V-shaped, and 13% were sided U-shaped. In this study, the percentage of crescent, U, and V shapes was lower, but sickle shapes were predominant [19]. Murlimanju *et al*. have found that 82.1 % of lateral menisci were non-discoid; among them, 62.3% were C-shaped and 19.8% were crescentic-shaped. These results were similar to our study, where 82.5% of lateral menisci were non-discoid. But most of the shape was circular (75%). These results may suggest race differences or congenital abnormal meniscal variations [4].

Jordan MR reported that the lateral meniscus was morphologically more variable than the medial meniscus. 72% of the lateral menisci were C-shaped, and 26% were crescent-shaped. One partial discoid lateral meniscus (2%) was observed. Although our study's C and crescent-shaped meniscus were markedly less, the incomplete discoid shape was higher and was about 16.25% [20]. Rath mentioned that

the medial meniscus had a more crescentic shape, but the lateral meniscus was more circular, smaller, and more freely movable than the medial [21]. In primates, the medial meniscus always has a crescentic shape, but the lateral meniscus may have either a crescentic or disc shape. We found the medial meniscus had a sickle shape similar to the lateral one [22].

In this study, 5% of the right medial menisci were crescentic, 7.5% were horseshoe, 60% were sickle, 10% were U shape, 15% were V shape, and 2.5% were complete discoid shapes. In studying the shape of the left medial menisci, 7.5% were a crescentic shape, 7.5% were a horseshoe shape, 60% were a sickle shape, 10% were a U shape, and 15% were a V shape. There was no complete discoid shape at all. No author mentioned the shape of the medial menisci on the right and left sides.

In this study, 2.5% of right lateral menisci were horseshoe shapes, 2.5% were V shapes, 5% were C shapes, 2.5% were complete discoid shapes, 12.5% were incomplete discoid shapes, and 75% were circular shapes. In studying the shape of the left lateral menisci, 2.5% were horseshoe shapes, 2.5% were C shapes, 20% were incomplete discoid shapes, and 75% were circular shapes. There was no complete discoid shape in the left lateral menisci. This is the first report of the shape of the lateral menisci on the right and left sides.

We found 1 of 40 medial menisci (2.5%) was a crescent shape, 2 menisci (5%) were horse-shoe shaped, 32 menisci (80%) were sickle shapes, 2 menisci (5%) were U, and 3 menisci (7.5%) were V shape in males. In females, 4 of 40 medial menisci (10%) were crescent shape, 5 menisci (12.5%) were horse-shoe shaped, 15 menisci (37.5%) were sickle shape, 6 menisci (15%) were U shape, 9 menisci (22.5%) were V shape and 1 meniscus (2.5%) was found to be a complete discoid meniscus. 2 of 40 lateral menisci (5%) were horse-shoe shapes, 1 meniscus (2.5%) was a V shape, 1 meniscus (2.5%) was a C shape, 1 meniscus was an incomplete discoid shape, and 17 menisci (42.5%) were circular shapes in males. In females, 1 meniscus (2.5%) was a C shape, 1 meniscus was a complete discoid shape, 12 menisci (30%) were incomplete discoid shapes, and 26 menisci (65%) were circular shapes. There was no study differentiating males from females.

Kale A observed that discoid lateral meniscus was commonly found, with an approximate incidence rate ranging from 0.4% to 17%. In contrast, discoid medial meniscus is rarely detected, with an incidence of 0.06% to 0.3%. A higher prevalence has been reported in Asian populations (10–15%) than in Western populations. In the present study, the incidence of discoid shape is similar to that of Kale, and the incidence of discoid shape in the lateral meniscus was 8.8%, and in the medial meniscus was 0.8% [6]. The shape of the adult meniscus was the gradual resorption of the central zone of a complete plate in the early embryonic knee joint. The human menisci represented adult shape by 10 weeks of gestation, and a complete, solid disc was never present. In this study, we did not do it in the embryonic knee joint, but we can find it as a complete plate. [5, 23] Discoid medial menisci are rare. A study reports that out of 16895 subjects, only 15 cases (0.09%) were found. The simultaneous existence of a lateral and medial discoid meniscus was extremely rare, and only one case had ever been reported [6]. This study agrees with this author, as we found one case with a discoid shape of the lateral menisci on both sides in five cases. The discoid lateral meniscus was the most common anatomic variation, ranging from 0.4% to 17%. Others include ring-shaped, double-layered, hypoplastic, accessory, partially deficient, and abnormal bands of the lateral meniscus [24]. This study's incidence of discoid lateral menisci agrees with these findings. The discoid meniscus was first described in the late 1800s. The discoid shape in the medial meniscus was rare, and bilateral discoid medial meniscus was extremely rare. However, the discoid lateral meniscus is commonly reported in children [25, 26].

A greater incidence of discoid menisci in the Ascian population is observed; 17% of Koreans and Japanese descent might have a discoid meniscus. The frequency of a discoid medial meniscus was estimated to be 0.009%, and 1.45% of cases were discoid lateral menisci. Hereditary transmission was also one of the factors determining the discoid shape [22, 27]. The incidence of discoid menisci in Myanmar is lower than in Korea and Japan.

Conclusion

We conclude that the sickle shape was most abundant in the medial menisci and circular in the lateral menisci. The least common meniscal shape was discoid, found in both medial and lateral menisci. We observed anomalies from abnormal morphogenesis, such as embryological or environmental factors. But the exact cause of the discoid shape is unknown and may have many reasons. This study will support meniscal anatomy concerning the surgical procedure and arthroscopy of the knee joint and the effective management of rehabilitation for patients after meniscal injury and surgery in the future.

Limitations and future scope of the study

The study should also include neonates, ages, and different races to investigate more variations. The sample size in this study fairly represents the population, so future studies are recommended with a larger population. Variations in morphology and intrinsic afferent innervations must be studied for more information about the knee menisci.

Relevance of the study

Meniscal injuries in children and adolescents are being seen with increased frequency. The snapping knee syndrome is usually related to the type of meniscus or the presence of a meniscus tear and more often in children and adolescents. It is one of the most common sports-related problems and the most frequent injury to the knee joint. Understanding meniscal pathology is crucial to managing the meniscal repair system, arthroplasty, and allograft therapy. This study

will support meniscal anatomy concerning surgical procedures and knee joint arthroscopy. It may be important not only for orthopedic surgeons but also for morphologists. It may also exist in the meniscus, facilitating the rehabilitation process. This study will help fulfill anatomical knowledge concerning the knee joint.

Abbreviations

lateral meniscus (LM), medial meniscus (MM)

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Authors' contribution

a. Study planning: TT, LH
b. Data collection: TT, LH
c. Data analysis/ interpretation: TT, LH
d. Manuscript writing: TT, AR, YM, HTD, NHH
e. Manuscript revision: TT, AR, YM, HTD, NHH
f. Final approval: TT, LH, AR, YM, HTD, NHH
g. Agreement to be accountable for all aspects of the work: TT, LH, AR, YM, HTD, NHH

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Availability of data and materials

All data underlying the results are available as part of the article.

Competing interests

The authors declare that there are no conflicts of interest to disclose in relation to this manuscript.

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