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RESEARCH ARTICLE

MORPHOLOGY AND MORPHOMETRY OF KNEE MENISCI

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ABSTRACT

Aim of the study: To study the morphological and morphometric study of the menisci of the knee joint and its clinical significance.

Objectives: To estimate the incidence of different shapes of the medial and lateral menisci and the incidence of discoid meniscus. To evaluate the morphometric variations in the menisci.

Materials and Methods: The study was carried out over a period of three years in the Department of Anatomy, Sri Ramachandra Medical College and Research Institute, Sri Ramachandra University, Chennai.

Materials: The following materials were used for the study:

Human adult knee joints, available in the Anatomy dissection hall, were used for the present study. The study includes 116 menisci from 58 knee joints of adult cadavers. Among them, 31 were right-sided and 27 were left-sided isolated lower limbs.

Methods

1.**Morphological Study:** After the dissection of the skin and muscles, the approaches to the menisci were performed, opening anteriorly by a longitudinal incision on each side of the joint capsule, cutting the patellar ligament and the collateral ligaments transversely. In order to expose the menisci clearly, the joint capsule and the intra-articular ligaments were cut and the condyles were circumferentially detached from their soft tissue attachments and removed, exposing the tibial plateau. All dissections were performed in a systematic fashion and the data were recorded on a standardized collection sheet. Morphological variants of the shapes of the menisci were macroscopically noted and classified. The medial menisci (MM) were sub-grouped as sickle shaped, sided U shaped, sided V-shaped, crescent-shaped and C-shaped. The lateral meniscus (LM) was sub-grouped as crescent (semilunar)-shaped, C-shaped and discoid-shaped. When the meniscus covers the tibial plateau circularly, the meniscus is said to be a discoid type. Menisci, which had thin anterior and posterior horns and thin bodies, were defined as crescent (semilunar)- types. Menisci, which had thin anterior, posterior horns and thick bodies, were defined as sickle-shaped types. Menicsi which resembled sided U, sided V and C were named as sided U, sided V and C shaped respectively. Menisci that showed any structural changes, such as injuries or advanced degenerative changes were excluded.

2.**Morphometric Study:** To measure the length of the menisci, a line was positioned from the apex of anterior horn to the apex of posterior horn of the meniscus. The distance of the line was measured with Vernier Caliper. The width of menisci was determined by establishing three points: anterior third (a), medium third (b) and posterior third (c). From each point, one line was drawn from the peripheral margin to the central margin of meniscus. The values were recorded. The thickness of the meniscus was determined using the same width points, between the top and bottom edge in outer circumference only. The data were tabulated and statistically analysed.

Discussion: The present study was undertaken in 116 adult menisci from 58 adult cadaveric knee joints. Menisci were studied for a review of its morphology, morphometry and its comparison with previous studies. The main findings were: Five morphological types of menisci were determined.

Out of 58 medial menisci studied, 54.6% were crescent shaped; 34.6% were V shaped;10.8% were U shaped and no discoid medial menisci were found. Out of 58 lateral menisci studied, 41.6% were crescent shaped; 56.4% were C shaped; 2% discoid lateral menisci were found. Morphometry revealed the following results: The length of lateral meniscus is smaller than that of the medial meniscus; the width of the lateral meniscus is more than that of the medial meniscus; the medial meniscus is thicker when compared to lateral meniscus in both the left and right side knee. Difference in shape and size of menisci in the same knee as well as with different knees of different cadavers were observed. The obtained results presented variations regarding some parameters when compared to the previous studies.

Conclusion: The present study will provide support to the meniscal anatomy, concerning the surgical procedures and arthroscopy of the knee joint. The study has provided additional information on different shapes of the medial and lateral meniscus with contribution to a better delineation of meniscal anatomy and implications in regard to allograft meniscus transplantation. Therefore, health professionals that work with the treatment of meniscal injuries should be aware of the possible anatomical variations that may exist in the meniscus facilitating the rehabilitation process.

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INTRODUCTION

The word meniscus means "little moon" in Greek, a name evoked by its crescent shape (Joseph Bernstein, 2010).The menisci are two crescentic lamellae, which serve to deepen the surfaces of the articular fossae of the upper end of the tibia for the reception of the condyles of the femur (Morre *et al*., 1999; Standring *et al*., 2006; Snell, 2008). Various functions of the **menisci** include that of load transmission (Fukubayashi *et al*., 1980; Shrive, 1978), shock absorption (Brown *et al*., 1984), lubrication (MacConaill, 1950) and improvement of stability (Levy *et al*., 1982). Such functions are considered as primordial to protect the articular cartilage and prevent osteoarthritis (Messner and Gao, 1998). The menisci perform important mechanical functions and they are anatomical structures which are exposed to injury. These lesions may occur as part of a rotational trauma or bending, as the evolution of a joint degenerative process, or as a spontaneous injury resulting from a progressive structural failure without any correlation with trauma or a degenerative process. This is called as meniscal injury due to fatigue (Camanho, 2009), whatever the trigger for the injury, its morphology can be closely related to the injury. There are marked differences between the contour and the insertion of the medial and lateral menisci that are important concerning the mechanism of injury (Almeida *et al*., 2004).

The anatomical abnormalities and the variations of the intra articular structures of the knee joint have recently become significant because of the new techniques such as arthroscopy, Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) and the investigation of these variants is important to define the morphological features for clinical diagnosis and surgical procedures (Kale *et al*., 2006). The frequency and severity of knee injuries especially meniscal injuries are more in sports industry. The snapping knee syndrome is usually related with the type of the meniscus or to the presence of a tear of the meniscus and this syndrome appears more often in children and young adolescents (Kelly and Green, 2002). Injuries to the menisci are common in work, sports and everyday activities and can be disabling. In meniscus allograft transplantation, it is the responsibility of the tissue bank to provide a meniscal allograft that matches the size and shape of the meniscus to the recipient's knee (Haut *et al*, 2000). In both anatomical and orthopedic literature, more attention is given to the form of the menisci of the knee joint especially the occurrence of a discoid type of lateral meniscus.

Nowadays a ruptured meniscus is repaired rather than removed, but this treatment is only feasible when the meniscus tissue is otherwise of good feasible and of good quality. In the more frequent cases with irreversible damage of meniscal tissue, partial instead of total meniscectomy is the treatment of choice to minimize loss of this important meniscus (Karola Messner and Jizong Goa, 1998). Successful meniscus transplantation may depend on accurate sizing. Meniscal sizing is currently determined by measuring a combination of bony landmarks and soft-tissue insertion points through images obtained by radiographically or by Magnetic Resonance Imaging (Pollard *et al*., 1995). Therefore based on its clinical importance, the study was carried out to find out the shape, thickness of the outer circumference, width and distance between the anterior and posterior horns of the menisci of the knee joint.

Review of Literature

Morphological study of Menisci: Literature analysis revealed the study of different morphological features of the menisci.

Discoid lateral meniscus was observed by Young (1889), in a cadaver and Kroiss (1910) attributed the term 'snapping knee syndrome' to the same. Arthroscopy allows more precise diagnosis of the lesion (Watanabe *et al*., 1979; Ikeuchi, 1982; Hayashi *et al*., 1988) and confirms the clinical diagnosis and can identify an associated tear. Parson (1900), found that the medial meniscus always has a crescentic shape and the lateral meniscus is either crescentic or disc shape in a morphological study of 316 non human primates representive of 43 genera.
Fick and Rudolph (1904) described medial meniscus as a half, two thirds or three-fourths ellipse and lateral meniscus as almost complete circle. Charles (1935) and Gaillard (1966) classified the menisci both on the basis of the relative size of the anterior and posterior cornua and also on the degree of curvature. They found that lateral meniscus has a crescentic shape.

Smillie (1948) postulated that there are three types of discoid lateral meniscus – 1.Primitive 2.Intermediate and 3.Infantile. Also stated that the cause of anomaly was the persistence of a disc-shaped meniscus arrested at varying stages of embryological development.

Kaplan (1957) however was unable to find a cartilaginous disc representing the meniscus at any stage of human embryological development or in any of his comparative anatomical dissections. He contended that the discoid lateral meniscus begins as a normally shaped meniscus that has no attachment to the tibial plateau posteriorly. These have only one attachment to the tibial plateau posteriorly, the lateral meniscofemoral ligament, or the ligament of Wrisberg.

Watanabe et al., (1969) classified discoid meniscus, as seen arthroscopically, into three types: 1.Complete type 2.Incomplete type and 3. Wrisberg -ligament type. Albertson and Gillquist (1988), classified the shape of the menisci into hypoplasia or hyperplasia (discoid meniscus). The meniscal hyperplasia or discoid menisci have been the object of many studies, because they are frequently the source of symptoms.
*Le Minor (1990) and Davidson et al., (2003), described the discoid meniscus is an atavistic anamoly in which the meniscus of the knee, predominantly the lateral meniscus, is discoid rather than semilunar in shape.*Monllau *et al*., (1998) stated that the existence of abnormal-shaped menisci has been long recognized and the presence of discoid menisci in the human knee is considered to be a congenital malformation with a very low rate of incidence except in Asian populations. He had proposed that this observation of a ring shaped meniscus on the lateral side of the knee can be included as a fourth variant in a future classification, when compared with the classification in Watanabe's Atlas. Kelleys and Green (2002), described that the discoid shape resulted in a greater coverage of the tibia and was usually associated with increased thickness of the meniscus that might lead to abnormal shearing forces across the knee joint.

Kale et al.,(2006), conducted morphological study of 22 fetal knee joints and found that 18.8% of medial meniscus were crescent shaped, 22.72% were sided V shaped, 9.09% of medial meniscus were sided U-shaped, 36.36% of medial

meniscus were sickle shaped and 13.63% of the medial meniscus were C- shaped. In the same study, 13.63% of the lateral menisus were crescent shaped, 9.09% of the lateral meniscus was C-shaped and 77.27% of the lateral meniscus were discoid-shaped. Among the discoid shaped, 54.54% of lateral meniscus were incomplete discoid and 22.72% were completely discoid and no discoid medial meniscus were observed. They found that 73% of the cadavers they studied had the same shape of meniscus of each side.

Aysin Kale *et al*.,(2006) conducted a morphological study of 11 neonatal cadavers of 22 knee joints. They found that 77% of laternal meniscus were discoid and the different shapes of meniscus determined as horse shoe shaped, sickle shaped, sided U shaped, sided V shaped and C shaped but no discoid medial meniscus were observed.

Muralimanju et al., (2010) conducted a morphological study of 108 meniscus of 54 adult cadaveric knee joints. They found that 50% of the medial meniscus were crescent shaped, 38.9% were V-shaped and 11.1% were sided U-shaped. The percentage of the different types of lateral meniscus were 61.1% were C-shaped and 38.9% were crescent shaped and no discoid medial or lateral meniscus were observed.

Muralimanju *et al*., (2010) also conducted a morphological study of 106 fetal knee joints. They found that morphological variation of the shape of the medial meniscus were 46.2% were crescent shape, 23.6% V-shaped,13.2% sided U-shaped,9.4% of them were sickle shaped, 7.5% were C-shaped and no discoid medial meniscus, were observed. They found that 54.71% of the cadavers of the medial meniscus shape was different on each side of the fetus.

Morphometric Study of Menisci: *Testut and Latarjet (1975)* mentioned in a more generalized description of the morphometry study of menisci who had mentioned that the average thickness of outer circumference is 8mm for the lateral meniscus and 6mm for the medial meniscus and that the average width of menisci is 10-12mm.

Hayashi et al., (1988) stated about the necessity to reduce substantially the thickness and the width of discoid meniscus during the surgical procedure, and revealed that the normal menisci showed thickness and width of 6-8mm and 12- 13mm, respectively.

Erbagci et al., (2004) determined the dimensions of normal menisci in 174 healthy subjects by using MRI. The measurements were:

- For medial meniscus, the height and width of the anterior horn were 5.32 mm and 7.78 mm, the height and width of the mid-body were 5.03 mm and 7.37 mm and the height and width of the posterior horn were 5.53 mm and 11.71 mm, respectively.
- For the lateral meniscus, the height and width of the anterior horn were 4.33mm and 8.88 mm, the height and width of the mid-body were 4.94 mm and 8.37 mm and the height and width of the posterior horn were 5.36 mm and 9.70 mm respectively.

According to *Smillie et al., (1985)* and *Cohen et al., (1993),* the menisci cover from 1/2 to 2/3 of the articular surface of the corresponding tibial plate, with the lateral meniscus covering an area higher than the medial meniscus.

Almeida et al., (2004) conducted a morphometric study of 44 menisci of 22 knees. They found that the thickness of medial meniscus in anterior third , middle third, posterior third were 5.92mm, 5.31mm and 5.91mm respectively and for the lateral meniscus were 3.71mm, 6.10mm and 5.29mm respectively. The width of the medial meniscus was 9.02mm, 12.16mm and 17.37mm and for the lateral meniscus was 11.86mm, 11.97mm and 11.44mm for anterior third, medial third and posterior third respectively. The distance between the anterior and posterior horn of the medial meniscus were 29.70 mm and of the lateral meniscus were 12.71 mm.

Braz and Silva (2010) conducted a morphometric study of 40 menisci of 20 knees. They found that the thickness of medial menisci in the anterior third, middle third and posterior third was 6.17mm, 6.31mm and 5.18mm respectively and for the lateral menisci were 4.40mm, 6.52mm and 5.46mm. The width of the medial menisci were 7.68mm, 9.32mm and 14.96mm and for the lateral menisci were 11.32mm, 11.16mm and 11.67mm for the anterior third, middle third and posterior third respectively. The average length of the outer circumference was 91.85mm for the medial meniscus and 92.80 mm for the lateral meniscus respectively.

Muralimanju *et al*., (2010) conducted morphometric study of 212 menisci of 106 knees (53 right and 53 left side) from 27 female and 26 male fetuses. They found that peripheral length of medial meniscus was 26.66mm and lateral meniscus was 25.14mm. The inner body length was found to be 14.72mm and 12.59mm for medial and lateral meniscus respectively. The thickness of the medial meniscus in the anterior third, middle third and posterior third were 1.61mm, 1.47mm and 1.48mm respectively and for the lateral meniscus were 1.57mm, 1.52mm and 1.49mm. The width of medial meniscus were 2.94mm, 2.88mm and 3.28mm and for the lateral meniscus were 3.26mm, 3.53mm and 3.44mm for anterior third, middle third and posterior third respectively.

Development of Menisci

The meniscus develops from the differentiation of mesenchymal tissue within the limb bud and becomes a clearly defined structure by the eighth week of fetal development. (Kaplan (1957); Andrish (1996); Arrequi *et al*., (2003)). Clark *et al*., (1983) stated that during embryologic development, the blood supply of the meniscus enters from the periphery and extends throughout the entire width. However, by the ninth month of life, the central third will be avascular and by adulthood, only the peripheral one third will receive any blood supply. According to Merida – Velaseo *et al*., (1997), the menisci arises from the eccentric portion of the articular interzone during the O'Rahilly stage 22, however, until week 9 of development, they are not easily distinguishable. According to *Insal and Scott (1999), the differentiation* of synovial mesenchyme into rudimentary menisci begins during 8th week of gestation. Organization proceeds rapidly and the structures are distinguished clearly by 9th to 10th weeks, growth of the menisci is more rapid than that of the corresponding tibial plateau relative to the meniscus equalizes and remains fairly constant through the remainder of fetal and postnatal development and the lateral meniscus covers a greater percentage of its plateau than the medial meniscus at all ages.

Robert et al., (2000) stated that, progressive and gradual changes occur from birth to mid-adolescence, consisting of decreased cellularity, decreased vascularity, and increased collagen content. In a developing child, the collagen fibers become oriented in order to adapt to the weight-bearing stresses. According to an arthroscopic study done on fetal knee joint by *Jose et al.,*(2003), suprapatellar and infrapatellar septa were an almost consistent finding in the 20 frozen fetuses (gestational age of 24 to 40 ± 2 weeks) obtained from spontaneous abortions. The suprapatellar septum always opened laterally and was intact in the developmentally younger specimens. They found two medio-patellar septa. The femoral attachment of the anterior cruciate ligament (ACL) differed in appearance from that of the adult, in that it was more ribbon-like. The lateral meniscus had a more spread-out appearance than its adult counterpart, especially in the specimens of a younger gestational age. There was an easy accessibility of popliteal hiatus and clear arthroscopic vision was obtained of the involved structures.

Vascular Anatomy of Menisci

Arnoczky et al., (1982) stated that the vascular supply to the menisci is provided by the lateral and medial geniculate arteries which form a perimeniscal capillary plexus with radial branches directed towards the centre of the joint. Danzig *et al*., (1983) and Day *et al*., (1985) stated that in the adult, the degree of vascular penetration from the periphery was 10-30% of the width of the medial meniscus and 10-25% of that of the lateral meniscus. The anterior and posterior horns of the menisci are more vascularized than their bodies. Peterson and Tillmann (1995) stated that the blood vessels could be identified in the peripheral third of the menisci around the 22 weeks of gestation in man and at birth almost the entire meniscus was vascularised and in the second year of life an avascular area developed along the central margins of the menisci.

Composition of Meniscal Tissue

- Herwig *et al*., (1984) stated that the normal human meniscal tissue has been found to be composed of 72% water, 22% collagen, 0.8% glycosaminoglycans and 0.12% DNA.
- According to Proctor *et al*., (1989), the water content of the meniscal tissue was found to be higher in specimens taken from posterior areas than central or anterior areas.
- Ingman *et al*., (1974) stated that on a dry weight basis, normal adult menisci contained 78% collagen, 8% non-collagenous protein and 1% hexosamine.
- Bland and Ashhurst (1996) stated that as the menisci grow, the cells become more widely separated and by 12-14 week postnatally, the cartilaginous areas with large cells in lacunae are found.
- Ghadially *et al*., (1978) stated that in adult fusiform cells are found in the superficial layer of the human meniscal tissue and ovoid or polygonal shape cells are found in the deeper layer of the human meniscal tissue.
- According to Eyre and Wu (1983); McDevitt and Webber (1990), Type I collagen accounts for over 90% and types II, III and V collagens for the remaining meniscal tissue collagens. The distribution of different collagens shows significant regional variations.
- Herwig *et al*., (1984) stated that normal human meniscal proteoglycans contain approximately 40% chondroitin 6 sulphate, 10-20% chondroitin 4 sulphate, 20-30% dermatan sulphate and 15% keratin sulphate.

Age Related Menisci

Ishido (1923) noted that in the new born both menisci are broad and cover the entire tibial surface. Ishido(1923) and Mandl(1927) stated that meniscus of the new born is divided into three layers- an outer vascular one, a middle zone rich in fibres and an inner cellular layer. According to Michael Burman and Charles Sutro (1933), in the first few months of life, the width of the meniscus regresses, the inner zone diminishes and the middle zone becomes coarser and more homogenous. In the second year of life, with the assumption of erect posture and walking, there is a further alteration of structure. The ground substance or substantia of the middle layer shows wavy, interplaiting, homogeneous fibres and reduction of cell nuclei. At twelve to fifteen years of age, the typical appearance of fibrocartilge is present and meniscus becomes somewhat yellow. The meniscus of old cannot be differentiated from the young.

Meniscal Tears

Smillie(1968) reported on 3000 meniscal tears treated with open meniscectomy. He found that 72% were medial, 15% were lateral and 13% were either congenital discs or "other"(cysts, and no lesion) and also he found that 58% of the tear horizontal and 42% were longitudinal. Poehling *et al*., (1990) reported on 6039 meniscal tears and found that 42% of the tears to be considered horizontal and 56% to be vertical. Metcalf (1981), reviewed 258 tears and found 15% to be horizontal and 84% to be vertical. Arnoczky and Warren (1982) demonstrated that medial meniscus has vascular penetration to only the outer 10% to 30% of the width. The lateral meniscus has vascular penetration to 10% to 25% of its width. Based on this work, Cooper *et al*., (1991) described a system of classifying meniscal tears. Zone 0 is the menisal-synovial junction; zone 1 is the outer third of the meniscus; zone 2 is the middle third and zone 3 is the central third of the meniscus. This classification is clinically useful because it gives more information on the healing potential of meniscal repairs. Tears in either zone 0 or zone 1 would have the highest potential for healing. Dandy (1990), Metcalf (1988), Noble *et al*., (1980) stated that tears were described by the appearance of the meniscus using similar terms that were used by open surgeons: bucket handle, flap, oblique, horizontal, vertical, longitudinal, and complex. Despite several large studies using this type of system, there is variation between the studies on the relative percentage of patients with each type of tear. Joseph Bernstein (2010) stated that in bucket handle tear, large piece of meniscus is torn from the periphery yet anchored at its end. This meniscal fragment can block extension of the knee. The diagnosis of a meniscal tear is best established by Magnetic Resonance Imaging. There are three broad categories of treatment: nonoperative modalities, partial meniscectomy and meniscal repair. Dandy (1990), reported on the anatomy of 1000 symptomatic meniscal tears and 75% of the medial meniscal tears were found to be vertical and 23% to be horizontal.

Meniscal tears remain one of the most common injuries seen in orthopedic clinics. Arthroscopic treatment is the standard of care, and many authors have advocated repairing meniscal tears when possible (Barber (1985), DeHaven (1985), Aglietti

(1994), Biedert (2000)). According to Cipolla *et al*.,(1995) and Bellabarda *et al*., (1997) in acute case of anterior cruciate ligament(ACL) injury, the rate of menisal injury were 28.5% to 44% for the medial meniscus and 56% to 61% for the lateral meniscus. In chronic cases, the rate of the medial meniscal injury was 70% to 74.5% and that of the lateral meniscus was 30% to 41.6%. According to Vedi *et al*., (1999), the posterior horn is relatively immobile compared to other parts of the medial meniscus, it is vulnerable to tears. Ozkoc *et al*., (2008), reported that this type of meniscal tear is strongly associated with obesity and older age and is usually accompanied by degenerative chondral damage in the compartment involved. Horizontal tears are known as degenerative tears and are more common in the elderly population. According to *Timothy Brindle et al., (2001),* the major determinants of whether a meniscal tear is amenable to surgical repair are the location of the tear, the type of lesion and its related vascular supply. Three zones determine the healing prognosis for meniscal lesions: red-red, red-white and white-white. The red-red zone is fully vascular and therefore has an excellent healing prognosis. The red white zone is at the border of vascular supply and has a generally good healing prognosis. The white-white zone is relatively avascular and has a poor prognosis. Michael Metcalf and Gene Barrett (2004), prospectively evaluated 1485 meniscal tears in stable knee and found that 40% of tear are vertical and 60% are horizontal. Garrett *et al*. (2006) postulated that meniscal tears can cause considerable symptoms (pain, catching or locking, and effusions) and may subject the knee to premature degeneration of the joint. They also are one of the most common indications for an orthopedic surgical procedure. Chul Jun Choi *et al*., (2011), conducted a retrospective review on 387 patients with medial meniscal tear and found that 23.5% were radial tears, 24.6% were chorizontal tears, 37.2% were complex tears and 14.7% were longitudinal tears.

Meniscal Repair

According to Annandale (1885), the first reported surgical human meniscal repair occurred in 1885 and described as tedious. Henning (1990) stated that meniscal repair procedures are divided into two major types: open and arthroscopically assisted. The open procedure is less common compared to "all-inside" techniques in an arthroscopic procedure because of its benefits of incisions and a reduced risk of neurovascular injury particularly when peripheral tears within the meniscal red zone are repaired. Northmore Ball and Dandy (1982) stated that there is a slightly greater frequency of excellent clinical results after partial medial meniscectomy than after partial lateral meniscectomy.

According to DeHaven (1983) and Arnoczky *et al*., (1988) three methods are commonly used to enhance healing.

- Fibrin clot is injected into the meniscal lesion to promote healing through hematoma chemotactic factors.
- Vascular Access Channels (trephination) enables fibrovascular scar proliferation in the damaged meniscal section.

Abrasion of the synovium with a surgical rasping device activates chemotactic factors that stimulates meniscal healing.

Partial meniscectomy replaced the total meniscectomy as the surgery of choice, along with other options such as repairs and transplantations. Before selecting a particular surgical technique, the surgeon considers the patient's age, health, lifestyle and willingness to undergo major surgery and the location and type of meniscal tear. (Cooper et al.,(1990), DeHaven (1990), Warren(1990)). Cannon et al., (1992) stated that vertical longitudinal meniscal tear is considered ideal for repair because of minimal circumferential fibre disruption. The bucket-handle tear is less amenable to repair, as stray circumferential fibres may interfere with healing. Flap and radial meniscal tears also disrupt these circumferential collagen fibres and are more amenable to debridement than repair. According to Cannon (1993), partial menisectomy is the surgical treatment of choice for patients older than 30 years.

Meniscal Reconstruction

A meniscal allograft is donated from a cadaver and transplanted into an injured knee. There are four types of meniscal allograft preparations: fresh, deep frozen, cryopreserved and freeze dried (Buck *et al*.,(1988)). *Arnoczsky et al., (1990)* used a dog model to study the histologic properties of cryopreserved meniscal tissue and reported that the number of metabolically active cells after transplantation decreased and cellularity and peripheral vascularity increased by 3 months after surgery. *Duncan et al., (1995) stated* that meniscal transplantation using frozen donor tissue is probably the simplest and least expensive method; however, the process is known to destroy donor fibrochondrocytes and partially shrink the graft tissue.

MATERIALS AND METHODS

The study was carried out over a period of three years in the Department of Anatomy, Sri Ramachandra Medical College and Research Institute, Sri Ramachandra University, Chennai.

Materials

The following materials were used for the study: Human adult knee joints, available in the Anatomy dissection hall, were used for the present study. The study includes 116 menisci from 58 knee joints of adult cadavers. Among them, 31 were right-sided and 27 were left-sided isolated lower limbs.

Methods

Morphological Study

After the dissection of the skin and muscles, the approaches to the menisci were performed, opening anteriorly by a longitudinal incision on each side of the joint capsule, cutting the patellar ligament and the collateral ligaments transversely. In order to expose the menisci clearly, the joint capsule and the intra-articular ligaments were cut and the condyles were circumferentially detached from their soft tissue attachments and removed, exposing the tibial plateau. All dissections were performed in a systematic fashion and the data were recorded on a standardized collection sheet. Morphological variants of the shapes of the menisci were macroscopically noted and classified. The medial menisci (MM) were sub-grouped as sickle shaped, sided U shaped, sided V-shaped, crescent-shaped and C-shaped (Fig.1). The lateral meniscus (LM) was sub-grouped as crescent (semilunar)-shaped, C-shaped and discoid-shaped (Fig.1). When the meniscus covers the tibial plateau circularly, the meniscus is said to be a discoid type. Menisci, which had thin anterior and posterior horns and thin bodies,

were defined as crescent (semilunar)- types. Menisci, which had thin anterior, posterior horns and thick bodies, were defined as sickle-shaped types. Menicsi which resembled sided U, sided V and C were named as sided U, sided V and C shaped respectively. Menisci that showed any structural changes, such as injuries or advanced degenerative changes were excluded.

Morphometric Study

To measure the length of the menisci, a line was positioned from the apex of anterior horn to the apex of posterior horn of the meniscus. The distance of the line was measured with Vernier Caliper (Fig.2). The width of menisci was determined by establishing three points: anterior third (a), medium third (b) and posterior third (c). From each point, one line was drawn from the peripheral margin to the central margin of meniscus, as shown in (Fig. 3). The values were recorded. The thickness of the meniscus was determined using the same width points, between the top and bottom edge in the outer circumference only. The data were tabulated and statistically analysed.

Morphometric study of Menisci: The following morphometric data were noted in 58 knee joints of adult cadavers.

Length

Medial Meniscus

Length of the medial meniscus in the right - sided knee:

The average length of the medial meniscus is 7.02 cms (Tables -3,5 & Fig.11).

Length of the medial meniscus in the left - sided knee:

The average length of medial meniscus is 7.46 cms in left-sided knee (Tables – 4,5 & Fig.11).

Lateral Meniscus

Length of the lateral meniscus in the right -sided knee:

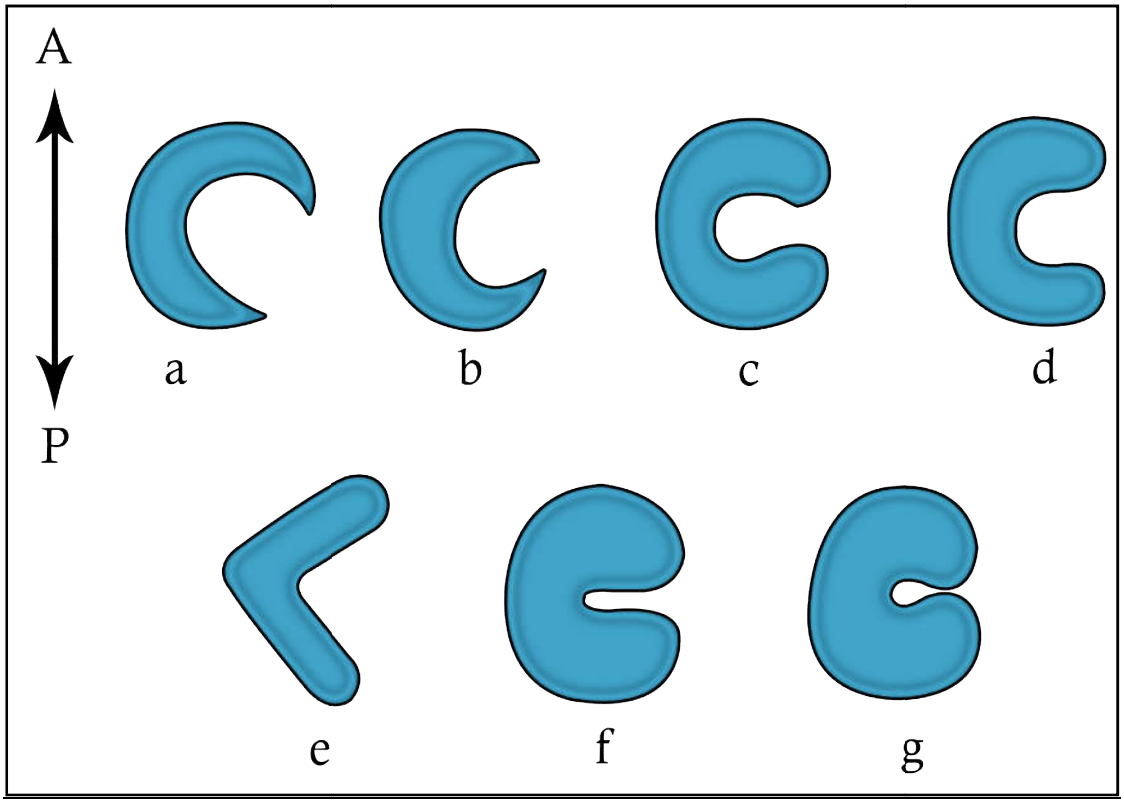

Fig. 1. Diagram showing the various shapes of the menisci (source of classification - Kale et al., 2006)
a. Crescent-shaped. b. Sickle-shaped, c. C-shaped, d. Sided U-shaped, e. Sided V- shaped
f. Incomplete discoid, g. Complete discoid. (A-anterior & P-posterior)

Observations: The following datas were noted in 116 menisci from 58 adult cadaveric knee joints on dissection.

Morphological study of Menisci: Five morphological types of menisci were determined.

Medial Menisci: Out of 58 medial menisci studied, 54.6% of were crescent shaped (Fig.4), 34.6% were V-shaped (Fig.5), 10.8% were U-shaped (Fig.6) and no discoid medial menisci were observed [Table 1 & Fig.9].

Lateral Menisci: Out of 58 laternal menisci studied, 56.4% were C-shaped (Fig.7), 41.6% were crescent shaped (Fig.4) and 2% were discoid (Fig.8) [Table 2 & Fig.10].

The average length of the lateral meniscus is 6.13 cms in right-sided knee (Tables-3,5 & Fig.11).

Length of the medial menisci in the left-sided knee:

The average length of the lateral meniscus is 6.28cms in left sided knee (Tables-4,5 & Fig.11).

Width

Medial meniscus: Width of the medial meniscus in the right-sided knee:

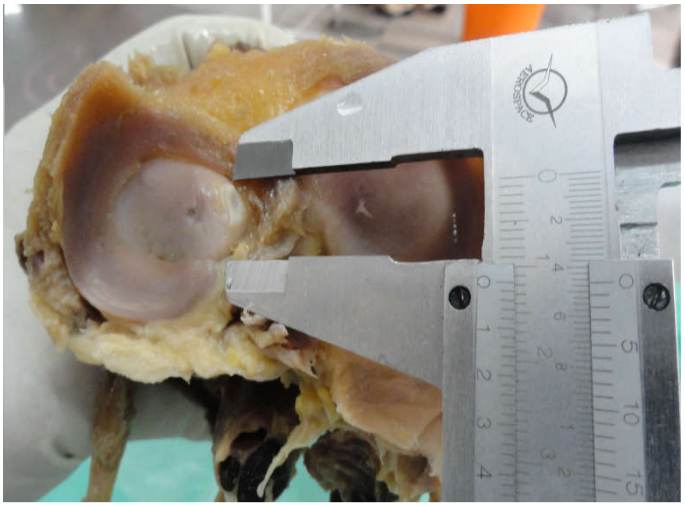

Fig. 2. Picture representing the length of the menisci, a line was positioned from the apex of anterior horn to the apex of posterior horn of the meniscus using vernier caliper

V – Vernier Caliper

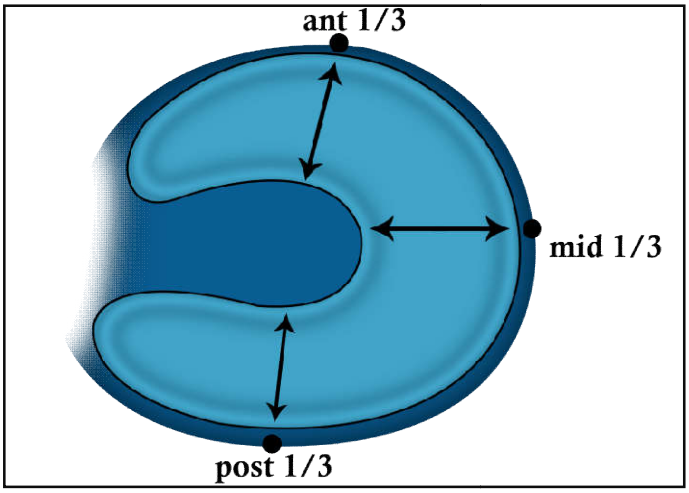

Fig. 3. Picture representing the three points of morphometric analysis of menisci in the anterior, middle and posterior thirds

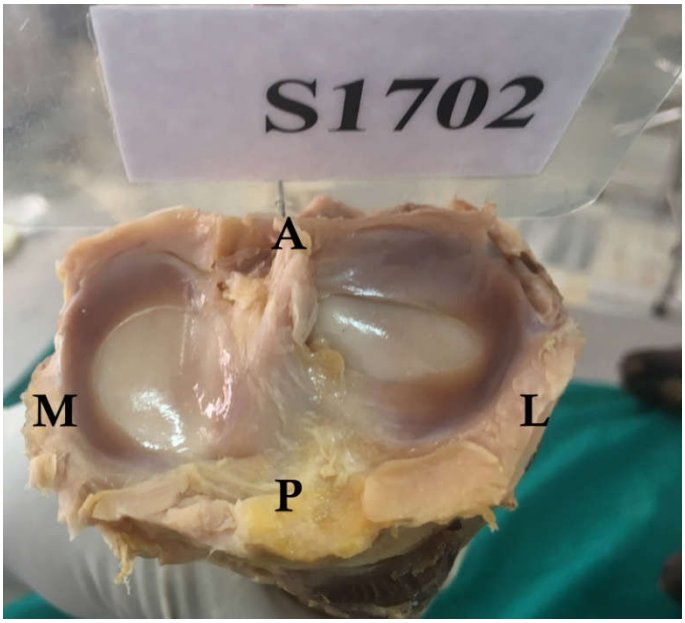

Fig. 4. Left tibial plateau showing crescent-shaped medial meniscus. (M - Medial meniscus, L – Lateral meniscus, A – Anterior, P – Posterior)

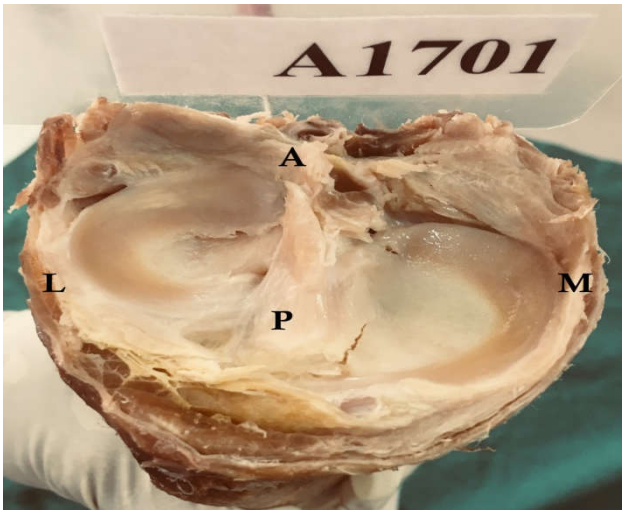

Fig.5. Right tibial plateau showing sided V-shaped medial meniscus (M - Medial meniscus, L – Lateral meniscus, A – Anterior, P – Posterior)

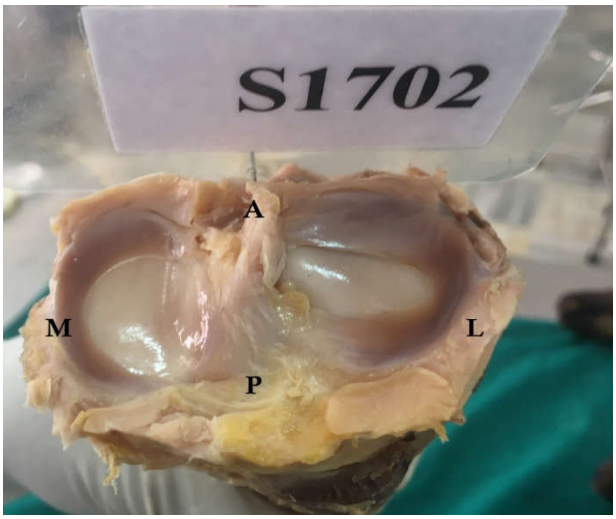

Fig. 6. Left tibial plateau showing sided U-shaped lateral meniscus (M - Medial meniscus, L – Lateral meniscus, A – Anterior, P – Posterior)

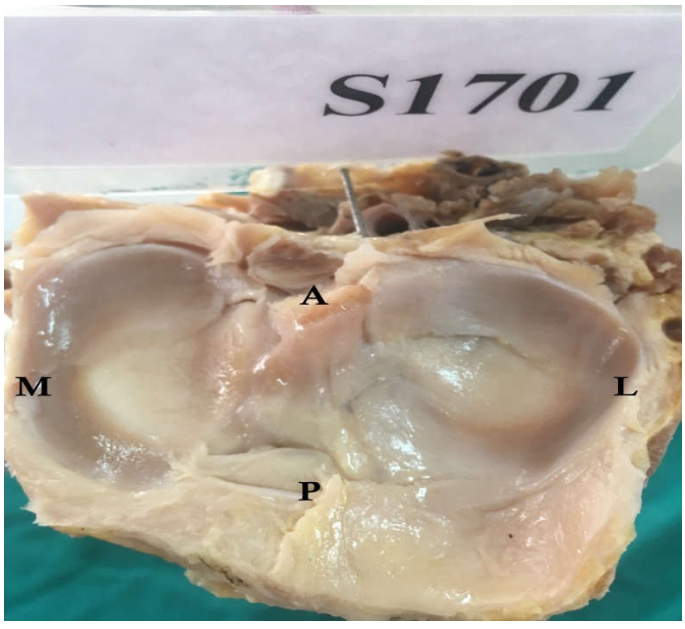

Fig. 7. Left tibial plateau showing C-shaped lateral meniscus. (M - Medial meniscus, L – Lateral meniscus, A – Anterior, P – Posterior)

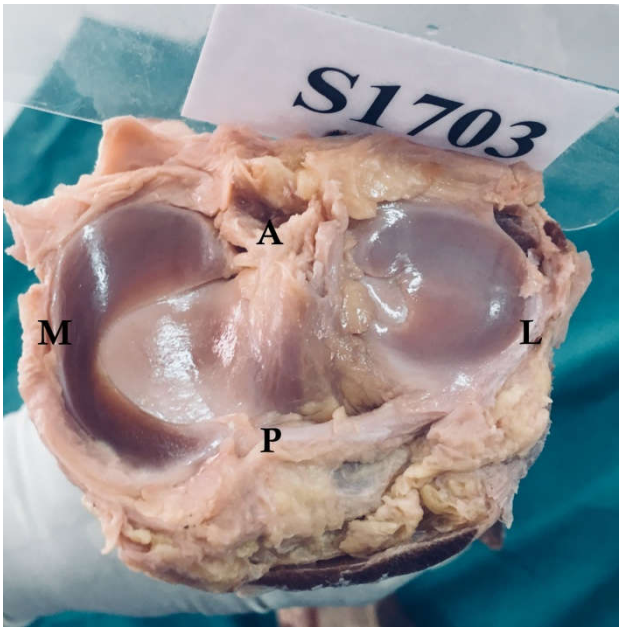

Fig. 8. Left tibial plateau showing discoid-shaped lateral meniscus. (M - Medial meniscus, L – Lateral meniscus, A – Anterior, P – Posterior)

Fig.9: various shapes of the menisci

1. **Crescentic**
2. **C shaped**
3. **Discoid**
4. **Sided V**
5. **Sided U**

Table 1. Showing the incidence of different shapes of medial meniscus (n=58)

Shape	total no	percentage
Crescentic	32	54.6%
Sided V	20	34.6%
Sided U	06	10.8%
Discoid	Nil	0%

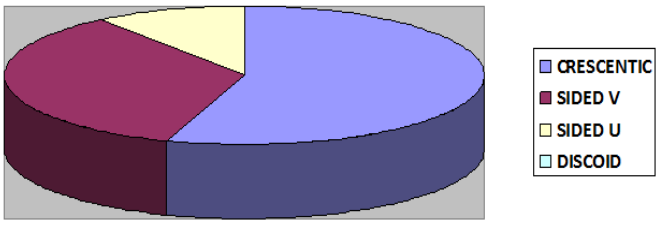

Fig. 9. Pie diagram showing the incidence of different shapes of medial meniscus

Table 2. Showing the incidence of different shapes of lateral meniscus(n=58)

SHAPE	TOTAL NO	PERCENTAGE
C shaped	33 (56.4%)	56.4%
Crescentic	24 (41.6%)	41.6%
Discoid	1 (2%)	2%

he average width of the anterior third was 5.2 mm, the average width of the middle third was 5.55 mm and the average width of the posterior third was 5.60 mm (Tables-6, 8 & Fig.12).

Width of the medial meniscus in the left-sided knee: The average width of the anterior third was 5.29 mm, the average width of the middle third was 5.56 mm and the average width of the posterior third was 5.83 mm (Tables-7, 8 & Fig. 12).

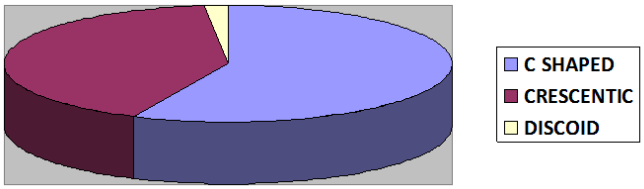

Fig.10. Pie diagram showing the incidence of different shapes of lateral meniscus

Lateral meniscus

Width of the lateral meniscus in the right-sided knee: The average width of the anterior third was 5.43 mm, the average width of the middle third was 5.64 mm and the average width of the posterior third was 5.90mm, respectively (Tables-6, 8 & Fig. 12).

Width of the lateral meniscus in the left-sided knee:

The average width of the anterior third was 6.02 mm, the average width of the middle third was 6.11 mm and the average width of the posterior third was 6.28 mm (Tables-7, 8 & Fig.12).

Table 3. Showing the length of medial and lateral menisci in the right

SNO	LENGTH(cms)	
	Medial Menisci	Lateral menisci
1	7.2	6.2
2	6.4	4.8
3	8.1	5.8
4	6.0	6.9
5	7.8	6.4
6	7.2	5.0
7	8.2	6.8
8	5.9	7.2
9	6.6	5.5
	7.0	4.9
11	6.8	5.2
12	7.2	6.2
13	6.2	5.5
14	7.1	7.4
15	7.4	7.1
16	6.5	6.3
17	7.3	7.9
18	8.2	6.4
19	5.9	5.6
20	6.9	6.9
21	7.3	4.8
22	8.3	5.4
23	7.8	5.6
24	7.6	7.7
25	6.7	6.1
26	6.3	5.8
27	7.1	7.0
28	6.4	5.2
29	7.2	5.8
30	6.9	6.3
31	6.1	6.5

Thickness

Medial meniscus: The average thickness of the medial meniscus is 2.29 mm in the right- side knee (Table - 9) and for the left-side knee is 2.14mm (Table -10 & 11) [Table-11 & Fig.13].

Table 4. Showing the length of the medial and the lateral menisci in the left side knee

Sno	Length(cms)	
	Medial Menisci	Lateral Menisci
1	6.3	4.9
2	6.5	5.2
3	7.2	5.4
4	7.9	6.8
5	8.3	6.9
6	6.3	4.8
7	8.5	5.3
8	7.4	5.8
9	7.7	7.8
10	8.1	5.1
11	8.5	7.5
12	9.3	5.0
13	6.5	4.9
14	7.8	7.1
15	6.9	6.4
16	7.5	8.6
17	9.6	7.6
18	6.3	5.0
19	8.7	7.9
20	6.5	4.8
21	7.0	6.1
22	7.8	8.6
23	6.4	4.8
24	6.5	5.7
25	7.2	8.8
26	6.7	7.4
27	8.0	5.5

Table 5. Showing the average lengths of the medial and lateral meniscus

Side	Medial Meniscus	Lateral Meniscus
RIGHT	7.02 ± 0.69	6.13 ± 0.86
LEFT	7.46 ± 0.95	6.28 ± 1.34

Values are means ± SE, n=58.

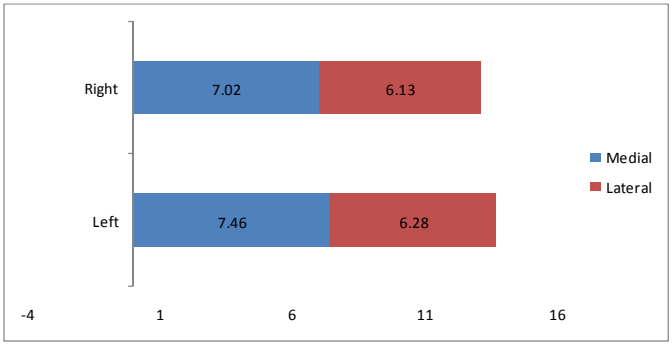

Fig. 11. Bar diagram showing the average length of the medial & lateral meniscus

Lateral meniscus: The average thickness of the lateral meniscus is 1.71 mm in right- side knee (Table - 9) and for the left-side knee is 1.9mm (Table -10) [Tables-11 & Fig.13]

DISCUSSION

Morphological study of the menisci

Meniscal injuries in children and adolescents are being seen with increased frequency (Kale *et al*., 2006). In meniscal allograft transplantation, it has been stated that providing a meniscal allograft that matches the size and shape of the meniscus to the recipient's knee is the responsibility of the tissue bank providing the graft (Haut *et al*., 2000). Parsons (1900) observed in primates that the medial meniscus always has a crescentic shape but the lateral meniscus may have either a crescent or a disc shape.

Table 6. Showing the widths of the medial and the lateral menisci of right side knee

Sno	WIDTH(mm)					
	Medial menisci			Lateral menisci		
	Anterior third	Middle Third	Posterior third	Anterior third	Middle third	Posteri or third
1	5.0	5.0	5.9	5.5	5.5	5.4
2	4.9	5.5	5.8	5.7	5.8	5.8
3	5.6	5.1	5.9	5.1	5.5	5.6
4	4.8	5.3	6.0	5.4	5.4	5.4
5	5.5	6.1	5.1	5.0	5.8	6.2
6	5.1	5.5	5.2	5.3	6.0	6.3
7	5.5	5.0	5.9	5.2	5.3	5.7
8	5.2	5.6	5.7	5.6	5.97	6.0
9	5.1	5.8	5.6	5.9	5.6	5.9
10	5.4	5.8	6.0	5.2	5.8	5.7
11	4.8	5.4	5.5	5.6	5.5	5.46
12	5.6	5.3	5.8	5.1	5.9	6.0
13	5.3	5.0	5.2	5.0	5.3	6.1
14	5.0	5.3	6.0	5.6	5.6	6.7
15	5.5	5.5	5.8	5.0	5.4	5.8
16	4.9	5.4	5.5	5.4	5.7	6.0
17	5.4	5.7	5.3	5.8	6.0	6.2
18	4.9	6.1	5.7	5.6	5.8	5.5
19	5.5	5.9	5.6	5.1	5.3	5.6
20	5.3	5.4	5.2	5.7	5.8	6.0
21	4.8	5.8	5.4	5.3	5.4	5.9
22	5.2	6.8	5.3	5.5	5.9	6.4
23	5.1	5.3	5.7	5.0	5.3	5.9
24	5.4	5.4	5.6	5.3	6.0	6.5
25	5.2	5.2	5.5	5.9	5.4	6.0
26	4.8	5.7	5.9	5.8	5.9	5.5
27	5.6	5.9	5.8	5.9	6.0	6.0
28	5.2	5.3	5.4	5.3	5.4	6.3
29	4.9	6.2	5.9	5.8	5.9	5.9
30	5.4	5.6	5.5	5.5	5.6	5.4
31	5.3	5.4	5.1	5.1	5.3	6.1

Vallois (1914) confirmed this observation and studied the whole morphology of the knee joint in primates. Fick and Rudolph (1904) noted the medial meniscus as a half, two thirds or three-fourths ellipse and the lateral meniscus as an almost complete circle where as Charles (1935) noted that the lateral meniscus has a crescentic shape. Monllau *et al*.,(1998) noted ring shaped meniscus on the lateral side of the knee. Smillie (1948) noted that there are three types of discoid lateral meniscus – primitive, intermediate and infantile. Watanabe *et al*., (1969; 1974) classified discoid meniscus as complete, incomplete and Wrisberg – ligament type. Albertson and Gilliquist (1988) classified menisci shape into hypoplasia or hyperplasia (discoid meniscus). Le Minor (1990) and Davidson *et al*., (2003) noted that the discoid menisci are more common on the lateral side. Dickhaut(1982) noted the incidence of discoid meniscus is ranging from 0.4% to 17% on the lateral side of the knee. Noble (1977), Casscels (1978) and Woods (1990) postulated that the incidence of lateral discoid meniscus is between 0% to 7% in cadaveric studies. According to Smillie (1948) and Nathan (1969), frequency of discoid meniscus is 1.4% to 4.5% for the lateral and 0.3% for the medial meniscus. But the present study revealed the *presence of discoid meniscus in which 2% in the lateral meniscus and no discoid meniscus on the medial side. Kale et al., (2006) found six morphological types of shapes of the menisci. Regarding the medial meniscus, 18.8% were crescent shaped, 22.72% were sided V shaped, 9.09% of were sided U-shaped, 36.36% were sickle shaped and 13.63% were C- shaped. Regarding the lateral meniscus, 13.63% were crescent shaped, 9.09% were C-shaped and 77.27% were discoid-shaped.*

Table 7. Showing the widths of the medial and the lateral menisci of left- side knee

Sno	Width					
	Medial menisci			Lateral menisci		
	Anterior third	Middle third	Posterior third	Anterior third	Middle third	Posterior third
1	5.1	5.5	6.1	6.3	6.1	6.2
2	5.4	5.3	5.5	5.6	5.9	5.9
3	5.3	5.9	5.9	5.8	5.7	6.6
4	5.2	5.0	5.2	6.1	6.2	6.3
5	5.6	5.4	5.7	6.9	6.2	6.0
6	5.4	5.8	5.8	5.8	6.1	6.2
7	5.1	5.7	6.2	5.9	6.8	6.8
8	5.5	5.3	5.9	5.0	5.9	5.8
9	5.0	5.1	5.9	6.3	5.6	6.4
10	4.8	5.4	5.5	5.5	6.9	7.0
11	5.2	6.1	6.2	5.8	5.9	6.0
12	5.4	5.5	6.9	6.8	5.8	6.3
13	5.6	5.4	5.4	6.1	6.0	5.8
14	5.3	6.8	5.8	5.9	6.2	6.1
15	5.4	5.2	5.6	6.4	6.0	6.2
16	5.5	5.7	5.9	5.8	5.6	6.3
17	4.9	5.3	5.7	6.1	5.9	6.6
18	5.3	5.5	6.2	6.0	6.4	6.1
19	5.6	6.2	6.0	6.3	5.6	6.9
20	5.2	5.0	5.4	5.8	6.8	6.5
21	5.6	5.8	5.9	5.5	6.2	6.7
22	5.1	5.0	6.2	5.9	6.3	5.9
23	5.4	5.4	6.0	6.0	5.7	6.1
24	5.5	6.3	5.9	6.1	6.5	6.1
25	5.1	5.5	5.1	6.4	6.0	6.9
26	4.9	5.3	5.8	6.7	6.2	6.2
27	5.5	5.9	5.9	5.8	6.5	5.9

Table 8. Showing the average widths of the medial and lateral meniscus

Right side	Anterior third	Middle third	Posterior third
Medial meniscus	5.2 ± 0.27	5.55 ± 0.39	5.60 ± 0.28
Lateral meniscus	5.43 ± 0.29	5.64 ± 0.25	5.90 ± 0.33
Left side	Anterior third	Middle third	Posterior third
Medial meniscus	5.29 ± 0.23	5.56 ± 0.43	5.83 ± 0.06
Lateral meniscus	6.02 ± 0.41	6.11 ± 0.36	6.28 ± 0.35

Values are means ± SE, n=58.

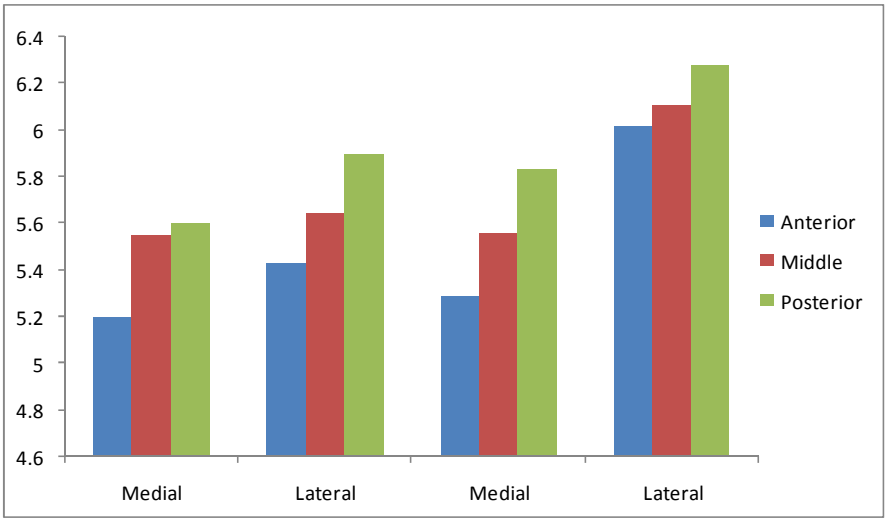

Fig. 12. Bar diagram showing the average widths of the medial and lateral meniscus

Among the discoid shaped, 54.54% were incomplete discoid and 22.72% were completely discoid. No discoid medial meniscus was observed and they found that 73% of the cadavers had the same shape of meniscus of each side. Aysin Kale et al., (2006) found six morphological types of shapes of the menisci. They are horse shoe shaped, sickle shaped, sided U shaped, C-shaped and discoid. They found that 77% of the lateral meniscus were discoid and no discoid medial meniscus.

The study was conducted in 11 neonatal cadavers of 22 knee joints. But, in the present study, horse shoe shaped and sickle shaped menisci were not observed. Muralimanju et al., (2010) found four morphological types of shapes of menisci in the adult cadavers. The medial meniscus were crescent shaped in 50%, V-shaped in 38.9% and sided U-shaped in 11.1%. The lateral meniscuswere C-shaped in 61.1% and crescent shaped in 38.9% and no discoid medial or lateral meniscus were

observed. Muralimanju et al.,(2010), found five morphological types of shapes of menisci in featuses . The medial menisci were crescent shape in 46.2%, V-shaped in 23.6% , sided U-shaped in 13.2%, sickle shaped in 9.4% , C-shaped in 7.5% and no discoid medial meniscus was observed. They found that 54.71% of the cadavers of the medial meniscus shape was different on each side.

Table 9. Showing the thickness of the medial and lateral menisci in the right side knee

SNO	Thickness(mm)	
	Medial Menisci	Laternal Menisci
1	2.3	1.3
2	2.1	2.3
3	2.1	1.4
4	2.6	1.7
5	2.4	1.5
6	2.2	2.1
7	2	1.3
8	2.2	1.5
9	2	1.4
10	2.3	2.3
11	2.5	1.8
12	2.3	1.4
13	2	2.1
14	2.3	1.5
15	2.2	1.4
16	2.1	1.6
17	2.6	2.0
18	2.4	1.3
19	2.6	2.2
20	2	2.2
21	2.6	1.5
22	2.5	2.2
23	2.4	2.1
24	2.1	1.4
25	2.4	1.3
26	2.3	1.3
27	2.5	1.4
28	2.4	1.6
29	2.3	1.9
30	2.6	2.2
31	2.1	2.0

Table 10. Showing the thickness of the medial and lateral menisci in the left side knee

Sno	Thickness(mm)	
	Medial Menisci	Lateral Menisci
1	1.8	1.4
2	2.4	2.3
3	2.0	1.5
4	1.9	2.4
5	1.8	2.1
6	2.1	1.6
7	2.5	2.0
8	2.4	1.4
9	2.0	1.6
10	1.8	1.6
11	2.5	1.7
12	2.4	2.0
13	2.1	1.4
14	2.3	1.8
15	1.9	2.3
16	2.2	2.2
17	2.0	2.0
18	2.1	1.6
19	1.8	1.9
20	2.3	1.5
21	2.4	2.3
22	2.0	2.1
23	2.0	2.4
24	2.2	1.7
25	2.5	2.3
26	2.3	1.8
27	2.1	2.4

Table 11. Showing the average thickness of the medial and lateral meniscus

Side	Medial meniscus	Lateral meniscus
RIGHT	2.29 ± 0.20	1.71 ± 0.36
LEFT	2.14 ± 0.23	1.9 ± 0.34

Values are means ± SE, n=58.

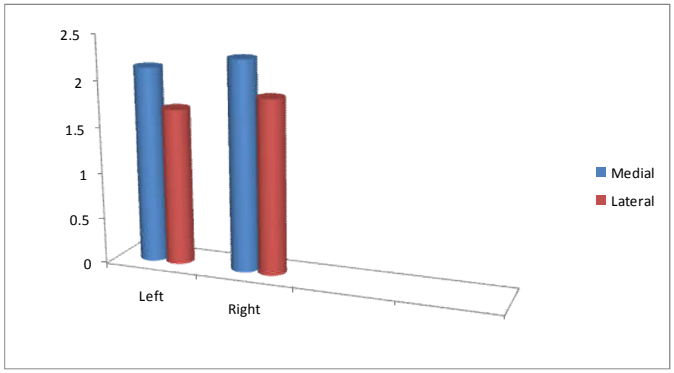

Fig 13. Showing the average thickness of the medial and lateral meniscus

In the present study, five morphological types of the menisci were determined in which 54.6% of medial menisci were crescent shaped, 34.6% were V-shaped, 10.8% were U-shaped and no discoid medial menisci were observed. Regarding the shape of the lateral meniscus, 56.4% were C-shaped, 41.6% were crescent shaped and 2% were discoid which is more or less similar with the observations of Muralimanju *et al*.,(2010) except the presence of discoid lateral meniscus in the present study.

Morphometric study of the menisci: Since the knowledge of morphometry of the menisci are scarce, the present sudy was to analyze the morphometric variations present in the human meniscus, enriching the literature on this subject, and correlating these variations with the possibility, location and type of lesion as shown in the literature review.

Length of the Menisci: According to Braz and Silva (2010), the distance between the anterior and posterior horns of the lateral meniscus is 12.55mm and the medial meniscus is 25.88mm.

Almedia(2004) found that the distance between the anterior and posterior horn of the lateral meniscus is 12.70mm and the medial meniscus is 29.70mm. According to Moore and Dalley (2001), Didio (1998) and Kapandji(2000), the lateral meniscus is smaller than the medial meniscus.

In present study, the medial meniscus length of the right-side knee is 7.02cms and left side knee is 7.46cms. The lateral meniscus length of the right side knee is 6.13cms and left side knee is 6.28cms. This greater proximity of the horns of the lateral meniscus may explain why they are less prone to injury.

Width of menisci: According to Smillie(1948), the lateral menisci shows a width higher than the medial meniscus. Almedia et al.,(2004) revealed that the width of the middle third of the lateral menisci was more when compared to posterior third of the lateral meniscus. In the present study, the width was assessed in three different points i.e., Anterior third, middle third and posterior third. Relating to width of the medial menisci, the width was less on the right side (5.2mm, 5.55mm

and 5.60mm respectively) when compared to the width on the left side (5.29mm, 5.56mm and 5.83mm respectively). Relating to width of the lateral menisci, the width was also less on the right side (5.43mm, 5.64mm and 5.90mm respectively) when compared to the width on the left side (6.02mm, 6.11mm and 6.28mm respectively). The present study revealed that the width of the lateral meniscus is more than that of the medial meniscus. This observation differs from the previous studies.

Thickness of Menisci: Almeida *et al*.,(2004) had observed the average thickness of the medial meniscus as 5.71mm and of the lateral meniscus as 5.03mm. Braz and Silva (2010) found the average thickness of the medial meniscus as 5.87mm and of the lateral meniscus as 5.46mm. But the present study revealed the thickness of medial meniscus of the right side knee is 2.29mm and for the left side it is 2.14mm. In the case of lateral meniscus, the thickness of right side knee is 1.71mm and for the left side knee is 1.9mm.The thickness of the medial meniscus is more when compared to lateral meniscus in both the left and right side knee. When compared to the observations of the previous workers, the thickness of the meniscus are less in the present study.

Overall the present study revealed the following observations:

- The dominance of crescent shape medial meniscus is 54.6% and C shaped lateral meniscus is 56.4%.
- The discoid meniscus was present in 2% cases only on the lateral meniscus and absent on the medial meniscus.
- The length of the lateral meniscus is smaller than that of the medial meniscus.
- The width of the lateral meniscus is more than that of the medial meniscus.
- The medial meniscus is thicker when compared to the lateral meniscus in both the left and right side knee.

Summary

The present study was undertaken in 116 adult menisci from 58 adult cadaveric knee joints. Menisci were studied for a review of its morphology, morphometry and its comparison with previous studies. The main findings were: Five morphological types of menisci were determined. Out of 58 medial menisci studied,54.6% were crescent shaped ;34.6% were V shaped;10.8% were U shaped and no discoid medial menisci were found. Out of 58 lateral menisci studied,41.6% were crescent shaped ;56.4% were C shaped; 2% discoid lateral menisci were found. Morphometry revealed the following results: The length of lateral meniscus is smaller than that of the medial meniscus; the width of the lateral meniscus is more than that of the medial meniscus;the medial meniscus is thicker when compared to lateral meniscus in both the left and right side knee. Difference in shape and size of menisci in the same knee as well as with different knees of different cadavers were observed. The obtained results presented variations regarding some parameters when compared to the previous studies.

Conclusion

The present study will provide support to the meniscal anatomy, concerning the surgical procedures and arthroscopy of the knee joint. The study has provided additional information on different shapes of the medial and lateral meniscus with contribution to a better delineation of meniscal anatomy and implications in regard to allograft meniscus transplantation. Therefore, health professionals that work with the treatment of meniscal injuries should be aware of the possible anatomical variations that may exist in the meniscus facilitating the rehabilitation process.

Key to Abbrevations

- A – Anterior.
- P – Posterior.
- MM – Medial meniscus .
- LM – Lateral meniscus.
- ACL – Anterior Cruciate Ligament.
- CT – Computed Tomography.
- MRI – Magnetic Resonance Imaging.
- mm – millimeter.
- cms- centimeters.

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