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# Discoid Meniscus-Histology and Pathology

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## Abstract

Discoid meniscus is an abnormality in which the cartilaginous meniscus is differently shaped, thick, and contains less collagen. It is mostly seen in children; and in the adult, it is rarely symptomatic. We have certain knowledge of discoid meniscus shape, its ultrastructure, epidemiology, and pathology. The discoid shape of the meniscus, which is seen mostly on the lateral meniscus, is described as an abnormality in which the cartilaginous meniscus, instead of the usual crescent type, is shaped like a full or partial disc, thickened, and covers more of the tibial lateral articular surface. The origin of the discoid shape is still not known. Some theories state that it is a normal finding during embryological development of the knee joint, some consider it as an atavism, and some consider it as a morphologic change during development. There are not many published studies on histological examinations. What is common is that the microstructure of the discoid meniscus differs in terms of the content and arrangement of collagen fibers. It is rarely symptomatic, so the true epidemiology of this abnormality is difficult to determine. In this chapter, we tried to make a cross-section of the current findings considering lateral discoid meniscus.

**Keywords:** discoid meniscus, histology, morphology, pathology

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## 1. Introduction

Over 130 years have passed since the discoid lateral meniscus of the knee was described as a morphologic entity of the lateral meniscus. We have certain knowledge of discoid meniscus shape, its ultrastructure, epidemiology, and pathology. Yet, we still do not know its origin. The discoid shape of the meniscus, which is seen mostly on the lateral meniscus, is described as an abnormality in which the cartilaginous meniscus, instead of the usual crescent type, is shaped like a disc, thickened, and covers more of the tibial lateral articular surface. Young, in

1889, first described it in a paper after a cadaveric dissection [1]. Discoid meniscus is mostly located on the lateral side, although cases are also described in the medial compartment. In the adult, the lateral discoid meniscus is often found during knee arthroscopy. The reason is that it is rarely symptomatic, so the true epidemiology of this abnormality is difficult to determine.

## 2. Discoid meniscus

### 2.1. Epidemiology

Several studies have reported the incidence and prevalence of discoid meniscus. In the work of Sun and Jiang, the incidence of lateral discoid meniscus ranges from 0.4 to 17%, as compared with medial discoid meniscus. Medial discoid meniscus is a rather rare finding. In the work of Sun and Jiang, the incidence for medial discoid meniscus ranges from 0.06 to 0.3% [2]. Ikeuchi reported the incidence of discoid lateral meniscus (DLM) of about 16.6% [3], while Fukuta reported 10.6%, in Japanese populations [4]. Kim reported 10.9% in Korean populations [5], and Rao reported an incidence of 5.8% in India [6]. Greis in 2002 reported the incidence of discoid lateral meniscus to be 0.4–17% [7]. In white populations, according to the work of Papadopoulos, the incidence is quite low, 0.4–5% [8]. In a study on 1357 knee arthroscopies, Glisic et al. reported an incidence of 1.03% discoid lateral meniscus [9]. In our series, we found an incidence of 0.28% of discoid lateral meniscus out of 1071 knee arthroscopies. Regarding bilateral discoid lateral meniscus (DLM) in the Asian population, Bae et al. found out a high prevalence of 79% of symptomatic DLM [10]. There are also reports of anomalies of knee anatomy conjoined with DLM, such as high fibular head, hypoplasia of the lateral femoral condyle and fibular muscles [11, 12], osteochondritis dissecans of the lateral femoral condyle [13], and hypoplasia of the lateral tibial spine [14] and dipped lateral tibial plateau [15]. Thicker body, lack of blood vessels, and different ultrastructure make discoid lateral meniscus more susceptible to injury.

### 2.2. Histology

Meniscus of the knee has a specific microstructure. Most of the content is water, approximately 70%, and the remaining 30% belongs to organic residue. Organic matter is mostly collagen, approximately 60–70%, and the rest are noncollagenous proteins [16–19]. Collagen type I is predominant in normal meniscus (90%), in regard to articular cartilage where collagen type II is predominant, and that makes the major difference [20]. Collagen types II, III, V, and VI are present in smaller concentrations. The collagen and extracellular matrix are synthesizing in the fibrochondrocytes, which represented cellular components [21, 22]. Meniscus cells appear in two forms. Superficial cells are oval, and deeper cells are more rounded, both with a lot of endoplasmic reticula and Golgi complex, and with a few mitochondria [23]. The collagen fibers are set in three layers. Most superficial fibers are radial; in the middle, fibers run circumferentially, and in the deep layers, fibers are parallel to the periphery. Radial fibers seem to act like a connection to the circumferential ones, resisting splitting. Specific organization

of the collagen fibers transfers compressive loads to circumferential stress. The rest of the extracellular matrix is composed of proteoglycans. Chains of aggregate proteoglycans, the glycosaminoglycans, participate only by 1% of the meniscus wet weight, but their ability to retain and repel water during knee movement is essential to the stiffness and elasticity, and to resist compressive loads [24]. Also, water exudation from glycosaminoglycans has a role in joint lubrication. The highest concentrations of glycosaminoglycans are at the highest weight-bearing areas: anterior and posterior horns of the menisci and the inner half [25]. The ability of the meniscus to recover its form after deformation is small, probably because of low concentration of elastin, less than 0.6% [26].

The etiology of discoid meniscus is not known clearly. There are several explanations. Smillie in 1948 gave a theory that the lateral discoid meniscus is a normal fetal stage of development with the failure of resorption of the central area of the cartilage plate [27]. In several embryological studies, it was shown that the lateral meniscus does not have the discoid shape during development. Kaplan, on the contrary, demonstrated that the discoid meniscus is a pathological entity [28, 29]. Ross et al. reported that the plate of undifferentiated mesenchyme from which the meniscus develops resembles a disc at the very earliest phase during the embryonic period [30]. Several embryological studies showed that the lateral meniscus does not normally assume a discoid configuration during its development [28]. On the contrary, Kale et al. in the neonatal cadaver study found 77.27% discoid lateral meniscus and 22.72% of them were complete discoid menisci. They concluded that the primary shape of the lateral meniscus in the earlier intrauterine period is discoid, and it transforms to other shapes [31]. The rate of growth of both menisci is uniform; so is the ratio of the area of both menisci and corresponding tibial plateau. Another theory stated that the discoid shape may be the result of instability due to absence of the meniscomfemoral attachment. The lateral meniscus covered 80–93% of the lateral tibial plateau, and it is thicker, so that fact may lead to increasing shearing forces in the knee joint [32]. At the end of embryological development, the meniscoligament complex is clearly defined (at 8 weeks by Streeter Stage 23) [33]. The blastema of human embryo does not have joint space. With chondrifying of mesenchyme in the region of the future knee joint can be identified intermediate zone of two parallel chondrogenic layers and one intermediate that has low density. By condensation in the intermediate layer, the menisci and cruciate ligaments show up. [33–35]. Both menisci are highly cellular, well vascularized, and have a characteristic shape. Vascularization of the menisci changes from the time of birth to 10 years of age: at birth, the whole meniscus is vascular; but by 9 months of age, the inner third becomes avascular; and at the age of 10, vascularity constantly decreases, and meniscus is similar to the meniscus of adults. Blood vessels are present only at the rim of the meniscus, according to Arnocky and Warren, in outer 10–25% of lateral and outer 10–30% of medial meniscus [36]. Meniscus vessels are branches of medial and lateral genicular arteries. A lot of studies show the ultrastructure of the normal menisci. Only a few published studies have investigated the histology of the lateral discoid meniscus. In the study of Atay et al. [37], by examination of partial-thickness biopsy of the symptomatic menisci, it is shown that the highly organized collagen matrix is not present in the discoid lateral meniscus. Collagen fibers are disorganized and decreased in number, and collagen concentration is low. Those facts lead to decreasing capability of the meniscus to act as stress absorber, similar to degenerated

menisci [25]. Papadopoulos et al. reported the histomorphological study of discoid lateral meniscus, taking samples during arthroscopy. They found out that there was no significant difference in the architecture of the radially arranged collagen, and significant distortion of the circumferential fibers, especially in whole high of anterior and posterior thirds, and on the medial and posterior thirds of discoid meniscus near the tibial surface. Also, the posterior third shows signs of extended myxoid degeneration, osseous metaplasia, and void spaces that make it the most disorganized part [38]. Choi et al. in his transmission electron microscopy study also stated low density and disorganization in the collagen ultrastructure of discoid lateral meniscus, that can lead to meniscal tear [39].

### 2.3. Discoid meniscus morphopathology

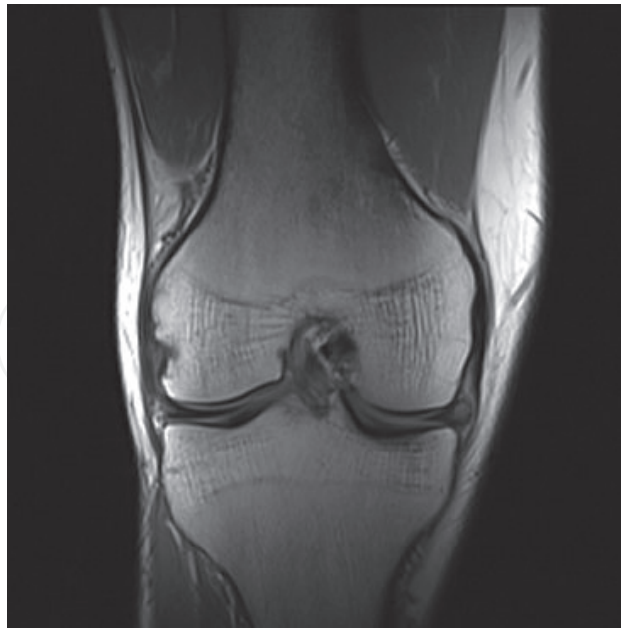
Discoid meniscus is a more common finding in children. Diagnosis is usually set on the basis of physical examination and MRI finding of the knee (**Figure 1**, **Figure 2**). Clinical findings varied from asymptomatic cases, often snapping and locking, and sometimes severe pain combined with swelling of the knee joint. Discoid meniscus is different by morphology. Normal meniscus is usually C-shaped and wedged from outer to inner edge, a form that increases the contact area between femur and tibia. In discoid meniscus, the central area is completely filled; in some cases, there is a very small aperture in the central part (**Figure 3**). The outer part that is connected to the joint capsule is much thicker than in normal meniscus. This variation disturbs normal mechanical loading and share stress and are predisposing factor to meniscal tears.

Classical classification of discoid meniscus was given by Watanabe in 1969, as complete, incomplete, and Wrisberg type, by the presence or absence of a normal posterior attachment of the meniscus, and the amount of tibial plateau coverage. According to Watanabe's classification, the most common is type I, complete discoid meniscus, which is a much thicker



**Figure 1.** An MRI sagittal view. Note the longitudinal rupture of lateral discoid meniscus.





**Figure 2.** An MRI coronal view. Note the difference between thickness of the body of lateral and medial menisci.

lateral meniscus that covers the whole of the lateral tibial plateau, and is more vulnerable to tear during sports activities than normal meniscus. The next, type II, is incomplete discoid meniscus, which is smaller than type I, varies in size, structure, and shape and does not cover the whole of the lateral compartment. Common to both types are normal peripheral and posterior horn attachments and stability during arthroscopy probing. The least common is type III, the so-called Wrisberg type. The shape of this type is near to normal, not necessarily discoid, but with the absence of the posterior meniscal tibial attachments, including meniscotibial (coronary) ligament. The only attachment is the ligament of Wrisberg that connects the posterior horn of the lateral meniscus to the lateral surface of the medial femoral condyle. This leads to hypermobility of the posterior horn of the lateral meniscus during knee extension, displacement of the meniscus, and is probably the cause of the snapping. [40, 41]. Husson et al. in 1985 proposed a classification based on arthroscopic and clinical findings. They considered complete and incomplete discoid meniscus types as stable, because of the presence of firm anterior and posterior tibial and menisiofemoral attachments. Further, stable types were divided as symptomatic or asymptomatic, and torn or not torn. Unstable types were divided as unstable discoid or normal shape [32, 42]. Klingele et al. in 2004 proposed a newer classification based on the size, stability, and presence or absence of meniscal tear [43]. Kale et al. in 2006 based on a neonatal cadaver study, divided the lateral meniscus as discoid and undiscoid, and further divided discoid menisci as complete and incomplete. They stated that the primordial shape of the meniscus is discoid, and that transforms to other shapes [31].

Clinical findings differ discoid meniscus can be asymptomatic, and symptoms can be present regarding meniscal tear or meniscal instability. Typically, symptomatic discoid meniscus is presented in children between 5 and 10 years, by knee popping and snapping that can be heard or felt, with no trauma. Associated symptoms include pain, swelling, giving way,



**Figure 3.** An MRI axial view. Note the difference in the volume of the lateral meniscus.

decrease in range of motion, quadriceps atrophy, locking, and lack of knee extension. If tear of discoid meniscus occurs, symptoms can be severe pain, knee locking, and inability to bear weight, and snapping during knee flexion-extension. Sometimes, the patient complains of knee instability, due to posterior meniscomfemoral ligament. In symptomatic types, the method of treatment choice is operative, which will be explained in other chapters.

### 3. Conclusion

Discoid meniscus, despite numerous studies, remains a great unknown. There is no conclusive evidence on the cause of discoid shape, or what causes its further design. The differences that exist with respect to normal histological meniscus are largely documented. The lack of histological study of the ultrastructure is reflected in the fact that the samples obtained during arthroscopic surgery were parts of symptomatic discoid meniscus. An undamaged and complete discoid meniscus that is asymptomatic is almost impossible to examine histologically, as this would lead to deterioration of the knee joint. Nevertheless, the first studies give us a guideline for further work.

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## Conflict of interest

I have no conflict of interest.

## Author note

The author is an orthopaedic surgeon; president of ASTAS (Association for Sports Traumatology and Arthroscopy of Serbia); former member of the ESSKA educational committee (2010–2014); former member of the ESSKA arthroscopy committee (2014–2016); as well as a member of EFORT, ISAKOS, SOTA (Serbian Orthopaedic and Traumatology Association), and the Serbian Medical Chamber.

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