# Lateral Meniscal Variations and Treatment Strategies

Özgür Ahmet Atay, İlyas Çağlar Yılgör, and Mahmut Nedim Doral

## Contents



Ö.A. Atay (✉), İ.Ç. Yılgör, and M.N. Doral
Faculty of Medicine, Department of Orthopaedics and Traumatology, Chairman of Department of Sports Medicine, Hacettepe University, Hasırcılar Caddesi, 06110 Ankara, Sihhiye, Turkey
e-mail: oaatay@hacettepe.edu.tr; caglar@yilgor.com; ndoral@hacettepe.edu.tr

## History

The menisci consist of semilunar fibrocartilage, partly filling the space between the femoral and tibial bones. The most common meniscal anomaly is discoid shape of the lateral meniscus. Other anomalies are: hypoplasias, abnormal insertions, and double-layered lateral meniscus.

Discoid lateral and medial menisci were first described in cadaver specimens by Young in 1889 [77] and Watson-Jones in 1930 [73], respectively. Kroiss attributed the term "snapping knee syndrome" to it in 1910 [42]. A more precise diagnosis and classification was made by Watanabe et al. in 1979 [72].

## Embryology

The normal menisci differentiate within the limb bud from mesenchymal tissue early during fetal development. They are clearly defined at the 8th week of gestation and gain mature anatomical shape at the 14th week [7], without ever possessing a discoid shape [34].

## Anatomy

The lateral meniscus is somewhat more circular than the C-shaped medial meniscus. This is because the posterior and anterior horns of the lateral meniscus attach to the nonarticular area of the tibial plateau. A normal lateral meniscus forms five-sixths of a circle. It has an average width of about 12 mm and a height of 4–5 mm, although the normal anatomy varies considerably with regard to dimension and shape.

In adults, the C-shaped medial meniscus covers 50% of the medial tibial plateau and is connected firmly to the joint capsule by coronary, meniscotibial, and deep medial collateral ligaments; whereas the lateral meniscus covers 70% of the lateral tibial plateau and has firm anterior and posterior attachments, while its lateral joint capsule attachment is

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loose because there is no attachment at the popliteal hiatus and lateral collateral ligament. Therefore, the normal lateral meniscus has more mobility than the medial meniscus, allowing an increased excursion of the lateral femoral condyle. Variably present posterior and anterior meniscofemoral ligaments (Wrisberg's and Humphrey's ligaments) pass from the posterior horn of the lateral meniscus to the medial aspect of the notch. Wrisberg's ligament passes posteriorly to the posterior cruciate and Humphrey's ligament passes anteriorly. Usually only one of these structures is present, and they vary quite markedly in size. The posterior third of the lateral meniscus receives a strong insertion from the popliteus muscle into its posterior horn, which allows the meniscus to be pulled posteriorly as the knee flexes [31]. Together with the popliteal tendon, the lateral meniscus stabilizes the knee against excessive posterolateral rotational forces.

The most common lateral meniscal variant is discoid in shape, which implies greater coverage of the tibia and usually increased thickness. It was believed that this variant may involve only part of the meniscus (in which case it was so called an anterior or posterior megahorn), or it may involve the entire meniscus. Recent studies suggest that these megahorns can be caused by partial tears of the relevant meniscal part and are not congenital variants. Variants can be normal in shape but hypermobile due to abnormal insertions or abnormal in shape, such as circular (ring-shaped) meniscus [8, 10, 28, 37, 50]. Other anomalies of the lateral meniscus include partially duplicated lateral meniscus and double-layered lateral meniscus [19, 40, 66].

## Epidemiology

The actual incidence of lateral meniscus variations is difficult to estimate due to the high rate of asymptomatic patients. The reported prevalences of discoid lateral meniscus vary, depending on the method of investigation, the selection criteria, and the patient population. The Wrisberg type is considered to be less common.

Earlier studies suggested the prevalence of lateral discoid meniscus of symptomatic patients who underwent open menisectomy ranged from 2% to 5% [63, 72]. More recent arthroscopic studies have recorded prevalences varying from 0.4% to 16.6% [6, 22, 24, 29, 53]. These studies may be more accurate representations of the true prevalence, because asymptomatic discoid menisci are also included. Cadaveric studies suggest a prevalence ranging from 0% to 7% [17, 54, 74]. Discoid menisci have been reported more frequently in Asian countries than in other regions of the world [29, 38].

Bilateral occurrence has been reported in 20% of patients with discoid lateral menisci [14].

## Etiology

The underlying causes of lateral meniscal abnormalities are multifactorial. Several theories try to explain the etiology of the variant lateral meniscus. Smillie [63] hypothesized that the discoid meniscus results from the lack of resorption of a central cartilaginous disk during normal development. Kaplan [34]; Clark and Ogden [18], and Andrish [7] later disputed this theory, because they could not identify a discoid meniscus at any stage of the embryonic development. The menisci are clearly defined at the 8th week of gestation and gain mature anatomical shape at the 14th week. Kaplan [34] suggested that a normally shaped meniscus with abnormal attachments would have abnormal medial-to-lateral motion which will cause repetitive trauma that results in a change in the meniscal shape. During extension, due to the tension in the meniscofemoral ligament, the meniscus subluxates posteromedially into the notch, and due to the pull of the popliteus and capsule reduces back into the joint on flexion [34]. The abnormal lack of a posterior tibial attachment could be a failure of formation due to phylogenetic incompletion [44]. A circular meniscus [37] could be further evidence of this implication. The problem with this theory is that stable discoid menisci with normal attachments have been identified.

Woods and Whelan [74] and Clark and Ogden [18] favor a congenital origin. Woods and Whelan explain the unstable discoid meniscus as being a congenitally stable discoid shaped meniscus that became unstable by posterior capsular separation due to increased shear forces. The causes of the other unstable types are even less clear. Originally, Watanabe [72] described the Wrisberg type as a normally shaped meniscus with abnormal attachments. Since then, other unstable variants have been included in this category; these probably represent several subtypes and as many different origins [22, 29, 47, 53].

Kaplan [34] described a normally shaped meniscus with abnormal attachments due to repeated trauma. Woods and Whelan [74] and Hayashi et al. [27] described a stable discoid meniscus becomes unstable due to shear forces. A third possibility is a discoid meniscus without posterior tibial attachments. Neuschwander [53] suggested a forth type as a normally shaped meniscus with lack of posterior tibial attachments. These all suggest a wide range of abnormalities leading to unstable meniscus presenting with similar symptoms often resulting in the "snapping knee" syndrome. It remains unclear whether all unstable types have the presence of the meniscofemoral ligament in common, which would allow subluxation and reduction to occur, accompanied by snapping [33]. Jordan [33] believes the primary pathology derives from the lack of a posterior tibial attachment in the presence of a meniscofemoral ligament attachment. The meniscofemoral ligament acts like a checkrein, allowing subluxation and reduction rather than dislocation.

## Classification

The lateral meniscus is more variable than the medial meniscus morphologically in size, thickness, shape, and mobility. Abnormal lateral menisci are classified as stabile or unstable according to their attachments. Less common abnormalities are hypoplasy, partial deficiency [69], and double-layered lateral meniscus.

The traditional classification of the discoid menisci was made by Watanebe [72] in 1979: (1) complete discoid meniscus, (2) incomplete discoid meniscus, and (3) Wrisberg-type meniscal variant. Watanabe [72] pictured Wrisberg type as a nearly normal shaped meniscus but hypermobile due to lack of posterior tibial attachments. Since then, other unstable menisci with both normal and discoid shape have been included as Wrisberg type [22, 34, 74]. Neuschwander et al. [53] described a lateral meniscal variant with the absence of the posterior coronary ligament; that is nearly normal in morphology but lacks a posteriortibial attachment, which results in hypermobility which nowadays can be classified within the Wrisberg type.

This traditional classification was expanded by Monllau et al. [50] in 1998. They've added a fourth type to describe a ring-shaped meniscus characterized by a ring-shaped morphology with a normal posterior tibial attachment (Fig. 1).

Jordan [33] proposed a new classification based on both arthroscopic and clinical findings, which describes more completely the various lateral meniscal types and how they influence treatment (Table 1).

A more recent article by Ahn et al. [4] suggests a classification based on magnetic resonance imaging (MRI) findings. In their study of 82 knees they classified the findings into four categories: (1) No shift: the peripheral portion of the discoid meniscus is not separated from the capsule. (2) Anterocentral shift: the periphery of the posterior horn is detached from the capsule, and meniscus is displaced anteriorly or anterocentrally; as such, the anterior horn appears to be thick in sagittal sections. (3) Posterocentral shift: the periphery of the anterior horn is detached from the capsule, and meniscus is displaced posteriorly or posterocentrally; as such, the posterior horn appears to be thick in sagittal sections. (4) Central shift: the periphery of the posterolateral portion is torn and loose, and the entire meniscus is displaced centrally toward the notch [4]. Although a meniscus can be reduced at the time the MRI is performed and therefore a meniscus can have a peripheral tear but appears to have no shift, thus there is a low sensitivity of no shift in predicting the absence of a peripheral tear; in their study Ahn et al. [4] have found out that a significantly larger number of repairs and subtotal menisectomies were performed for the shift groups than for the no shift group. So, it can be

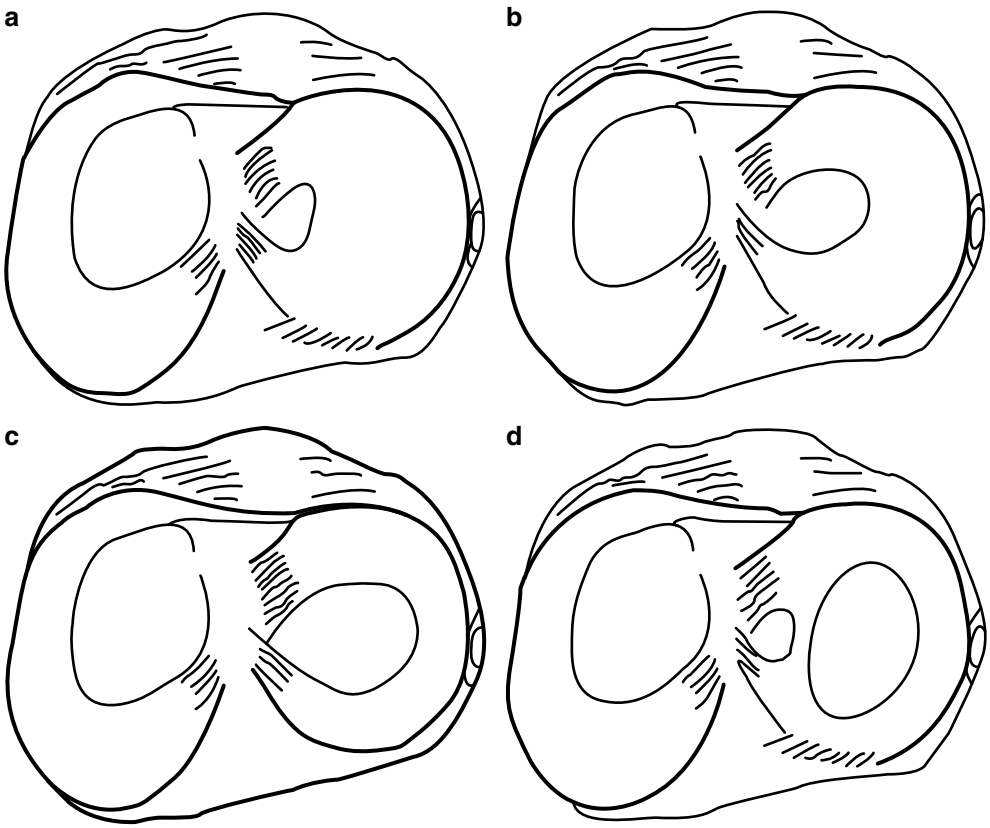


**Fig. 1** Schematic drawing of modified Watanabe's classification for lateral meniscal variants. (**a**) Complete discoid meniscus, (**b**) incomplete discoid meniscus, (**c**) Wrisberg type, and (**d**) ring-shaped meniscus

**Table 1** Jordan's classification of discoid lateral menisci

| Classification | Correlation | Tear | Symptoms |
|---|---|---|---|
| Stable | Complete/ incomplete | Yes/no | Yes/no |
| Unstable with discoid shape | Wrisberg type | Yes/no | Yes/no |
| Unstable with normal shape | Wrisberg variant | Yes/no | Yes/no |

predicted that knees with a shift on the MRI are more likely to be treated with repair or menisectomy than knees with no shift.

## Tears

Discoid menisci are more prone to mechanical trauma because of their thickness, relatively bad vascularization, and weak attachments to the posterior capsule [27]. A recent study has shown that discoid menisci have decreased amount of collagen fibers and that the fibers are arranged heterogeneously which may contribute to vulnerability of the discoid meniscus [12]. However patients with tear of the discoid meniscus may not have a history of traumatic events. Tears are more common after the age of 15 [21,58]. Discoid menisci are associated with an increased incidence of tears ranging from 38%to 88% [11,15,64]. The most common tear pattern is that of degenerative horizontal cleavage, which comprises 58–98% of all cases of symptomatic discoid meniscus [5,14,55].

Lateral meniscal variants have been classified into six tear patterns by modifying O'Connor's [61] classification by Kim et al. [41] in 2006. This classification includes six simple and comprehensive categories (Fig. 2): (1) a simple horizontal tear; (2) a combined horizontal tear, in which the major tear component is horizontal and another tear component is accompanied according to Bin et al. [15]; (3) a longitudinal tear including peripheral tear; (4) a radial tear including a oblique and a flap tear; (5) a complex tear

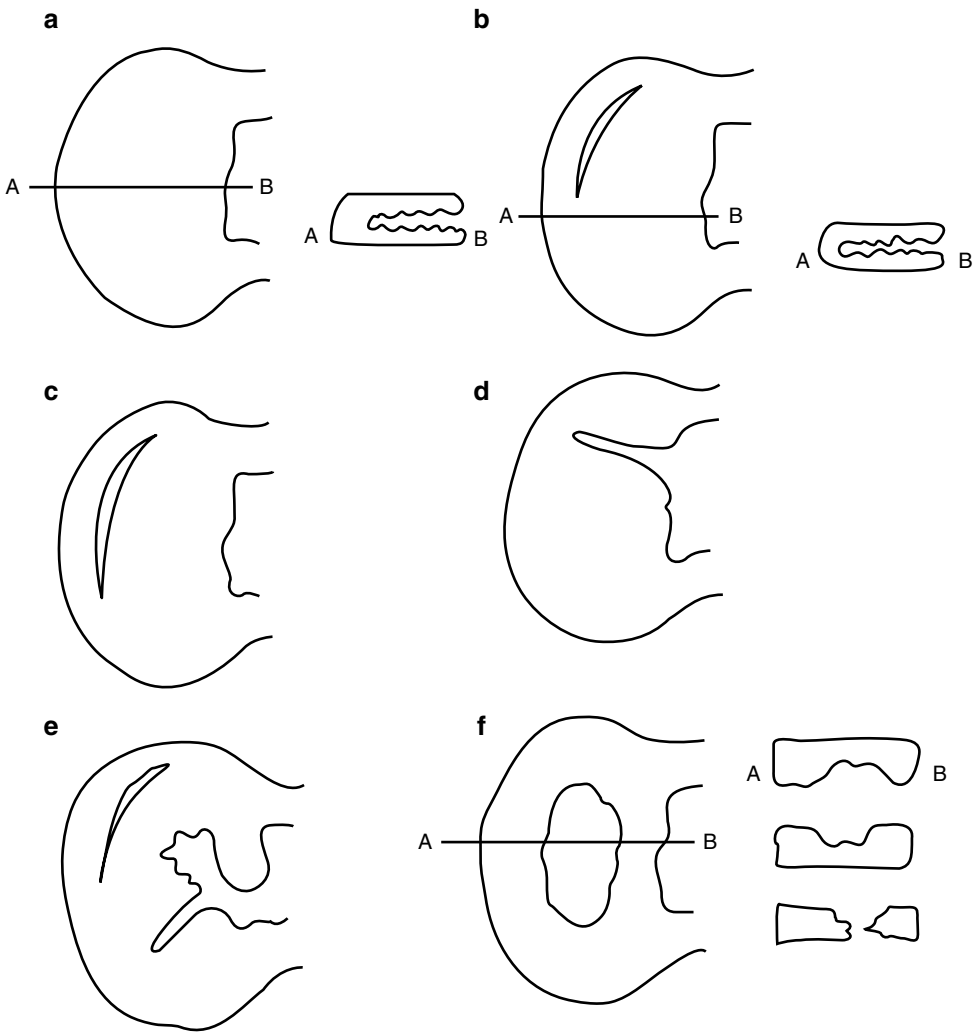


**Fig. 2** Schematic drawings of the modified O'Connor's classification for lateral discoid meniscal tears. (**a**) Simple horizontal, (**b**) combined horizontal, (**c**) longitudinal, (**d**) radial, (**e**) complex, and (**f**) central

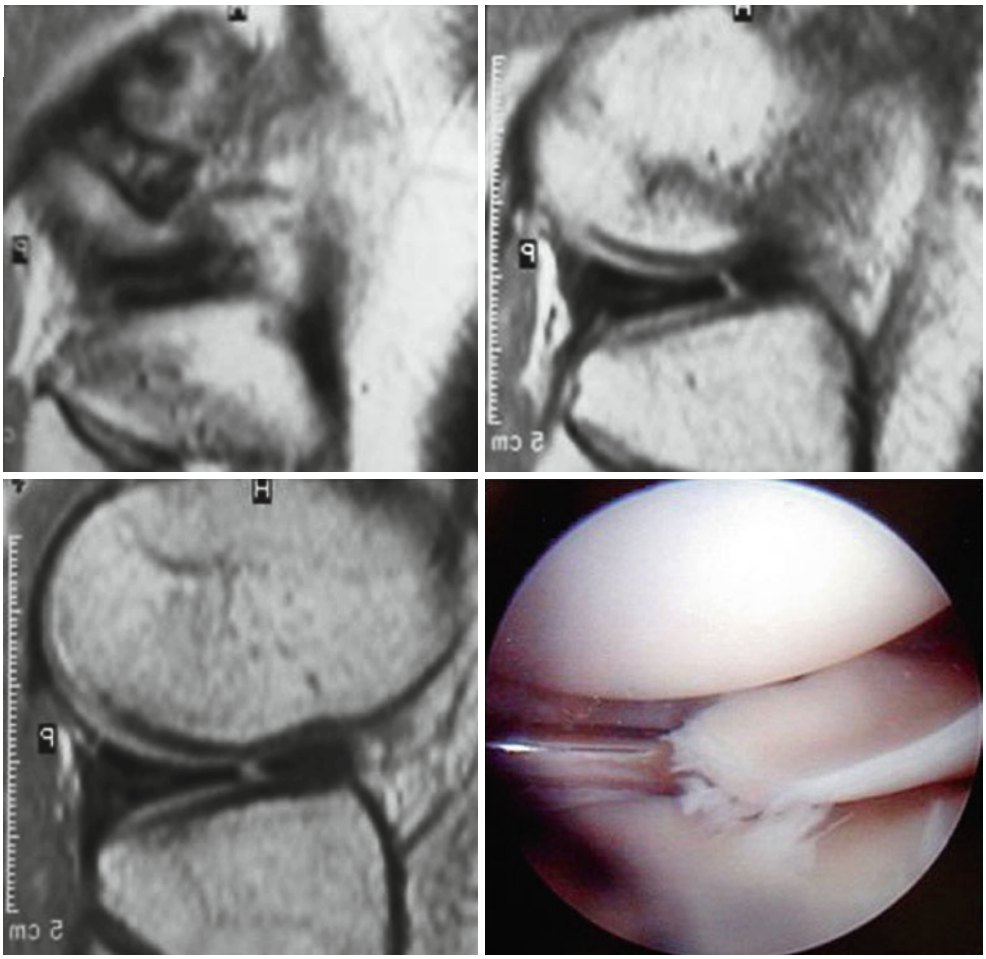

**Fig. 3** MRI and arthroscopic views of a radial tear of a discoid lateral meniscus

including a degenerative tear, which is a combination of two major components except a horizontal tear or a combination of three or more major tear components including a horizontal tear; and (6) a central tear which is a broad spectrum of the wear in the central portion of the discoid meniscus as a result of repeated maceration [41]. Figures 3 and 4 demonstrates MRI and arthroscopic views of discoid lateral menisci from our clinic with a radial and horizontal tear.

## Clinical Presentation

Many stable lateral meniscal variants are asymptomatic and are found incidentally. Moreover, patients might have unilateral symptoms but bilateral discoid menisci.

The most common symptoms, which usually occur during childhood and adolescence, are a clunking sound with flexion of the knee, pain, a decreased range of motion (usually lack of full extension), joint line tenderness, sensation of a foreign object within the knee, quadriceps atrophy, and effusion [5, 22, 27, 29, 32, 53, 58, 70, 71].

The sound and feeling of this clunking and popping made Kroiss [42] attribute the term "snapping knee syndrome" to discoid meniscus (See: Video 1). Yet, pain is the predominant symptom in majority of cases. Pain generally begins with a minor trauma, and is not always associated with a tear [9].

According to Ahn [3], the type of the discoid meniscus is associated with the clinical symptoms. In his study, he concluded that lack of extension is more common when the anterior horn thickness is greater than 7.7 mm and extension is full when the thickness is less than 4 mm.

## Accompanying Conditions

Lateral meniscal variation can be associated with other musculoskeletal anomalies. High fibular head, fibular muscular defects, hypoplasia of the lateral femoral condyle with lateral joint-space widening, hypoplasia of the lateral tibial spine, abnormally shaped lateral malleolus of the ankle, and enlarged inferior lateral geniculate artery are examples of such anomalies.

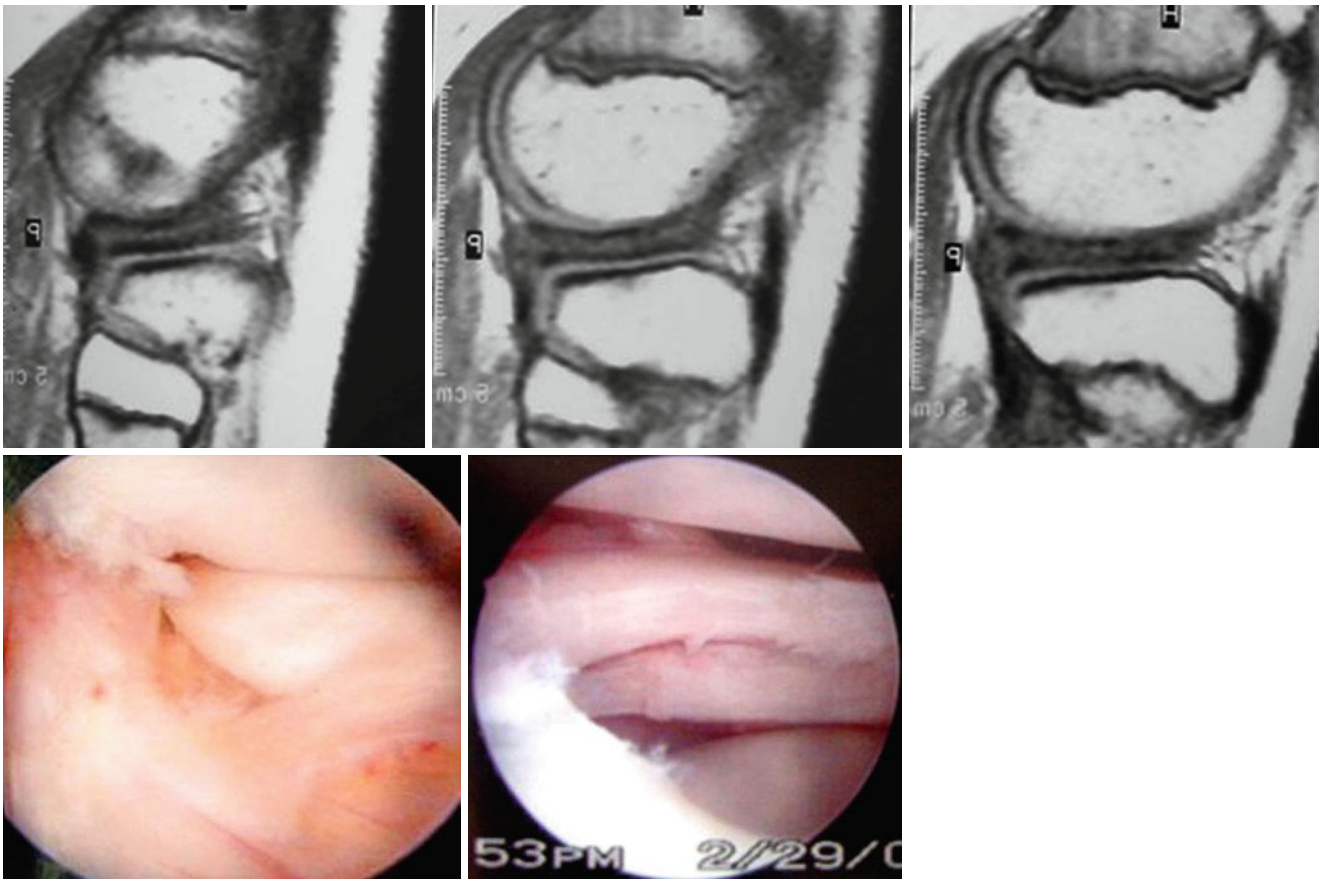


**Fig. 4** MRI and arthroscopic views of a horizontal tear of a discoid lateral meniscus

One of the most clinically demanding conditions is the association between lateral discoid meniscus and an osteochondral lesion of the lateral femoral condyle. It was first described by rani et al. [30]. Osteochondritis dissecans of the lateral femoral condyle is relatively rare and oftentimes combined with lateral discoid meniscus and usually a torn discoid meniscus [49], and associated with a poorer prognosis when present. The discoid meniscus itself might produce an abnormal contact force onto the lateral femoral condyle even if the meniscus is not torn. This abnormal contact force may lead to an osteochondritis dissecans lesion in the lateral femoral condyle [48]. The presence of lateral discoid meniscus was reported to occur in a majority of the osteochondritis dissecans lesions that occurred in the lateral femoral condyle [76]. A lateral discoid meniscus tear, young age and high activity, and valgus alignment can be predisposing factors for osteochondritis dissecans of the lateral femoral condyle [68]. Partial meniscectomy is shown to permit the healing of an osteochondral lesion [76].

## Radiology: X-Ray

Standard anterior-posterior, lateral, tunnel, and skyline views contribute significantly to the establishment of diagnosis [56] (Figs. 5 and 6). Lateral joint-space narrowing, lateral joint lipping, squaring of the lateral femoral condyle, cupping of the lateral tibial plateau, flattening of the lateral femoral condyle, tibial eminence hypoplasia, calcification of the meniscus, fibular head elevation, obliquity of the joint space, and degenerative changes may be demonstrated [35, 74]. These radiographic findings are present only in some cases. Associated pathologies such as osteochondritis dissecans and lateral malleolus abnormalities may also be visualized.

## Radiology: Ultrasonography

Ultrasonographic imaging of the menisci may demonstrate a wide and irregularly shaped lateral discoid meniscus. Sonography has been used to evaluate meniscal tears due to its availability, multiplanar capability, and economic benefit. The use of high-resolution micro-convex probes, which better fit the anatomic concavity of the popliteal fossa, achieves a better sensitivity and a specificity in detecting meniscal tears [51]. The disadvantage of the use of ultrasonography is that it is an examiner-dependent tool. The sonographic criteria for diagnosis of discoid meniscus in children is reported as the absence of a normal triangular shape, the presence of an abnormally elongated and thick meniscal tissue, and the demonstration of a heterogeneous central pattern [1].

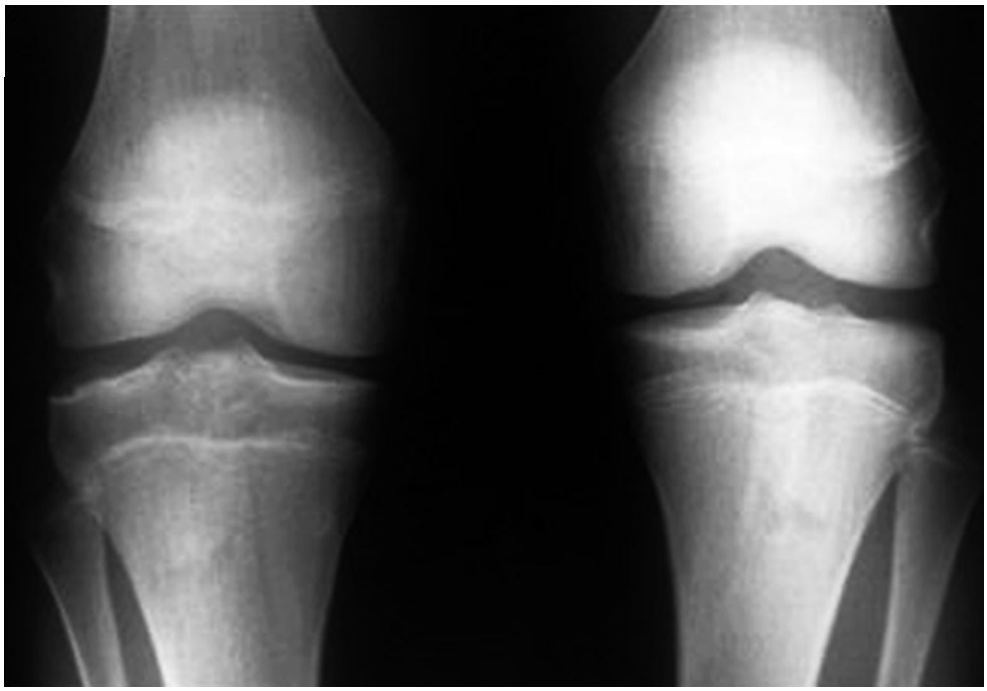

**Fig. 5** Anteroposterior x-ray of a knee with cupping of bilateral discoid menisci

**Fig. 6** Lateral x-ray of the knee medial plato with medial discoid menisci

## Radiology: MRI

On magnetic resonance imaging (MRI), the presence of a discoid meniscus is suggested in 5-mm sagittal sections when three or more contiguous sections demonstrate continuity of the meniscus between the anterior and posterior horns. Normally, this black "bow tie" appearance (Figs. 7 and 8) would be seen only on two contiguous sagittal sections [16, 62]. Although this is a useful sign, the finding will be absent in the unstable type if the meniscus has a normal shape. The presence of a discoid shape can be further confirmed if a coronal view demonstrates increased width of the midanteroposterior diameter. One may also note an increase in thickness of the anterior horn, the posterior horn, or the entire meniscus. A height difference of >2 mm or >15 mm transverse diameter in coronal view can suggest a discoid meniscus.

MRI can also be useful for detecting intrasubstance tear and/or degeneration of lateral discoid meniscus [26]. Although valuable in the diagnosis of the discoid meniscus and tears, MRI can be insufficient in determining the type of the tear [60].

Some authors indicate that the routine use of MRI is difficult and that arthroscopy should be used both for diagnostic and therapeutic purposes [58].

## Treatment

The menisci serve in distributing loads, absorbing shock, and have a role in joint stability, synovial fluid distribution, and cartilage nutrition. Partial meniscectomy of normal shaped menisci was shown to increase the contact stresses in proportion to the amount of removed meniscus [13]. Following total meniscectomy, the contact area was decreased by 75% while contact stresses increased by 235% [13]. Better understanding of the importance of the menisci to normal articular function has led to the preservation of stable meniscal tissue as part of treatment planning.

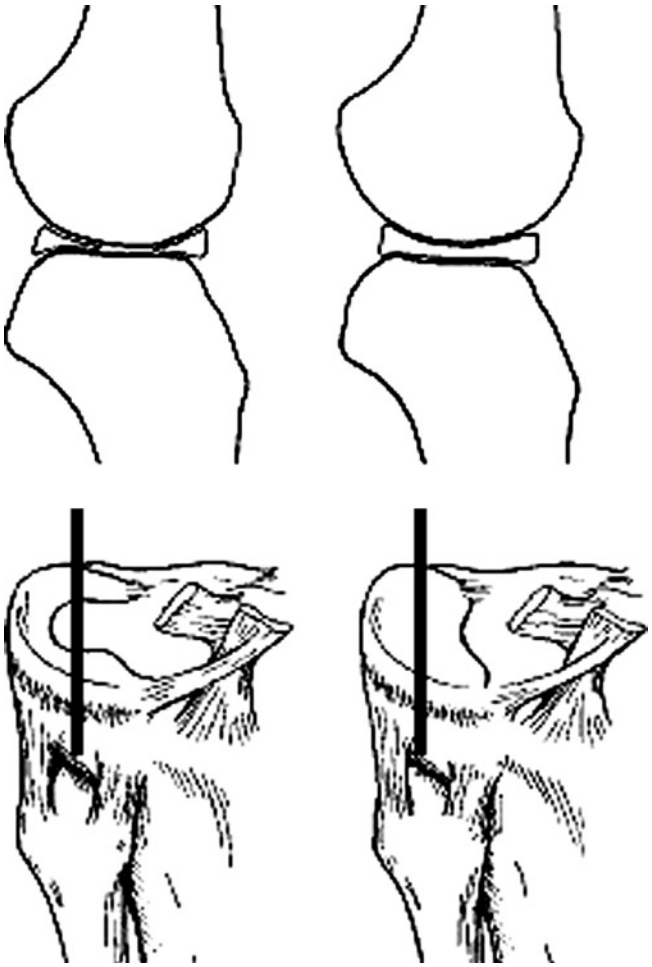

**Fig. 7** Diagrammatic explanation of the bow tie appearance on sagittal MRI sections

Historically, the preferred treatment of a stable symptomatic lesion was open excision [52, 63]. However, total meniscectomy of a lateral non-discoid meniscus often leads to osteoarthritis [23, 43, 46, 78], and this is also true for discoid menisci in adults. In children, the risk of lateral degenerative arthritis after meniscectomy is greater than in adults; therefore, total meniscectomy for treatment of a discoid meniscus in children should be avoided whenever possible.

In order to properly choose the treatment method for the lateral meniscal variant, one must consider the age and activity level of the patient, the anatomy of the lesion, the duration and extent of the symptoms, and the amount of joint destruction. One must realize that the patient with a lateral meniscal variant usually has an abnormal knee at the outset. There may be no good treatment option; rather, the only choice may be the lesser of two evils.

The treatment options for the various lateral meniscal variants include observation, partial meniscectomy with or without reattachment, total meniscectomy, and for a normally shaped unstable lesion reattachment to the adjacent capsule. Many stable discoid menisci are found incidentally; therefore, it is reasonable to observe asymptomatic patients and inform them regarding an increased risk of having to undergo surgical treatment in the future. However, it should also be pointed out that the joint probably has adapted and could continue to function reasonably well. Snapping knee with no other symptoms and no radiographic signs of accompanying articular lesions can be followed-up and then treated should it become symptomatic. A patient may become symptomatic due to instability or a new tear of the meniscus, or as the result of accompanying findings, such as osteochondral lesions to the lateral femoral condyle.

Current treatment of choice for symptomatic stable, complete, or incomplete discoid lateral meniscus is arthroscopic partial meniscectomy (saucerization) [27, 29, 55]. Motored and radio frequency tools may be used for meniscal reshaping. In the past, some authors recommended total or subtotal

**Fig. 8** Consecutive sagittal MRI sections showing bow tie appearance

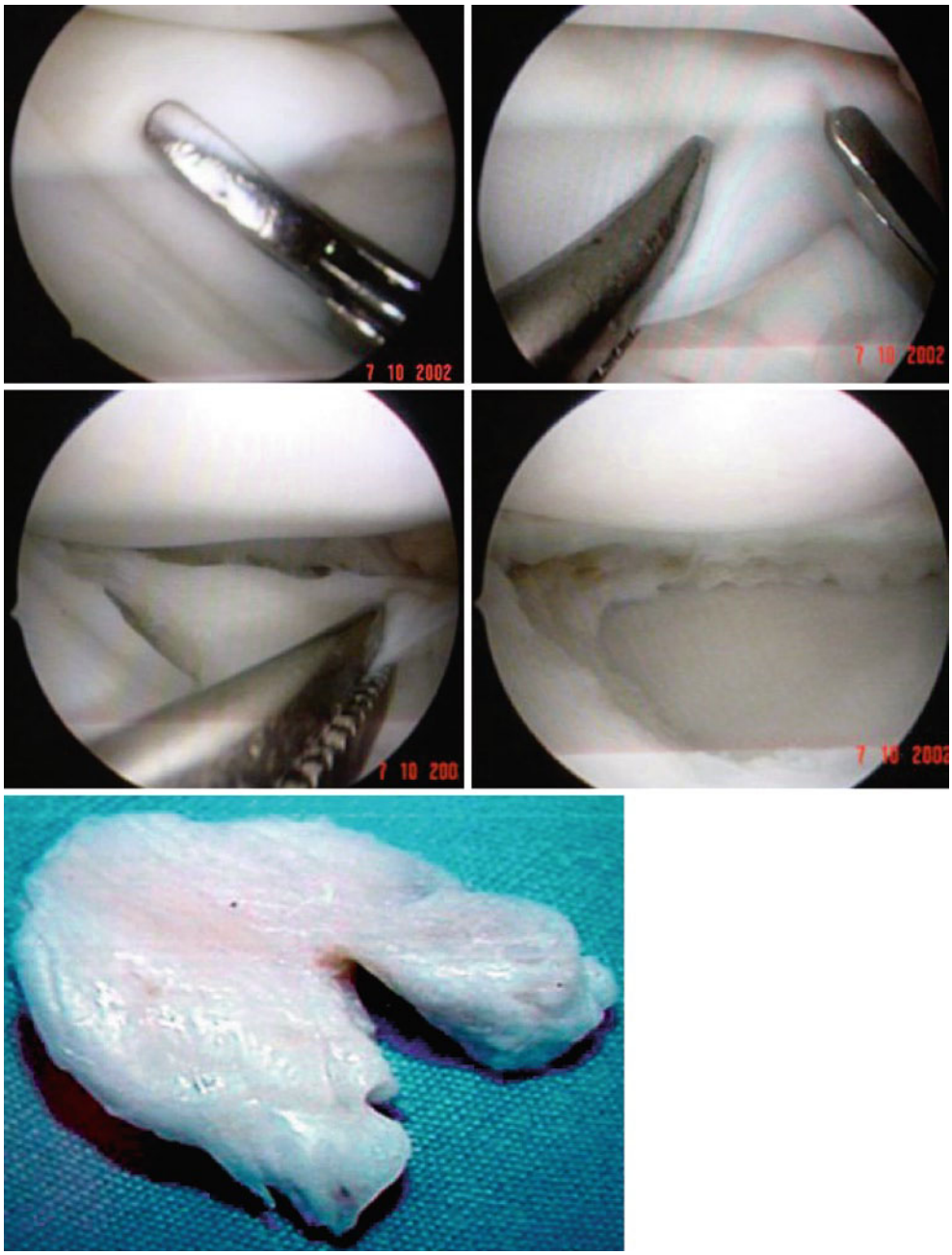


**Fig. 9** One-piece excision of discoid lateral meniscus

meniscectomy as being better than partial meniscectomy due to higher reoperation rates [65], because the increased thickness at the rim was thought to result in high shear forces concentrated at the resected margin due to the incongruity between meniscus and articular surface, which predisposed the abnormal meniscus rim to retear. Today, it is believed that a stable rim should be preserved, even though it may be composed of abnormal tissue [14, 22, 24, 74]. The commonly used method for partial meniscectomy is one-piece excision that was described by Kim et al. in 1996 [39]. Most authors agree that the width of the remaining peripheral rim should be between 5 and 8 mm to prevent impingement and instability of the remaining part that may lead to future secondary meniscal tear and to decrease the rehabilitation time [27, 38, 64, 70]. Saucerization and reattachment are also recommended for Wrisberg types [53, 59].

During arthroscopy, a tear may not be visualized in some symptomatic discoid menisci. In such cases, one should carefully search for tears in the inferior of the meniscus. In other cases, there may be intrasubstance tears. Such tears can't be visualized before starting the resection. If clinically suspected and/or MRI revealed an increase in intrameniscal signal, one should start resection. Trimming or saucerization is the recommended treatment for such tears [29, 71].

(Fig. 9) shows a one-piece excision performed at our clinic step by step.

## Treatment Outcome

Ikeuchi rating system [29] and Lysholm knee scale [67] are frequently used to evaluate the treatment outcome. Ikeuchi's system depends on mechanical symptoms, pain, and range of movement (Table 2). Lysholm's scale is a numerical scale where one gets points on limping, use of support, stair climbing, squatting, instability, swelling and pain of the knee, and atrophy of the thigh.

In 1991, it was reported that arthroscopic partial meniscectomy should be recommended only when the posterior attachment of the discoid meniscus is stable and that total meniscectomy is indicated for the Wrisberg ligament type of discoid meniscus with posterior instability [5]. In following years, results of longer follow-up studies showed that total meniscectomy results in osteoarthritic changes such as joint-space narrowing and osteophytes in the lateral compartment [2,57,71]. In 2003, Atay et al. [11] have reported excellent results for partial meniscectomy in 85% of their patients that had Watanabe complete- and incomplete-type discoid menisci. In the same year, Davidson et al. concluded that partial resection of discoid menisci is preferable in children, but in complete dislocation of the entire menisci, total removal is necessary [20]. A more recent study concluded that although there were no differences in clinical results between the partial and subtotal/total meniscectomies, partial meniscectomy yielded better radiologic results for torn discoid lateral menisci in children [45]. The long-term prognosis after arthroscopic meniscectomy for the torn discoid lateral meniscus was related to the volume of the meniscus removed [25]. Short-term results confirm that meniscal allograft transplantation after total meniscectomy could be reasonable in symptomatic patients [36]. However, long-term observations are required to evaluate these results.

It is suggested that there is a need for early diagnosis and greater caution in the treatment of discoid lateral menisci [45]. Heightened awareness of the clinician to the possibility of discoid meniscus, its variable presentations and complications, and management considerations may improve therapeutic outcome [75].

**Table 2** The knee rating system

| Grade | Description |
|---|---|
| Excellent | No mechanical symptoms (click, locking), no pain, full range of movement |
| Good | No mechanical symptoms, occasional mild pain on exercise, full range of movement |
| Fair | Mechanical symptoms, mild to moderate pain on exercise, full range of movement |
| Poor | Mechanical symptoms, moderate to severe pain on exercise or pain at rest, limitation of movement |

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