RadioGraphics

Anatomy and MR Imaging Appearances of Synovial Plicae of the Knee[1]

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LEARNING OBJECTIVES

After reading this article and taking the test, the reader will be able to:

- Discuss the embryologic development of synovial plicae of the knee.
- Identify the types of plicae of the knee and recognize their MR imaging appearances.
- Describe the pathophysiologic features and clinical manifestations involved in the development of plica syndrome.

Synovial plicae are normal anatomic structures of the knee that sometimes become symptomatic. Magnetic resonance (MR) imaging and MR arthrography are useful tools in the evaluation of synovial plicae and allow differentiation of these entities from other causes of knee pain. At MR imaging, synovial plicae appear as bands of low signal intensity within the high-signal-intensity joint fluid. Gradient-echo T2-weighted and fat-suppressed T2-weighted or proton density–weighted MR images are optimal for the evaluation of plicae. Plica syndrome, the painful impairment of knee function in which the only finding that helps explain the symptoms is the presence of a thickened and fibrotic plica, should be included in the differential diagnosis of internal derangement of the knee. A diffusely thickened synovial plica, perhaps associated with synovitis or erosion of the articular cartilage of the patella or femoral condyle, in a patient with no other significant MR imaging findings suggests the diagnosis of plica syndrome. Once the diagnosis has been made, nonsurgical treatment is preferable initially. Failure of the patient to improve with conservative treatment leaves arthroscopic excision of the pathologic plica as the treatment of choice.

Introduction

A plica is a fold of synovial tissue found in the lining of a joint. These folds are quite filmy, thin, and vascularized and have no known function. Plicae manifest at magnetic resonance (MR) imaging as linear low-signal-intensity structures, sometimes delineated by joint fluid.

The synovial plicae are normal structures that represent remnants of synovial membranes from the embryologic development of the knee. Some authors have

Abbreviation: ACL = anterior cruciate ligament

Index terms: Knee, 452.25 • Knee, anatomy, 452.92 • Knee, arthrography, 452.122 • Knee, MR, 452.1214

RadioGraphics 2002; 22:775–784

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suggested that the synovial plicae may act like eyelids, aiding in lubrication of the joint. The most commonly encountered plicae of the knee (in descending order) are the infrapatellar plica (ligamentum mucosum) (Fig 1), the suprapatellar plica, and the mediopatellar plica (1,2).

Asymptomatic synovial plicae may be found normally within the knee. Chronic inflammation secondary to direct trauma, repetitive sports activities, or other pathologic knee conditions affects the pliability of the synovial folds and can become symptomatic. With motion of the knee, the thickened fibrotic plicae can irritate the synovium of the condylar margins, leading to inflammatory synovitis and articular cartilage wear. The mediopatellar plica is considered the one most likely to cause problems when it becomes thickened, fibrotic, or bowstrung (3). The exact prevalence of medial plica syndrome is a subject of debate, as are the criteria that allow recognition of a clinically significant plica.

In this article, we discuss and illustrate the embryologic development and MR imaging features of synovial plicae of the knee. We also discuss the pathophysiologic features, clinical manifestations, and treatment of plica syndrome.

Embryologic Development

Although there is no consensus, it is widely believed that the knee joint is originally composed of three compartments—medial, lateral, and suprapatellar—that are partitioned by synovial septa. The incomplete resorption of these septa would leave well-developed plicae. These plicae are remnants of the synovial septa that occupy the space between the distal femoral and proximal tibial epiphyses in the 8-week-old embryo during embryologic development of the knee (4,5). The motion of the fetal knee joint in utero may contribute to both the resorption of plicae and the development of the joint cavity. This theory would explain the presence of suprapatellar and infrapatellar plicae; however, it does not explain the presence of a mediopatellar or lateral plica because at no time does a membrane separate the patellofemoral joint into two cavities along a coronal plane (6). The embryologic work of Ogata and Uhthoff (5) showed that the mediopatellar plica is not a remnant of a septum of a distinct compartment during the development stage. Instead, it seems to be linked to the lateralized position of the patella and constitutes a remnant of mesenchymal tissue that was larger at the medial side of the patellofemoral region.

There is no consensus in the literature concerning the prevalence of these persistent embryonic structures in the general population. In an anatomic study by Jouanin et al (1), 11% of knees had all three main plicae and 10% had no plica of any kind. The suprapatellar and infrapatellar plicae are the most common but have little clinical relevance. Because of its clinical implications, the mediopatellar plica is by far the most studied plica. The lateral patellar plica is very rare (7).

Figure 1. Multiple synovial plicae in an asymptomatic patient. Sagittal fat-saturated T1-weighted MR arthrogram (repetition time msec/echo time msec = 500/20) demonstrates suprapatellar (black arrow), mediopatellar (arrowhead), and infrapatellar (white arrow) plicae.

MR Imaging Features

At MR imaging, synovial plicae can be seen as bands of low signal intensity within the high-signal-intensity joint fluid. Gradient-echo T2-weighted MR images and fat-suppressed T2-weighted or proton density–weighted images are the most valuable for the evaluation of plicae. MR arthrography performed with fat suppression, T1 weighting, and intraarticular injection of gadolinium-based contrast material is a useful technique when there is not enough articular fluid and a clinically significant plica is suspected. The contrast agent highlights joint surfaces and distends the capsule, thereby providing excellent visualization of the plicae (Fig 1).

Although the size and morphologic features of a given plica seen at MR imaging do not in themselves indicate whether the plica is clinically significant, symptomatic plicae usually appear thickened with synovitis and sometimes cause erosion about the condyle and patellar cartilage.

Suprapatellar Plica

The terms suprapatellar septum, *suprapatellar plica*, *superior plica*, *septumlike folds*, and *suprapatellar bursa* are used in the literature to describe the

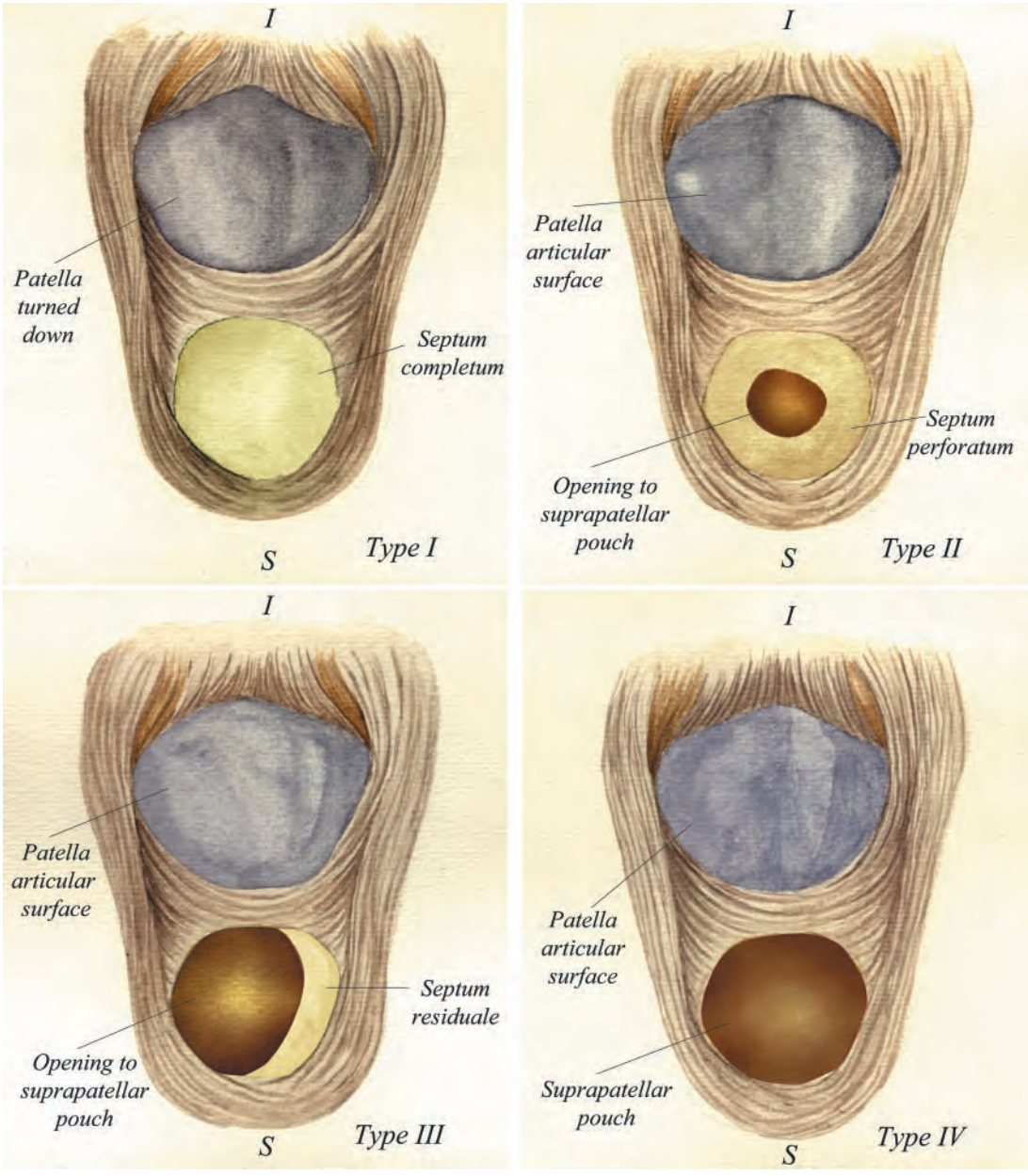
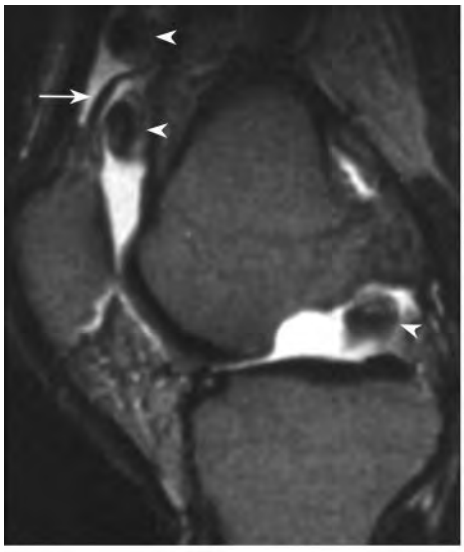


Figure 2. Drawings illustrate the Zidorn classification scheme for suprapatellar septa: Type I (septum completum), in which the suprapatellar bursa and knee joint are completely separated by the septum; Type II (septum perforatum), in which there are one or more openings of varying size in the septum; Type III (septum residuale), in which there is a remaining fold, usually in a medial location; and Type IV (septum extinctum), in which the septum is completely involuted. *I* = inferior, *S* = superior.

structure that is located at the border between the suprapatellar bursa and the knee joint cavity. The suprapatellar plica runs obliquely downward from the synovium at the anterior aspect of the femoral metaphysis to the posterior aspect of the quadriceps tendon, inserting above the patella. It can impinge on the articular cartilage of the superomedial angle of the trochlea in flexion (8).

By the end of the 4th fetal month, the suprapatellar septum completely separates the knee joint cavity from the suprapatellar bursa. A communication between the suprapatellar bursa and the knee joint is normally observed by the end of the 5th fetal month. Mechanical factors are said to determine the form and extent of suprapatellar septum perforation, which varies from a fissure to partial or complete loss of the septum. Zidorn (9) classified suprapatellar plicae into four groups on the basis of morphologic features (Fig 2). In



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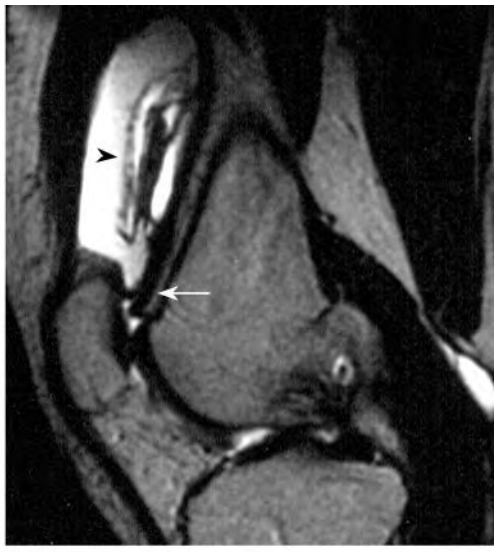


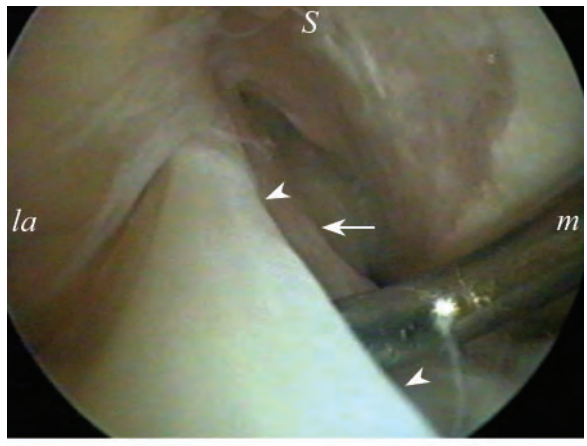
4.

Figures 3, 4. **(3)** Suprapatellar plica. Sagittal gradient-echo MR image (523/20, 35° flip angle) shows a bandlike structure with low signal intensity at the suprapatellar space (arrow). Note also the intraarticular loose bodies (arrowheads). **(4)** Symptomatic complete suprapatellar plica. Sagittal turbo spin-echo T2-weighted MR image (2,566/90) demonstrates a large suprapatellar pouch that is separated from the articular cavity by a complete septum (arrow). Synovial thickening is also present (arrowhead).

5a.

6.

Figures 5, 6. Infrapatellar plica. **(5a)** Sagittal three-dimensional gradient-echo MR image (523/20, 35° flip angle) shows a linear low-signal-intensity structure (arrow) in the intercondylar notch anterior to the ACL. **(5b)** Arthroscopic image shows a membranous structure (infrapatellar plica [arrowheads]) close to the ACL (arrow). *la* = lateral, *m* = medial, *S* = superior. **(6)** Sagittal turbo spin-echo T2-weighted MR image (2,566/90) shows a thickened low-signal-intensity band (arrow) anterior and parallel to the ACL.



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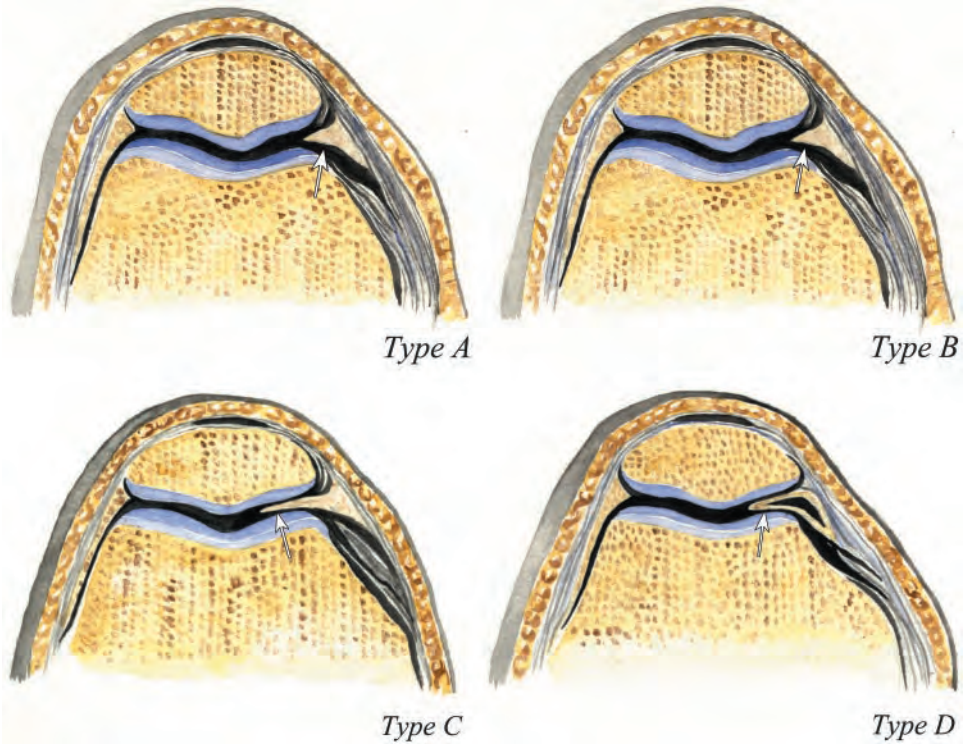


Figure 7. Drawings illustrate the Sakakibara arthroscopic classification scheme for mediopatellar plicae: Type A, which consists of a cordlike elevation in the synovial wall (arrow); Type B, which has a shelflike appearance (arrow) but does not cover the anterior surface of the medial femoral condyle; Type C, which is large with a shelflike appearance (arrow) and covers the anterior surface of the medial femoral condyle; and Type D, in which the plica (arrow) has a central defect (fenestrated plica).

Zidorn type II plicae, the perforation that allows the joint fluid to circulate between the pouch and the bursa is called a porta. Its location and size are variable. The suprapatellar plica is seen in several forms in adult patients, with a prevalence of 89% at autopsy (10).

At MR imaging, the suprapatellar plica is best visualized on a sagittal view as a bandlike low-signal-intensity structure posterior to the patella (Fig 3). At arthroscopy, a complete suprapatellar plica (Fig 4) is suggested only by the presence of a short suprapatellar pouch. The diagnosis is almost never made at arthroscopy, except when the irrigation needle is inserted into the bursa instead of the knee joint cavity (7).

Infrapatellar Plica

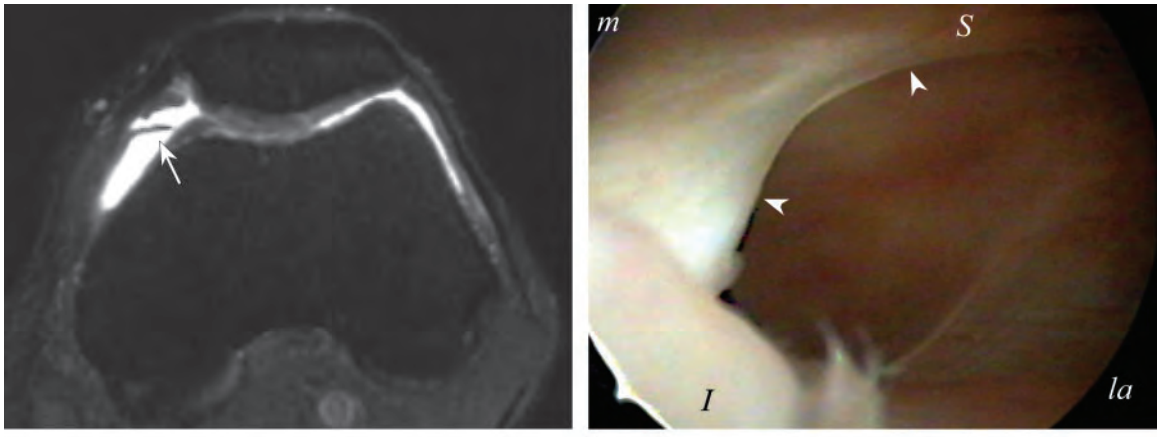
The infrapatellar plica, or ligamentum mucosum, is the most common plica in the knee. It is a normal structure, formed at approximately the 8th to 12th weeks of gestation, that is present when the primitive embryologic septum between the medial and lateral compartments of the knee does not completely regress. Its shape, which depends on the degree of regression, has been used as the basis for classifying infrapatellar plica as (*a*) having a vertical septum, or as being (*b*) separate from the anterior cruciate ligament (ACL), (*c*) split or bipartite, or (*d*) fenestrated. The infrapatellar plica has a narrow femoral origin in the anterior part of the intercondylar notch, widens as it descends anteriorly and inferiorly through the infrapatellar fat pad, and attaches distally to the inferior pole of the patella (11). Its dimensions vary from extremely thin to very thick, possibly as large as the ACL.

The infrapatellar plica is easily identified at MR imaging as a linear low-signal-intensity structure anterior and parallel to the ACL on sagittal images (Fig 5). Because of its location and orientation, the infrapatellar plica is sometimes mistaken for the ACL in an ACL-deficient knee, especially when it is wide and thick (Fig 6). It may also be mistaken for focal nodular synovitis, postoperative changes, or a loose body within the infrapatellar fat pad. Familiarity with the infrapatellar plica should eliminate confusion of this anatomic structure with these knee lesions.

Mediopatellar Plica

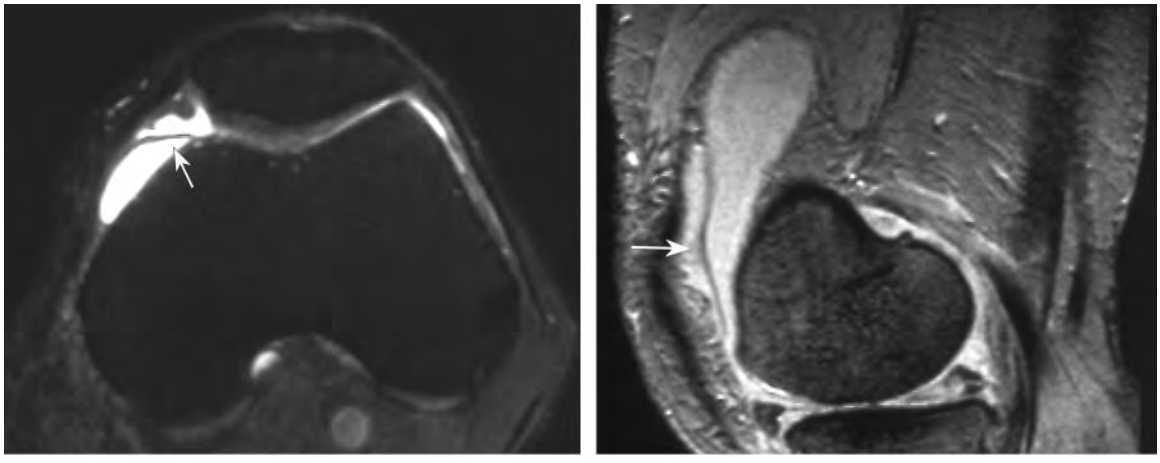
The mediopatellar plica is also referred to as the medial plica, plica synovialis patellaris, Iino band, plica alaris, synovial shelf, or patellar meniscus. The mediopatellar plica originates from the medial wall of the knee joint, runs obliquely downward, and inserts into the synovium covering the infrapatellar fat pad. It may be connected with the suprapatellar plica but more frequently has a separate attachment or occurs in the absence of the suprapatellar plica. If it is large, its free border can extend over the medial facet of the trochlea or under the medial facet of the patella.

Sakakibara (12) classified mediopatellar plicae into four types on the basis of size (Fig 7). This



a. b.

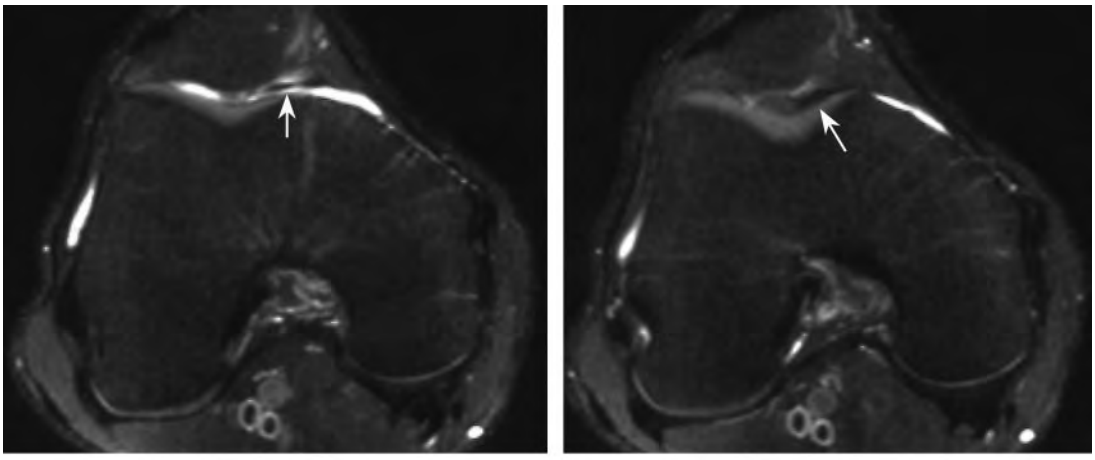
Figure 8. Asymptomatic medial plica (Sakakibara type A). **(a)** Axial fat-saturated spin-echo proton density–weighted MR image of the knee (3,000/50) demonstrates a cordlike elevation in the medial synovial wall (arrow). **(b)** Arthroscopic image shows a thin band (mediopatellar plica) in the medial wall of the knee (arrowheads). *I* = inferior, *la* = lateral, *m* = medial, *S* = superior.



a. b.

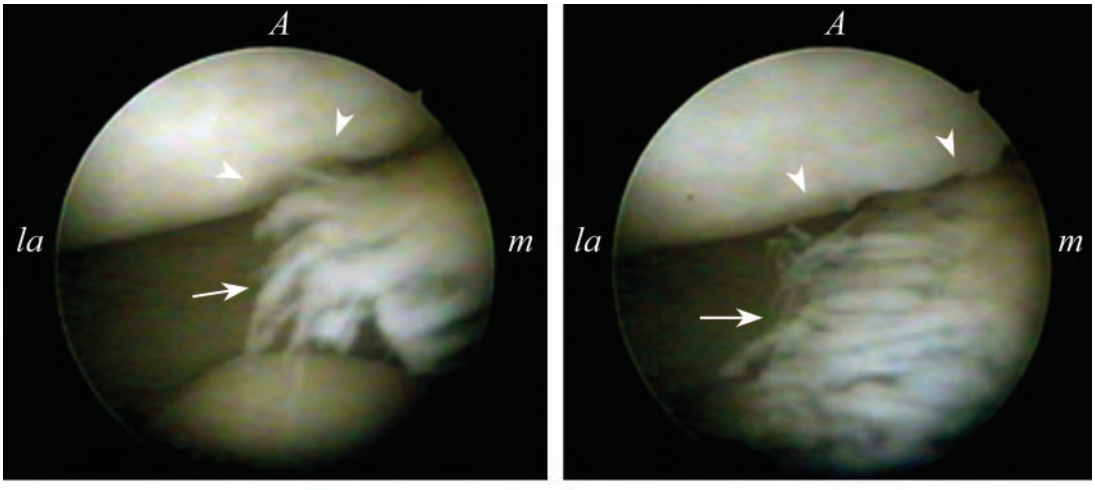
Figure 9. Medial plica (Sakakibara type B). Axial fat-saturated spin-echo proton density–weighted (3,000/50) **(a)** and sagittal three-dimensional gradient-echo (523/20, 35° flip angle) **(b)** MR images demonstrate a thin, hypointense line (arrow) that originates at the medial wall of the knee joint.

classification scheme is accepted almost universally because it is simple to use and is supposed to be of clinical significance. Types A and B are not likely to produce symptoms (Figs 8, 9). Types C and D can be trapped between the medial condyle and the patella, becoming thickened and hard and even causing internal damage to the knee joint. They can symptomatically impinge on the articular cartilage of the medial patellar facet in flexion or the cartilage of the medial femoral condyle in extension (Fig 10). In such cases, arthroscopic resection is the treatment of choice (Fig 11). Some authors suggest that fenestrated



a. b.

Figure 10. Symptomatic medial plica (Sakakibara type C) in a professional bicyclist. Axial fat-saturated spin-echo proton density–weighted MR images (3,000/50) obtained at different levels demonstrate a hypointense band (arrow) that covers the anterior surface of the medial femoral condyle.



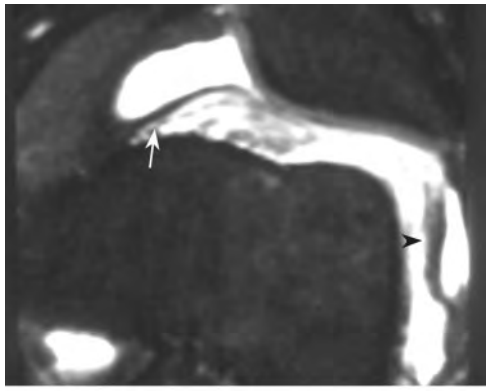
a. b.

Figure 11. Symptomatic mediopatellar plica (Sakakibara type C). Arthroscopic images demonstrate a mediopatellar plica (arrow) with patellar erosive changes (arrowheads). *A* = anterior, *la* = lateral, *m* = medial.

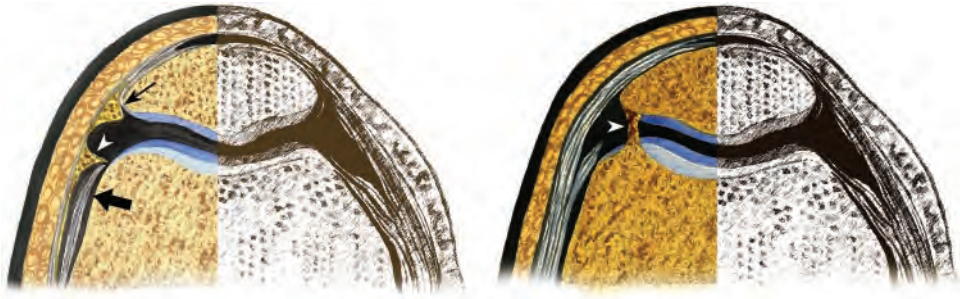
plicae (type D) are more likely to be symptomatic than normal plicae (13).

Axial and sagittal T2-weighted MR images obtained with or without fat suppression are optimal for visualizing mediopatellar plicae. The signal intensity of a mediopatellar plica is low on both T1- and T2-weighted images and is easily identified with some degree of joint distention. However, a more distended joint could pull the medial plica away from the medial condyle, making a type C plica look like a type B plica. A large mediopatellar plica that covers a wide area might interfere with arthroscopic visualization of the medial compartment of the knee.

Figures 12, 13. **(12)** Symptomatic lateral plica. Axial fat-saturated T1-weighted MR arthrogram (500/20) shows a linear low-signal-intensity structure 3 mm wide in the lateral recess of the knee joint (arrowhead). A mediopatellar plica is also noted (arrow). **(13)** Drawings of the lateral gutter illustrate a lateral plica (thick arrow in **a**), lateral alar fold (thin arrow in **a**), transverse synovial arcuate fold (arrowhead in **a**), and superolateral fold (arrowhead in **b**).



12.



13a. 13b.

Lateral Patellar Plica

The lateral patellar plica is the least common plica of the knee; indeed, its very existence is controversial. It is longitudinal, very thin, and located 1–2 cm lateral to the patella. It originates in the lateral wall above the popliteus hiatus and attaches to the infrapatellar fat pad (Figs 12, 13) (6,7). Ogata and Uhthoff (5) relate the rarity of this plica to the lateral subluxation of the patella, which leaves no space for the lateral plica to develop, unlike on the medial side. A lateral plica might obstruct an arthroscopic approach through the anterolateral portal.

There are other synovial structures in the lateral gutter—the lateral alar fold, superolateral fold, and transverse synovial arcuate fold—that should not be confused with a lateral patellar plica (Fig 13). The lateral alar fold is a longitudinal structure located closer to the patella that represents the equivalent of the medial alar fold. The superolateral fold is a type of suprapatellar plica located on the lateral side of the suprapatellar pouch (Dandy type J) (14). The transverse synovial arcuate fold is frequently present in the lateral gutter at the junction between the anteroposterior and vertical aspects of the gutter.

Pathophysiologic Features and Clinical Manifestations

Plica syndrome is defined as a painful impairment of knee function in which the only finding that helps explain the symptoms is the presence of a thickened and fibrotic plica.

The pathophysiologic features of plica syndrome are not clearly defined. Plica syndrome arises from an injury such as a direct blow, repeated activity (eg, sports that require repetitive flexion-extension motion), a twisting force that stretches the plica, or some other pathologic knee condition that results in an inflammatory process. Edema results in a loss of normal elasticity; consequently, the plica becomes fibrotic and thickened (Fig 14) and eventually symptomatic as it snaps over the femoral condyle in extension and over the patella in flexion. This results in a secondary mechanical synovitis and erosion about the margins of the condyle and patellar cartilage. In the early stages, the inflamed plica itself may be symptomatic, whereas in the later stages the cause of symptoms is the fibrotic plica that arises from underlying cartilage or from traction on adjacent synovium (3,15). However, anatomic studies demonstrate that there are many types of synovial plicae of the knee and that variations in thickness, width, and rigidity are congenital and constitutional. Most authors accept that wider

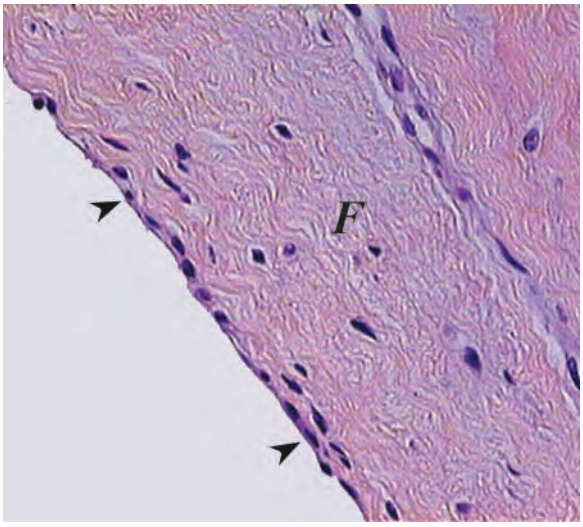


Figure 14. Mediopatellar plica. Photomicrograph (original magnification, ×40; hematoxylin-eosin stain) of a symptomatic synovial plica demonstrates a fibrotic band (*F*) covered with slightly inflamed synovium (arrowheads).

plicae are more often symptomatic and more frequently demonstrate pathologic changes at histologic analysis than thinner plicae (6).

Medial plica syndrome is more common in teenagers, in whom meniscal and ligamentous lesions are still rare. The onset of symptoms after blunt trauma to the knee is typical. Medial patellar pain, whether during physical activity or at rest, that increases with repeated flexion and extension is the most commonly encountered symptom. The pain is located medial to the patella above the joint line. Nonspecific signs include crepitation, popping, snapping, catching, pseudolocking, and effusion. Clinical findings mimic those in a torn medial meniscus or a maltracking patella. A palpable, painful cord medial to the patella is almost pathognomonic for this pathologic condition.

The potential role of the suprapatellar plica in internal derangements of the knee is a subject of debate. In a study of 23 patients with vague knee pain, Bae et al (16) reported 34 cases in which the pain was attributable to a total separation of the suprapatellar bursa and knee joint by a complete septum. Suprapatellar plica syndrome manifests clinically as chronic, intermittent dull pain about the superior portion of the knee that is aggravated by climbing stairs or sitting for a long time. Objective findings include local tenderness, a palpable band on the superomedial side, and audible snapping. The cause is not easily found at physical examination, and MR imaging is useful in making the diagnosis.

A large suprapatellar plica might interfere with arthroscopic visualization of the ACL. Rarely, traumatic rupture of the plica with an intact ACL may cause hemarthrosis.

The rare lateral patellar plica is usually thin and is likely to produce no symptoms. In a study of 21 lateral plicae seen at 3,000 arthroscopic procedures, Tearse et al (17) estimated that 14 were fibrotic and symptomatic. Resection led to complete healing in 13 patients. Signs and symptoms included pain above the lateral joint line and snapping. Physical examination findings consisted of lateral tenderness and a palpable cord.

Treatment

If a diagnosis of plica syndrome has been made, nonsurgical treatment is always preferable initially. This treatment combines rest from all strenuous physical activities, massage, cryotherapy, ultrasonography, and hamstring stretching. Medication may include nonsteroidal antiinflammatory agents administered percutaneously, orally, or by means of intraplical injection (6,18).

Failure of the patient to improve with conservative treatment leaves arthroscopic excision of the pathologic plica as the treatment of choice. The plica should be entirely removed by resecting it to its base throughout its length. If the pathologic plica is only divided with scissors, it may heal itself, with recurrence of symptoms (6,18).

Conclusions

Synovial plicae are normal anatomic structures of the knee that sometimes become symptomatic. Plica syndrome should be included in the differential diagnosis of internal derangement of the knee, although the symptoms and pathophysiologic features of plica syndrome are ambiguous.

MR imaging is a useful noninvasive tool in the evaluation of synovial plicae and can be used as a screening method in the diagnosis of plica syndrome. A diffusely thickened synovial plica, perhaps associated with synovitis or erosion of the articular cartilage of the patella or femoral condyle, in a patient with no other significant MR imaging findings suggests the diagnosis of plica syndrome.

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