

Morphophysiology of synovial plica from knee joint: a literature review

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Abstract

Introduction: Synovial plicae around the knees are a relatively common occurrence. They have been the object of many clinical and anatomical researches, not only because of their intra-articular existence, but also for their painful symptomatology caused on knee joint. These plicae are excessive folds of synovial membrane and are remnants from embryonic septum, which were not properly absorbed during fetal development. These synovial plicae are divided anatomically, as location and existence, and are classified into suprapatellar, infrapatellar, medial patellar and lateral patellar plicae; being still each of these subdivided according to their appearance and juxtaposition. **Material and methods:** A retrospective literature review selected articles in PubMed and MEDLINE databases; papers were searched using the keywords: synovial plicae, knee, embryology, anatomy, histology and treatment. **Results:** In this literature review was verified the incidence about the types, shape, location, symptoms, pathophysiology, and the main methods of study for the verification of synovial plica and treatments. **Conclusion:** In summary, asymptomatic plica can become symptomatic due to a bucket-handle tear following a twisting injury and lateral traction to the knee, when carefully diagnosed; a synovial plica represents a potential cause of pain in patients. After careful examination, arthroscopic resection of the bucket-handle portion of the plica is sufficient for the improvement of the symptoms if conservative treatment of pathological plica fail.

Keywords: anatomy, knee joint, synovial plica.

1 Introduction

First described by Lino (1939) the knee synovial plica is identified as a normal structure that represents traces of the synovial membrane in embryological development of the knee (TINDEL and NISONSON, 1992). According to its corresponding anatomical site of origin, four types of synovial plicae can be identified in relationship to the patella as suprapatellar, infrapatellar, medial patellar and lateral patellar plicae (HARDAKER, WHIPPLE and BASSETT, 1980; CRENSHAW, 1996; KIM and CHOE, 1997).

The normal plica is a thin and flexible fold containing abundant elastic and areolar connective tissue. The elasticity of the tissue allows the plica to glide over bone prominences; however, trauma to the knee can cause inflammation, resulting in swelling, thickening and inelasticity of the tissue. The plicae may eventually scar into fibrotic bands that “bowstring” across the femoral condyle and then it is responsible for the so-called plica syndrome (HARDAKER, WHIPPLE and BASSETT, 1980; COTHRAN, McGUIRE, HELMS et al., 2003).

This synovial plica is not present in all individuals, and there is great disagreement among authors as its incidence. The average incidence of the plica in an adult population is stipulated between 20% and 60% (KINNARD and LEVESQUE, 1984; JOHNSON, EASTWOOD and WITHEROW, 1993). In arthroscopic procedures, the frequency with which the presence of the synovial plica has

been reported varies among 14% and 100%, and among 25% and 33% in cadaver dissections (KLEIN, 1983; BROOM and FULKERSON, 1986; DANDY, 1990; DUPONT, 1997).

They also describe the incidence of various types of plica isolatedly (Table 1).

There are reports indicating that a symptomatic plica is found in 4% of all arthroscopies and constitutes 28% of all internal disarrangement in knee joint (DORCHAK, BARRACK, KNEISL et al., 1991; SAENGNIPANTHKUL, SIRICHATTIVAPEE, KOWSUWON et al., 1992).

Due to the diverse forms approached in the literature on the morphological description, incidence, diagnosis and treatment of synovial plica, this review aims to explain generally the embryology, anatomy, histology and pathophysiology of knee joint synovial plica. The terms used in this study are agreed to Anatomical Terminology (SOCIEDADE..., 2001).

2 Material and methods

The PubMed (www.pubmed.gov) and MEDLINE databases were used to conduct the literature research using keywords without restrictions. In this systematization, papers were searched using the following keywords: synovial plicae, knee, embryology, anatomy, histology and treatment.

Table 1. Method used to analysis of knee synovial plica incidence.

Author	Analysis	Knees evaluated	Types of plica	Incidence (%)
Dai, Lin, He et al. (1988)	Necropsies	69	Suprapatellar	94
			Medial patellar	39
			Infrapatellar	100
Zidorn (1992)	Necropsies	210 adults 13 fetus	Suprapatellar	89
Kim, Min and Kim (1996)	Arthroscopy	200	Infrapatellar	85.5
			Suprapatellar	87
Kim and Choe (1997)	Arthroscopy	400	Medial patellar	72
			Infrapatellar	86
			Lateral patellar	1.3
Lyu and Hsu (2006)	Arthroscopy	1.587	Medial patellar	29.7
Paczesny and Kruczynski (2009)	Arthroscopy	91	Medial patellar	75
	Ultrasound			

3 Results

3.1 Synovial plica – embryology, anatomy, histology and pathophysiology

Synovial plicae are embryological remnants of synovial membranes from mesenchymal tissues that fill the empty areas between distal femoral and proximal tibial epiphysis during the early fetal life of an 8-week embryo (OGATA and UHTHOFF, 1990). These tissues are resorbed to form cavities or compartments divided by septa at 8-12 weeks fetal age. Where resorption of the mesenchymal tissue fails and cavitation is incomplete, the plicae form in suprapatellar, infrapatellar, mediopatellar, and, rarely, lateral plicae in the joint as septal remnants (SCHINDLER, 2004), signifying that the plicae develop when the joint space is formed (BOLES and MARTIN, 2001). The movement of the fetal knee joint in uterus appears to contribute to resorption of suprapatellar and infrapatellar plicae, and helps in development of joint cavity (GARCÍA-VALTUILLE, ABASCAL, CEREZAL et al., 2002).

The suprapatellar plica runs obliquely downward from the synovium fluid 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 trochlea in flexion, usually, shows an opening of communication between the proximal and distal portions called “porta” or “ostium” (DORFMANN, ORENGO and AMARENCO, 1982; COHEN, ABDALLA, QUEIROZ et al., 1987; DAI, LIN, HE et al., 1988; TINDEL and NISONSON, 1992; GARCÍA-VALTUILLE, ABASCAL, CEREZAL et al., 2002). The superolateral fold is a type of suprapatellar plica located on the lateral side of the suprapatellar pouch (Dandy’s type J) (DANDY, 1990).

The infrapatellar plica, a vestige of embryologic vertical septum, 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 patella and completely or partially separate from the anterior cruciate ligament (ACL) (COHEN, ABDALLA, QUEIROZ et al., 1987; DAI, LIN, HE et al., 1988; TINDEL and NISONSON, 1992; KIM,

MIN and KIM, 1996; GARCÍA-VALTUILLE, ABASCAL, CEREZAL et al., 2002).

In order to check the frequency, size and shape of the infrapatellar plica, Kim, Min and Kim (1996) examined arthroscopically 200 knee joints of 184 adult patients. The appearance of the intrapatellar plica of each knee was placed in one of the following categories: Vertical Septum Type, when the plica was in continuity with the anterior surface of the ACL and if the medial and lateral compartments were divided by the septum; Separate Type, if the plica was completely separate from the ACL; Split Type, when the plica was separated completely from the ACL and was also divided longitudinally split; Fenestra Type, if the plica was the vertical septum type with a fenestra; and finally, Absent Type, if there was no fold of synovium parallel to and above the ACL.

Among the four types of synovial plicae the medial patellar plica is the more often symptomatic. It originates from the medial wall of knee joint, runs obliquely downward, and inserts into the synovium covering the infrapatellar fat pad and can be trapped between the femoral medial condyle and the patella; this plica can be connected or separated of the suprapatellar plica, become a poorly defined structure due to its insertion in the medial meniscus (MUNZINGER, RUCKSTUHL, SCHERRER et al., 1981; COHEN, ABDALLA, QUEIROZ et al., 1987; DAI, LIN, HE et al., 1988; TINDEL and NISONSON, 1992; MAFFULLI, TESTA and CAPASSO, 1993; MOREIRA and CARVALHO, 2001; GARCÍA-VALTUILLE, ABASCAL, CEREZAL et al., 2002). Cohen, Abdalla, Queiroz et al. (1987) performed 523 arthroscopies and in 94 of them (18%) was verified the medial patellar plica, from which 74 (14,1%) were symptomatic.

There are several types of pathologic medial plica according to Sakakibara (1976), the separated group of plica was described as Type D, however, Matsusue, Yamamuro, Hama et al. (1994) later subdivided the group Type D into 3 subgroups (subtypes a, b, c) associated with anatomical and clinical aspects. Previously, Lino (1939) classified the medial patellar plica in 4 groups based on their shapes; Type A, thin synovial protrusion under the medial retinaculum; Type B, is a more prominent lesion in the shape of a thin fold, this thin fold, does not cause impingement on the medial femoral condyle; Type C, is a plica covering partially the medial

femoral condyle, and Type D, is a fenestrated variety of this or is a bundle-like structure in the same localisation.

The lateral patellar plica is the least common plica of the knee. 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 (DUPONT, 1997; KIM and CHOE, 1997). There are other synovial structures on the lateral gutter – the lateral alar fold, superolateral fold, and transverse synovial arcuate fold, that should not be confused with a lateral patellar plica (GARCÍA-VALTUILLE, ABASCAL, CEREZAL et al., 2002).

Dai, Lin, He et al., (1988) studied 101 knee joints of adult cadavers, and verified that the synovial plica varies in localisation, configuration and percentage. In this study was observed that the suprapatellar plica was present in 94% of the knees, being classified into the following subtypes: diaphragmatic in 17% of analyzed cases, unilateral in 19%, bilateral in 58%. However, the infrapatellar plica was present in 100% of the knees with subtypes: adipose in 4%, pointed in 13%, membranous in 82% of the cases. Finally, the medial patellar plica was present in 39% of the cases, with subtypes: flap shape in 24% and band-like in 15%.

The asymptomatic synovial plica, in normal conditions, is thin, pink and flexible, however, in inflammatory process it may hypertrophy, and may lose its primitive characteristics of loose and elastic connective tissue, to become edematous, thickened and symptomatic on chronic articular processes and interpose on movement patellofemoral, determining cartilaginous changes in patella and medial trochlear surface of the femur (AMATUZZI, FAZZI, VARELLA et al., 1987; COHEN, ABDALLA, QUEIROZ et al., 1987; MOREIRA and CARVALHO, 2001).

Anatomically, the pathological plicae are fibrotic, thickened and with irregular borders; histologically the plicae showed fibrosis, hyalinization and calcification; by microscope, multiple foci of granulation and inflammatory cells can be seen (DAI, LIN, HE et al., 1988; TINDEL and NISONSON, 1992; BOYD, EAKIN and MATHESON, 2005).

Farkas, Hargitai, Gáspár et al. (2004) observed histologically the medial patellar plica in two groups of patients, a group with the symptomatic plica (12 right knees and 9 left), and another, with the asymptomatic plica (7 right knees and 4 left). In both groups was observed positivity to neuro-filaments by immunohistochemical method. The peripheral nerves were branched and elongated, and organized perivascularly; longitudinal neuro-elements

were located near from each other and a neuro-extension running parallel. The presence of a greater number of neuro-elements in the soft tissue is indicative of an increased sensation of pain and higher sensitivity (SOIFER, LEVY, SOIFER et al., 1996; WITONSKI and WAGROWSKA-DANIELEWICZ, 1999).

Some authors have reported patellar chondromalacia and cartilage lesions of femoral condyle in association with the plica (JACKSON, MARSHALL and FUJISAWA, 1982; AMATUZZI, FAZZI, VARELLA et al., 1987; EWING, 1993; JOHNSON, EASTWOOD and WITHEROW, 1993; MAFFULLI, TESTA and CAPASSO, 1993). A study of the relationship between the kinematics of the patellar medial plica and the medial femoral condyle revealed that both structures remained in contact during all the movement variation. The medial plica was found altered medially when the knee moved from extension to flexion. This movement pattern of medial to lateral can produce shearing force acting in the cartilage of the medial femoral condyle (LYU, 2007). This can explain the high incidence of presence of chondromalacia associated to pathological medial plica (HARREWYN, AIGNAN, RENOUX et al., 1982; RICHMOND and MCGINTY, 1983; DORCHAK, BARRACK, KNEISL et al., 1991).

According to Dupont (1997) the medial patellar plica influences the quadriceps mechanism, and the patella becomes lateralized, causing these complaints. According to Tindel and Nisonson (1992) this plica occurs more frequently in patients who exhibit lateral subluxation of patella.

The most common symptoms associated to synovial plica include pain in the anterior part of the knee, as well as, edema associated with clicking, infection, blocking or pseudo blocking of the knee (JOHNSON, EASTWOOD and WITHEROW, 1993; TINDEL and NISONSON, 1992). It is thought that the symptoms are due to the impingement of plica by the femoral condyle during the flexion (JACKSON, MARSHALL and FUJISAWA, 1982).

The plica becomes symptomatic by various mechanisms (Table 2).

Some factors like age, left *versus* right knee, gender and race can influence the incidence and distribution of the types of synovial plicae (KIM and CHOE, 1997).

Zidorn (1992) verified 223 knees joints, 210 in adults and 13 in fetus between 15 and 30 weeks of pregnancy. In fetus with 15, 16, 17 and 22 weeks were observed the presence of an intact septum and a suprapatellar bursa; besides that, a

Table 2. Etiology of symptomatic synovial plica of the knee.

Direct trauma/blow to the plica	Broom and Fulkerson (1986); Irha and Vrdoljak (2003)
Blunt trauma	Dupont (1997); Schindler (2004); Dorchak, Barrack, Kneisl et al. (1991)
Twisting injuries	Dupont (1997); Schindler (2004)
Repetitive flexion/extension of the knee (rowing, cycling, running)	Boles and Martin (2001); Ewing (1993)
Increased activity levels	Schindler (2004)
Weakness of the vastus medialis muscle	D'Andrea Greve and Amatuzzi (1999); Hamill and Knutzen (2008)
Intra-articular bleeding/sinovite secondary to a loose body, osteochondritis dissecans, torn meniscus, patellar subluxation or after arthroscopy	Schindler (2004)

perforated septum in fetus knees with 22, 27 and 30 weeks; also were reported a residual plica of suprapatellar septum in a 20-week knee joint, and a complete evolution of this septum in 9 knees joints. In adults, the suprapatellar septum was classified into 4 groups: type 1 (16% of the joints) was characterized by an intact septum that separates the knee joint cavity from the suprapatellar bursa; type 2 (30% of knees), characterized by a perforated septum with one or more openings of different lengths; type 3 (43% of the cases), residual septum with only a small residual plica, and often constitutes suprapatellar plica; and type 4 (11% of the cases), extinct septum, that is also called suprapatellar plica.

Mota Neto and Leite (2003) evaluated by double-contrast computed tomography scans 52 knees of newborn cadavers, 17 (65%) men and 9 (35%) women; 5 (19%) were white, 10 (38%) were brown, 11 (43%) black, found that the incidence of normal synovial plica in black was 50%, in brown 90% and in white the synovial plica was found in 100% of the cases. The most frequent plica was the infrapatellar in 69% of knees evaluated, followed by 44% in suprapatellar and medial patellar in 31% of the cases; whereas the incidence of medial patellar plica was found in 9% of black, 50% in brown and 40% in white; the suprapatellar in black was 41%, in brown 40% and in white 60%.

3.2 *Diagnosis and treatment of pathological synovial plica syndrome*

The physical examination and anamnesis are appropriate resources to confirm the diagnosis of pathological synovial plica, and it is essential to avoid an unnecessary surgical treatment (TINDEL and NISONSON, 1992).

It is important the careful evaluation of the size and texture of the plicae through a visualization and probing, however, in especial if diagnosed by arthroscopic examination of the knee (CRENSHAW, 1996). The three major types of plica can be identified by arthroscopy according to their relationship with the patella (TINDEL and NISONSON, 1992).

At arthroscopy the patients usually receive either general or spinal anesthesia. According to the technique of each surgeon, a very tight band (tourniquet) is placed on the thigh of affected leg. Two or three small incisions are made in the knee. Thus, the usual six degrees of freedom are restricted to only four because translations in the X and Y directions are constrained by the skin and soft tissues around the incisions. The instruments are inserted through the incisions. First the knee is filled with sterile fluid that expands the knee joint. Next, a tube (arthroscope) that has a small light and a camera are inserted in the knee. The camera sends an image of the knee to a TV monitor. Then the joint is washed out with a stream of fluid, and the instruments are removed. The incisions are closed with stitches. Last, a dressing is put on the incisions (McKEON, BONO and RICHMOND, 2009).

Usually, it is not recommended to perform an arthroscopy to obtain the diagnosis to verify if a patient has an isolated irritation of the synovial plica; the most successful treatment for this type of plica irritation is not operating, and arthroscopy can result in the promotion of a greater commitment and healing of this plica (BOLES and MARTIN, 2001). Yet Tindel and Nisonson (1992) reported that three arthroscopic observations helpful in diagnosing of plica syndrome, which are the plica appearance, plica shock

between the patella and the femoral condyle, and the wear of the articular cartilage in areas of shock.

In order to verify the effectiveness of ultrasound in diagnosis of synovial plica, Paczesny and Kruczynski (2009) evaluated 88 patients (91 knees, 3 bilateral cases) with suspect of medial patellar plica. Three ultrasonographic criteria were evaluated, and arthroscopy was the standard reference. By arthroscopy, 68 folds presented pathological, however, by ultrasonographic evaluation, 61 of these plicae under the three ultrasonographic criteria established were noted; by arthroscopy, in 23 knees there was not change in plicae, by ultrasound, 19 of these plicae were correctly diagnosed. The accuracy of diagnosis was of 88%, sensitivity 90% and specificity 83%.

Irha and Vrdoljak (2003) described two diagnostic tests for the syndrome of medial patellar plica. One of them is the *active extension test*; supine position with the knee flexed to 90°, in which a rapid extension of the tibia is performed, imitating a kick. This test is defined as positive in case of pain, due to abrupt concentric traction of quadriceps muscle over the plica. The other, named *flexion test* is performed with patient in supine position, the patient performs tibia extension out of the bed, with a rapid movement of knee in flexion, and stops the movement between 30° and 60° of flexion, and thus, the “blockage of the movement” is performed. This test is considered positive if it results in pain, because the plica is stretched with the eccentric contraction of the quadriceps.

Besides the previously mentioned tests, by palpation of the medial border of the patella when compressed the plica, it is possible to verify its thickening. It is made the request of the contraction of quadriceps muscle with the patella attaches, so the plica will be pinched between the femur and the patella, with the individual reporting pain or not (COHEN, ABDALLA, QUEIROZ et al., 1987; TINDEL and NISONSON, 1992; D’ANDREA GREVE and AMATUZZI, 1999). The palpable and audible popping when the knee is impelled to the active extension between 60° and 45° of flexion is called by some author “sign of the stain”, because in the course of the day or the time, it may disappear by the presence of joint swelling or mechanical synovitis itself secondary to erosions around the borders of femoral condyle and patellar cartilage (AMATUZZI, FAZZI, VARELLA et al., 1987; CRENSHAW, 1996). The edema results in a loss of normal elasticity; therefore the plica becomes fibrous and thick, causing damage to the knee function (GARCÍA-VALTUILLE, ABASCAL, CEREZAL et al., 2002).

The treatment of synovial plica initially must be conservative with changes of daily physical activities, aiming at repetitive flexion reduction and extension movements of the knee, stretching exercises of anterior and posterior quadriceps muscles, exercises for the quadriceps associated with isometric practices, cryotherapy several times a day, microwaves diathermy, ultrasound, phonophoresis, occasional knee immobilization in the extended position for a few days associated with the use of anti-inflammatory, avoiding the maintenance of the knee in a flexed position during long periods; if the patient presents no improvement of the symptoms, the indication of arthroscopic removal of this plica should be evaluated (TINDEL and NISONSON, 1992; MAFFULLI, TESTA and CAPASSO, 1993; CRENSHAW, 1996; D’ANDREA GREVE and AMATUZZI, 1999;

DANDY, 2000; FULKERSON, 2000; MOREIRA and CARVALHO, 2001; GARCÍA-VALTUILLE, ABASCAL, CEREZAL et al., 2002).

Amatuzzi, Fazzi, Varela et al. (1987) treated 101 patients with pathological synovial plica; adopted as therapeutic the decrease of the compressive forces of the anterior knee by increasing of the structural flexibility, therefore, the treatment was basically physiotherapeutic. Obtained results were 41 good, those who had remission of the symptoms; 20 regular, whose symptoms persisted in some isolated kind of activity, and 40 bad, which were referred for surgical treatment for the symptoms persist.

After conservative treatment, which consisted of physiotherapy and abstinence to the sports activities, did not give results for the medial synovial plica, 98 knees of 89 patients were submitted to arthroscopic evaluation, in 86 cases the medial synovial plica was resected arthroscopically (O'DWYER and PEACE, 1988).

Camanho (2010) evaluated 63 patients with pathologic synovial plica of the knee; only 21 of these patients presented the diagnosis confirmed by magnetic resonance. Initially, all the patients underwent conservative treatment for 90 days, which involved muscle strengthening, improvement on the flexibility of muscles adjacent to the knee, as well as modification of sports activities. Among the patients who underwent to the conservative treatment, 55 improved; 6 patients presented recurrence of symptoms, not being disabling in some of them. In 8 patients was necessary the arthroscopic removal of the synovial plica; of these, six returned to their activities in physical pretreatment, and two had persistent symptoms during physical activity.

Two types of surgical treatments were performed in 24 knees of 22 patients diagnosed with the medial patellar plica syndrome; in one group, was performed the arthroscopic excision of synovial plica; at the other, in addition to the previous the retinacular bands were also excised completely. In all knees, a chondral erosion in the medial femoral condyle was present. In ten knees, the chondral erosion was graded as Outerbridge grade 1; in eight, grade 2; in five, grade 3; and in one, grade 4. Only 33% of patients who underwent excision of synovial plica, showed good/excellent results, recurrence in 2 knees and continuation of symptoms in one knee. Already the success rate increased to 100% when the retinacular bundle excision was associated with simple removal of the synovial plica (YILMAZ, GOLPINAR, VURUCU et al., 2005).

Only the section of synovial plica has been contraindicated due to the risks of relapse, the sectioned pathological plica can scar and be return of symptoms (YILMAZ, GOLPINAR, VURUCU et al., 2005); although the treatment, which involves the complete arthroscopic resection of the plica is a very efficient and appropriated method (COHEN, ABDALLA, QUEIROZ et al., 1987; GARCÍA-VALTUILLE, ABASCAL, CEREZAL et al., 2002).

The reported surgery results vary between 65% and 100% as good or excellent (HARREWYN, AIGNAN, RENOUX et al., 1982; RICHMOND and MCGINTY, 1983; KOSHINO and OKAMOTO, 1985; HANSEN and BOE, 1989; DORCHAK, BARRACK, KNEISL et al., 1991; FARKAS, GÁSPÁR and JÓNÁS, 1997). Good or excellent results decrease to 40% when a cartilage injury is present

(HARREWYN, AIGNAN, RENOUX et al., 1982). Some authors believe that the presence of chondral lesion does not alter the surgical outcome (RICHMOND and MCGINTY, 1983; HANSEN and BOE, 1989; FARKAS, GÁSPÁR and JÓNÁS, 1997); however, Harrewyn, Aignan, Renoux et al., (1982) report that the chondral lesion influences in long term results.

4 Conclusions

The plica syndrome has been well described but controversy still exists regarding its diagnosis and treatment. We have reviewed the published literature in detail regarding synovial plicae around the knee to provide a comprehensive and up-to-date review on the subject. The aim is to outline previous significant research into the embryology, anatomy and pathology of synovial plicae as well as providing a review of the current thinking on treatment options available for the different synovial plicae with reference to the evidence available. The treatment of pathological plica should initially be conservative, in case symptoms are not improved, the treatment proposed will be surgical; the technique of choice will be proposed by the doctor, through the use of arthroscopic resection or not.

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