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Imaging appearances of synovial plicae syndrome of the knee

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ABSTRACT

Synovial plicae are synovial folds that may be found as intraarticular structures within the knee joint. They are remnants of incomplete resorption of mesenchymal tissue during fetal development. Synovial plicae, if present, are supposed to be non-pathological and asymptomatic, however if they are exposed to special events like direct trauma or repeated activities, they may be inflamed and become fibrosed and rigid and irritates the synovium of the underlying femoral condyle resulting in secondary mechanical synovitis and chondromalacia leading to what is known as plica syndrome of the knee. Inspite plica syndrome is always suspected on clinical bases and can be clearly visualized by arthroscopic application, still diagnostic imaging by MRI, CT scan and Sonography play important role in the evaluation and diagnosis of this pathological condition. The aim of this article is to provide an overview of the imaging appearances of synovial plicae syndrome of the knee on ultrasound, magnetic resonance imaging (MRI) and computerized tomography scan (CT scan).

Key words: Synovial Plicae Syndrome, Synovial Membranes, Knee Joint Embryology, Ultrasound, Magnetic Resonance Imaging (MRI), Computerized Tomography scan (CT scan).

INTRODUCTION

The term “synovial plicae” is used to indicate embryonic remnants that may be present in the knee joint [1,2,3]. Plica is a Latin word meaning "fold". Synovial plicae are common folds of synovium that may be clinically important [4, 5]. They are common intraarticular structures within the knee that can become symptomatic and cause knee pain [6,7,8]. Although normal adult knee joint is supposed to be formed of a single cavity, there are two theories concerning the embryological development of the knee joint in early embryonic life, one theory proposes that the knee joint is divided by synovial membranes into three compartments, during embryonic development these synovial membranes are supposed to disappear completely and the knee joint becomes single cavity. If these synovial membranes did not resorb completely, there will be some degree of knee joint septation leading to what is known as Synovial Plicae inside the knee joint. The other theory says that the space between the femur and tibia is filled with mesenchymal tissue in early fetal life, during embryological development multiple cavities will develop inside the mesenchymal tissue, these cavities are supposed to coalesce gradually until they completely unite and the knee joint becomes single cavity. It is proposed that incomplete resorption of mesenchymal tissue and failure of cavitation lead to plica formation [6,11]. Synovial plicae are generally non pathological and asymptomatic, however if they are exposed to special events like repeated trauma or activities, they may become inflamed and painful leading to what is known as plica syndrome of the knee. Three plicae are commonly found: the superior, the medial, and the inferior [9]. A fourth, lateral plica is rarely seen and there is controversy regarding its existence [8] They are remaining traces of the embryologic knee development [10,11]. The most commonly encountered plicae of the knee (in descending order) are the infrapatellar plica (ligamentum mucosum), the suprapatellar plica, and the mediopatellar plica [7,12]. The normal plica is thin, pink, and pliable, but sometimes arthroscopists find abnormal plicae, which are thickened, white, and fibrotic [13,14]. Factors leading to these abnormalities are trauma, strenuous exercise, osteochondritis dissecans, meniscal injuries, and other internal derangements of the knee [3,15]. The thickened fibrotic plica becomes tight and rigid, forming a bowstring over the medial femoral condyle and irritates the synovium of the condyle with repeated knee joint movement, resulting in secondary mechanical synovitis, as a consequence this will lead to softening and degeneration of the articular cartilage and the development of chondromalacia.

Plica syndrome is always suspected on clinical bases. Symptomatic plicae may cause considerable dull pain in the anteromedial aspect of the knee; the pain may be intermittent or aggravated by physical activity, and can be associated with locking, giving way, and clicking within the joint [17]. Pain is located in the area medial to the patellar area above the joint line and in the supramedial patellar area [8,11]. Pain is also aggravated by knee joint flexion and subsides by extension. There will be characteristic popping sound when knee joint is extended in combination with internal rotation and medial gliding of the patella associated with crepitus. A special diagnostic test during which the patient holds his knee in extended position while the examiner tries to flex the knee joint and push the patella medially, the test will be positive if the patient starts to feel pain associated with clicking. 'Taut articular band reproduces pain' is a diagnostic test that palpates the medial peripatellar region to allocate the pathological plical band. Inspite all patients with plica syndrome appear normal on x-ray examination, it is mandatory to do x-ray on standing position anteroposterior, lateral and axial views to exclude arthritis, fractures, osteochondritis desiccans or any osteophytic or pathological bony changes. Computed tomography arthrography, though "out of fashion," enables determination of whether or not impingement is occurring, in addition to visualization of the medial plica [11]. The suprapatellar and infrapatellar plicae can be seen on standard arthrography, but the mediopatellar plica is easily missed. [3,15] Contrast arthrography and pneumoarthrography are of little use [18]. CT scan examination of plica syndrome is limited because of its invasiveness and high radiation exposure. With improved technology, the medial plica is more easily identified with noninvasive imaging techniques, specifically magnetic resonance (MR) imaging [7–19]. As a staging tool, magnetic resonance imaging also has good sensitivity (95%) and specificity (72%), depending on how far the plicae extending onto the medial facet [20]. At MR imaging, synovial plicae can be seen as bands of low signal intensity within the high-signal-intensity joint fluid [8]. MR evaluation of plica is done by the application of T2 weighted images (Gradient echo and fat suppressed)and T1 weighted image, when there is no enough articular fluid, gadolinium-based contrast technique can be applied to provide good visualization of the plica. 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 [8]. Sonography of the knee is a well-accepted diagnostic tool in orthopedics and sports medicine [21]. the application of sonography for the diagnosis of medial plica syndrome was described by Derks et al [22] In 1986, and verified its accuracy by using arthroscopy. Dynamic ultrasonography is highly effective at detecting abnormalities of medial plicae in the knee, and have good sensitivity (90%) and specificity (83%) [23]. Dynamic sonography of the knee allows tissue movement during examination and therefore relies not only on different tissue echogenicity but also on tissue adhesion in the dynamic state [24,25].

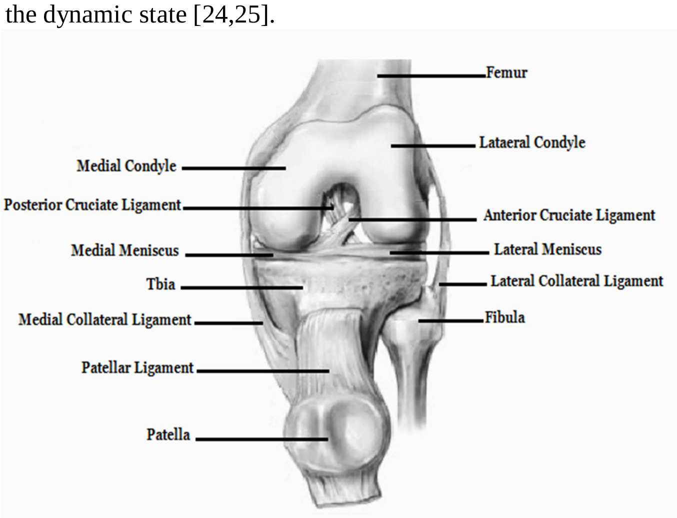

Figure.1: Illustration of anatomical components of Knee joint

Anatomy:
Knee joint is the largest synovial joint in the human body, it is mainly composed of four bones, two menisci, six ligaments, one capsule and one synovial membrane **(Figure.1)**.

The four bones that contribute in the formation of knee joint are the femur, tibia, fibula and patella. The distal lateral and medial femoral condyles articulate with the tibia and the fibular intercondylar fossa articulates with the patella. The proximal tibia articulates with the proximal fibula. Ligaments that contribute in the formation of the knee joint are: medial collateral ligament, lateral collateral ligament, anterior cruciate ligament, posterior cruciate ligament, meniscofemoral ligament and posterolateral ligamentous complex. There are two menisci in each knee joint, medial and lateral menisci, they are fibrocartilaginous structures that improve stability of the knee joint, transmit the load of the knee joint and act as shock absorbers. The capsule of the knee joint is a double layered structure surrounds the knee joint. The outer layer is mainly composed of fibrous tissue that hold the knee joint firmly in place, the inner layer is composed of a synovial membrane that secretes synovial fluid to provide lubrication for the knee joint. There is approximately 0.5 mL of synovial fluid present in a normal knee joint [26].

Synovial plicae of knee joint have 4 types of morphology: Infrapatellar, Mediopatellar, Suprapatellar and Lateral [9]**(*Figure.2*)**.

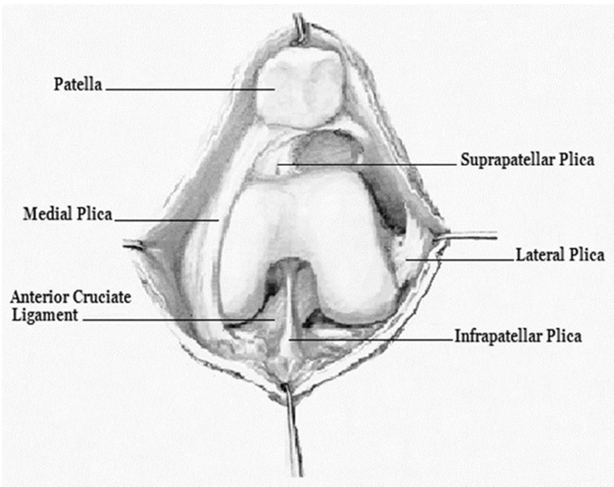

Figure.2: Illustration of a cut on the anterior view of the knee joint with slight flexion to reveal internal structures, displaying superior, medial, inferior and lateral plicae

The suprapatellar plica (plica synovialis suprapatellaris) is the most common plica, it is responsible of dividing the knee joint from the suprapatellar pouch. It has different morphological pictures; it may have the shape of porta or tissue plane originating from either the quadriceps tendon or the femoral metaphysis passing directly to the medial side of the knee joint. In some rare conditions, suprapatellar plica may cause suprapatellar bursitis or chondromalacia. According to its morphologic features Zidorn et al [27] classified suprapatellar plicae into four groups ***(Figure.3)***

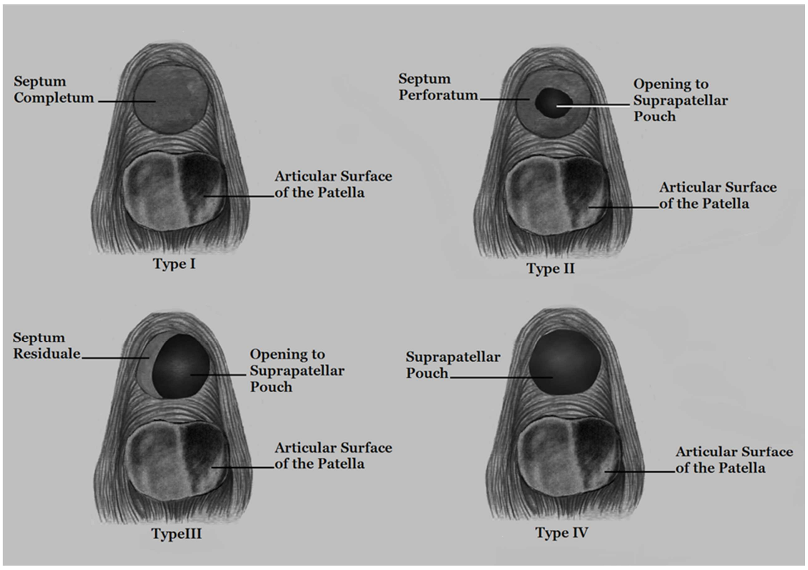

Figure.3: Illustration showing Zidorn classification of suprapatellar septa

Type I: also called septum completum, in this type there is a septum separating the knee joint from the suprapatellar bursa.

Type II: also known as septum perforatum, in this type there are one or more openings of different sizes in the septum that separates the knee joint from the suprapatellar bursa.

Type III: also known as septum residuale, in this type there is a fold, usually located in a medial side separating the knee joint from the suprapatellar bursa.

Type IV: also known as septum extinctum, in this type the septum that separates the knee joint from the suprapatellar bursa is completely involuted.

The infrapatellar plica (ligamentum mucosum) is synovial fold with a bell- shape. It originates from the intercondylar notch passing anteriorly to be attached in the synovium of the infrapatellar fat pad. According to the shape of the infrapatellar plica, it can be classified into 5 shapes: vertical septum, fenestrated, separate, split, or none of the previously mentioned. Infrapatellar plica is the most commonly seen during arthroscopy.

The mediopatellar plica (also known as the Aoki ledge plica, synovialis patellaris, Iino band, plica alaris, synovial shelf, or patellar meniscus. or Iino band), it is the most commonly responsible of the plica syndrome. This plica originates in the suprapatellar region passing inferiorly and obliquely on the medial aspect of the knee joint along the lateral parapatellar synovium to be inserted into the infrapatellar (Hoffa) fat pad.

Sakakibara [28] classified mediopatellar plicae into four types based on its appearance ***(Figure.4)***

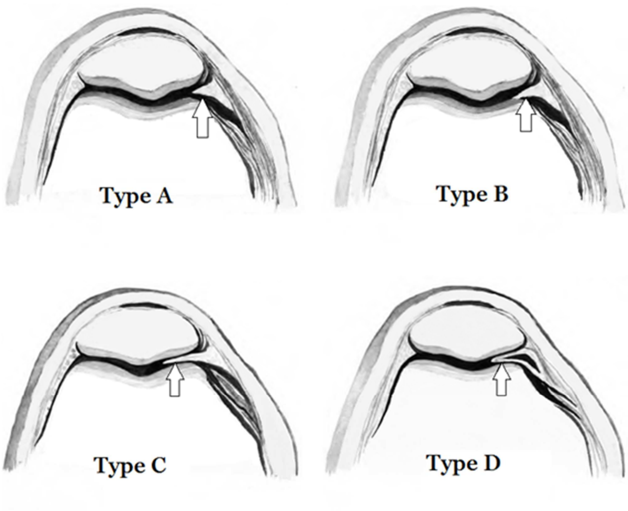

Figure.4: Illustration of the Sakakibara arthroscopic classification scheme for mediopatellar plicae

Type A is cord-like appearance with thin elevation of the synovial wall, under the retinaculum.
Type B is shelf-like appearance, but does not cover the medial femoral condyle.
Type C is large synovium with shelf-like appearance that covers the medial femoral condyle.
Type D is fenestrated and have got a double insertion.

The lateral patellar plica is the least common plica of the knee; indeed, its very existence is controversial [8]. Ogata and Uhthoff [29] have related the rarity of lateral patellar plica to the lateral subluxation of the patella, that leaves no space for the lateral plica to develop.

Embryology:
Two theories have proposed the embryological development of the knee joint and the subsequent formation of plicae. One theory considers plicae as embryological remnants of synovial membranes that divides knee joint into three compartments; the suprapatellar compartment, medial and lateral compartments. During embryological development these synovial membranes begins to resorb until the end of the 16th week of gestation. The suprapatellar septum is supposed to separate the knee joint cavity from the suprapatellar bursa by the end of the 4th fetal month and by the end of 5th month there will be communication between knee joint and suprapatellar bursa. Infrapatellar plica is supposed to be formed between the 8th and 12th gestation. All synovial plicae are supposed to completely disappear transforming the knee joint into a single cavity; but sometimes they do not completely resorb, in this case the remnants of synovial membranes will lead to the formation plicae. The second theory proposes that the space between the distal femur and proximal tibial epiphysis is filled with mesenchymal tissue, at the 7th week of gestation, as embryological development proceeds multiple cavities will develop in this tissue, the cavitation process starts at the patellofemoral, femoromeniscal and meniscotibial regions. During fetal development, these cavities are supposed to coalesce gradually until the end of the tenth week, when they completely unite, in order to transform the knee joint into a single cavity lined by synovial tissue,but in some conditions, coalescence of these cavities fails to progress and part of mesenchymal tissue does not resorb completely, this remnant of mesenchymal tissue will lead to synovial plica formation. An anatomical study has been done by Jouanin et al [12] found that 11% of adult knee joints had persistent synovial plicae, while 10% of adult knee joints had no synovial plica. Jouanin et al [12] found that among 200 cadaveric knees, Infrapatellar plica is the most common type of synovial plicae, followed by suprapatellar plica and medial plica was found to be the third most common. He found that 65.5% of all cadaveric knees have infrapatellar plica followed by 55.5% of cadaveric knees have suprapatellar plica, and 24.5% of cadaveric knees have medial plica, lateral plica is considered rare. On the other hand, a series of 400 arthroscopies done by Kim and Choe[30] has reported that the incidence of medial plica has reached up to 72%.

Pathophysiology of Plica syndrome:
Normally synovial plicae may exist inside the knee joint without any significant pathological symptoms, in this case normal plicae appear as thin, soft, flexible, vascularized structures covered in synovium. Plicae become pathological and symptomatic only in association with inciting events, such as acute trauma, repetitive stress injury or sport

movement, meniscal tears, osteochondritis dissecans or loose bodies. Inflammatory process due to these inciting events will lead to edematous swelling of synovial plica, thickening, scarring, fibrosis and loss of elasticity. Thickened, fibrosed plica will become unpliable and will snap against the femoral condyle. Repeated movement, continuous irritation and abrasion of the underlying articular cartilage will lead to erosive changes, degeneration and softening of the articular cartilage ending in secondary synovitis or chondromalacia. Sometimes the plica may be partially or completely torn due to violent twisting or direct trauma. They can be found in the patellofemoral joint during arthroscopy [31,32]. The medial plica can be responsible for symptoms of pain, snapping, pseudo locking, instability, effusion, and patellar subluxation [33,34,35]. Medial plica syndrome is common in young people of both genders, the main complaint being an intermittent dull aching pain located in the area medial to the patella area above the joint line and in the supramedial patellar area [8,11]. Popping is another common complaint that is associated with relief of pain [36]. Pain is aggravated by physical activity and may be associated with localized tenderness at the inferomedial and border of the patella, locking, giving way, and clicking within the joint.

On palpation a thick cord-like structure may be felt under the examiners finger with crepitus may be felt during flexion and extension of knee joint. Popping that can be felt by the examiner's fingers may occur between 60° and 45° [36,37].

There is an important diagnostic test known as ‘taut articular band reproduces pain’ the thick plical band is felt when the examiner palpates the medial peripatellar region. Another diagnostic test is the mediopatellar plicae test the knee will be flexed by force to 90º while keeping manual force to the inferomedial part of the patellofemoral joint. The test is positive when pain occurs in extension but is relieved at 90º flexion, it had 90% sensitivity and 89% specificity.

MR Imaging Features of Synovial Plica:

Medial plica was first studied in detail by Iino in 1939, but it was not until 1945 that plicae could be seen with an imaging study, the arthrogram [28,31]. The conventional arthrogram does not depict the medial plica as well as computed tomography arthrography, which has a reported sensitivity of 95% for detecting medial plicae [4,38]. When using axial multiplanar gradient recalled acquisition in the steady state (MPGR) and T2-weighted images in combination, the sensitivity for medial plicae was 95%, with 72% specificity [20]. There is a fair amount of recent data describing the appearance of plicae with MR and demonstrating that MR has comparable sensitivity and specificity to computed tomography arthrograms for the visualization of medial plicae [11,19,20,39]. Synovial plicae appear on MR imaging as bands of low signal intensity within the joint fluid which is of high-signal-intensity. For good MR evaluation of synovial plica, T2 weighted images of Gradient-echo and fat-suppression and proton density–weighted images are the most valuable. MR arthrography is done with intraarticular gadolinium-based contrast injection in this technique synovial plicae is evaluated with T1 weighted and fat suppression sequences. Contrast agent will provide excellent visualization of the plicae by distending the joint capsule and highlighting joint surfaces. To visualize the suprapatellar plica on MRI it is better to be done on sagittal view, it appears as low-signal band like structure posterior to the patella **(*Figure.5*)**.

Figure.5: Sagittal T1-weighted fat-suppressed MR image showing suprapatellar plica

Infrapatellar plica appears on sagittal view of MRI as a low-signal-intensity band like structure anterior to ACL (Anterior Cruciate Ligament) and running parallel to it ***(Figure.6)***. Due to its location, infrapatellar may be mistaken for ACL or focal nodular synovitis. The medial plica appears as low-intensity band on both T1- and T2-weighted images found anterior to the medial condyle of the femur. It is immediately posterior to the fatty triangular-shaped alar fold [7,19]. Mediopatellar plica has low signal intensity on T1 and T2 weighted images, it can optimally be visualized through T2 weighted images on axial and sagittal planes, T2 weighted images can be done with or without fat suppression (***Figures.7.8***).

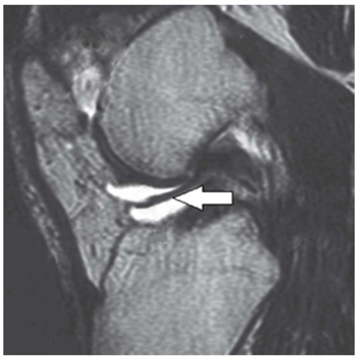

Figure.6: Sagittal T2-spin-echo MR image showing infrapatellar plica

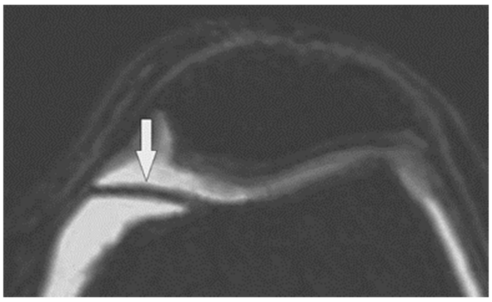

Figure.7: Axial fat-suppressed, T2-weighted MR image of mediopatellar plica

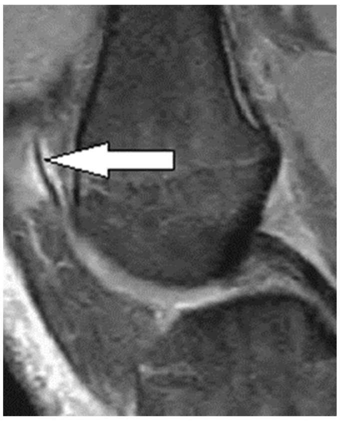

Figure.8: Sagittal fat-suppressed PD weighted MR image of mediopatellar plica

Sonographic Features of Synovial Plica:

Sonography of the knee is a well-accepted diagnostic tool in orthopedics and sports medicine [21]. Derks et al [22] described the use of sonography for the diagnosis of medial plica syndrome in 1986, he used arthroscopy to verify the accuracy of this method. The sensitivity of sonography was 92% and the specificity was 73%. Dynamic sonography of the knee allows tissue movement during examination and therefore relies not only on different tissue echogenicity but also on tissue adhesion in the dynamic state [25,26]. A study done by Łukasz et al [40] in 2009, he found that dynamic sonographic technique provides a high level of sensitivity and specificity in the diagnosis of the nature of medial plica interaction with the patella and medial femoral condyle. Łukasz et al [40] found that by placing the transducer in a transverse position over the anteromedial aspect of the knee joint, the presence of a medial plica can be defined as a continuous, band like echo located directly over the anterior surface of the medial femoral condyle. It should be differentiated from another anatomic structure in this region, namely the alar fold, which is a synovial fold that appears if the medial retinaculum is relaxed [39]. The features noted by Łukasz et al [40] during the dynamic test included the following: Criterion 1: The presence of a continuous echo sliding over the medial femoral condyle during medial and lateral movement of the patella, confirms the presence of a medial plica but does not determine whether it is a pathologic finding. Criterion 2: The entry of echo under the patella during medial movement of the patella, helps depict plica contact with the patellar cartilage, the so-called internal derangement caused by plica [33,40]. Criterion 3: Pain or discomfort during dynamic sonography.

CT scan Features of Synovial Plica:

Computed tomography-arthrography, though "out of fashion," enables determination of whether or not impingement is occurring, in addition to visualization of the medial plica [11]. Invasiveness, and exposure to high dose of radiation lead to avoidance of Computed tomography in diagnosing synovial plica syndrome. The suprapatellar plica is to best to be seen on double-contrast arthrography on the lateral view with the knee in full extension. Visualization of infrapatellar plica is done on the lateral and intercondylar views***(Figure.9)***.

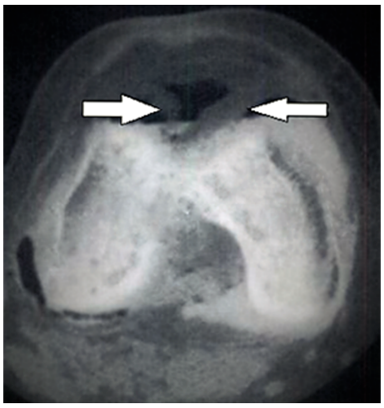

Figure.9: Ct scan intercondylar view showing infrapatellar plica

To visualize the mediopatellar plica the knee is positioned with the medial side facing upward and cross table anterior-posterior view is done, it can also be visualized on axial arthrogram with flexion on 30º and 60º. Inspite of that, there is no criteria to differentiate the pathological fold from the normal one. Frank Boven et al [1] have done a study on synovial plicae of the knee on computed tomography in 1983 he found that CT arthrography is the easiest way to prove the presence of synovial folds at that time.

CONCLUSION

Synovial Plica Syndrome of the knee is a pathological condition that occur due to inflammation of the embryonic remnants that may be present in the knee joint. Although it is always suspected on clinical basesand arthroscopic visualization remains the golden standard for diagnosis, Magnetic resonance imaging has been found very effective in visualization of synovial plicae and its thickness and a good staging tool with 95% sensitivity and 72% specificity, dynamic ultrasonography is very effective in the detection of synovial plicae abnormalities with sensitivity up to 90% and specificity reaches 83%. Computerized Tomography with Contrast arthrography may help in determining whether impingement is occurringor not, it is of little use, because of invasiveness and hazards of radiation. Although all x-rays of plica syndrome appear normal, it is mandatory to do x-ray to exclude arthritis, fractures, osteochondritis desiccans or any other osteophytotic or pathological bony changes.

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