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REVIEW ARTICLE

Synovial recesses of the knee: MR imaging review of anatomical and pathological features

S. Fenn · A. Datir · A. Saifuddin

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Abstract The knee joint is a complex anatomical structure playing host to a wide variety of pathological processes. Knowledge of the anatomy of the synovial recesses and plicae relating to the knee is important, as the appearance of pathology in these unusual locations may, even for commonly encountered conditions, lead to diagnostic uncertainty. This review article discusses the magnetic resonance imaging (MRI) anatomy of the knee joint with an emphasis on the synovial recesses and plicae. The MRI appearance of a variety of synovial and osteochondral diseases that may involve these sites is illustrated.

Keywords Synovium · Plicae · Knee joint · MRI

S. Fenn
Department of Radiology,
The Princess Alexandra Hospital NHS Trust,
Harlow, Essex, UK

A. Datir · A. Saifuddin (✉)
Department of Radiology,
The Royal National Orthopaedic Hospital NHS Trust,
Brockley Hill,
Stanmore, Middlesex HA7 4LP, UK
e-mail: Asif.Saifuddin@rnoh.nhs.uk

A. Saifuddin
The Institute of Orthopaedics and Musculoskeletal Sciences,
University College London,
London, UK

A. Saifuddin
The Alliance Medical Imaging Centre,
Bulstrode Place,
London, UK

Introduction

The knee joint is a complex anatomical structure that plays host to a wide variety of pathological processes. Many of these conditions can either primarily or secondarily affect the various synovial compartments of the joint, the latter being exquisitely demonstrated on magnetic resonance imaging (MRI) particularly in the presence of a joint effusion. It is important, therefore, for radiologists who routinely report knee MRI studies to be aware of the normal anatomy of the various synovial recesses around the knee.

The aim of this pictorial review was to discuss the anatomy of the knee joint synovial recesses with emphasis on MR imaging and to illustrate a variety of pathological processes involving them.

Synovial anatomy of the knee joint

Although historically defined as a hinge joint, in reality, the knee joint is a complicated interaction of three separate articulations, one between each femoral condyle and the corresponding tibial condyle and intervening meniscus and one between the femur and patella. The structure of a synovial joint differs fundamentally from that of a cartilaginous or fibrous joint. The articular capsule surrounding a synovial joint consists of a thick outer layer, the fibrous capsule and a more delicate inner layer, the synovial membrane. This highly vascular synovial membrane lines the non-articular portions of the synovial joint as well as any intra-articular ligaments and tendons. Composed of thin connective tissue, it is responsible for the secretion of the viscid synovial fluid, which lubricates and nourishes the joint. The synovial cells also have a role in the removal of intra-articular particulate matter, for example traumatic

Fig. 1 Central synovial recess. **a** Axial fat-suppressed PDW FSE image showing fluid between the patella and femoral shaft and extending medially and laterally (*arrows*) deep to the patellar retinacula. **b** Sagittal T2*W GE image showing fluid (*arrow*) in the deep part of the central recess, anterior to the ACL (*black arrowhead*)

cartilaginous debris, which is then deposited in deeper lying cells within the membrane.

The synovial lining

The synovial lining of the knee joint consists of several interconnected compartments.

1. *Central portion*—Anteriorly, the synovial membrane is attached to the patellar articular margins before extending circumferentially beneath the aponeuroses of the vastus medialis and lateralis to attach to the anterior femoral shaft (Fig. 1a). Below the patella, a large quantity of fat (the infrapatellar pad of Hoffa) displaces the membrane posteriorly, away from the ligamentum patellae (Fig. 1b). Within Hoffa's fat pad, a superior, vertically orientated supra-hoffatic (Fig. 2a) and an inferior, horizontal infra-hoffatic (Fig. 2b) recess may be demonstrated [1]. These are commonly linear or sometimes globular in shape and can be present without coexisting joint effusion.

On either side of the patella, reduplications of the membrane extend inferiorly and project into the joint cavity as *alar folds* or *plicae* [2]. These combine with the central infrapatellar fold to form the *ligamentum mucosum*, which attaches to the intercondylar fossa of the femur, anterior to the anterior cruciate ligament (ACL) insertion (Fig. 2c) and lateral to the posterior cruciate ligament (PCL) insertion. A horizontal cleft is present in the posterior aspect of infrapatellar fat pad and is seen in approximately 90% of individuals on MR imaging [3]. This cleft is lined with synovial tissue and can be variably shaped, a linear shape being the most common. It is located anterior to the distal insertion of the anterior cruciate ligament on the tibia with the ligament mucosum forming the roof of the cleft.

Fig. 2 Anterior knee recesses. **a** Sagittal T2*W GE image showing fluid in the suprapatellar pouch (*arrows*) and supra-hoffatic recess (*arrowhead*). **b** Sagittal T2*W GE image showing fluid in the infra-hoffatic recess (*arrow*). **c** Sagittal PDW FSE image showing the ligamentum mucosum (*arrows*) running through the intercondylar notch anterior to the ACL (*arrowheads*)

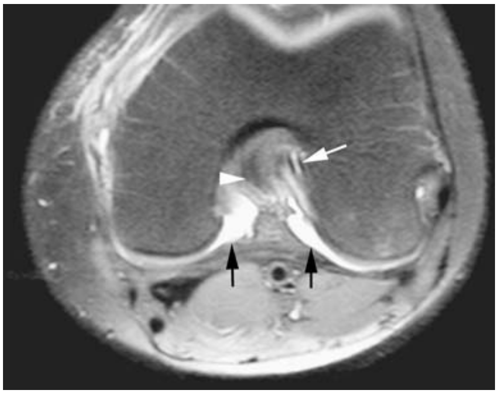

Fig. 3 Pericruciate recesses. Axial fat suppressed PDW FSE image showing fluid (*black arrows*) on either side of the ACL (*white arrow*) and PCL (*white arrowhead*)

The central portion then extends medially and laterally, covering the anterior aspects of the cruciate ligaments (Fig. 1b) before being reflected from the sides of the PCL onto the adjoining fibrous capsule. As such, this portion divides the knee cavity into medial and lateral components with an interposed extra-synovial space containing the cruciate ligaments [4] (Fig. 3).

Along the medial and lateral aspects of the capsule, the synovial lining extends inferiorly from the articular margins of the femur as far as the meniscal attachments. The peripheral surfaces of the menisci themselves are not covered by the synovial membrane (Fig. 4).

2. *Suprapatellar pouch*—Extending superiorly from the upper surface of the patella, a large pouch is formed between the quadriceps tendon anteriorly and the anterior surface of the femur posteriorly (Fig. 2a). The articularis genu muscle arises from the anterior surface of the lower part of the body of femur and inserts into the synovial membrane at the level of the junction of the suprapatellar pouch and proper joint cavity. It functions to pull the suprapatellar pouch during knee extension, thereby stabilising the suprapatellar pouch and allowing the patella to glide freely without friction over the femur [5].

3. *Posterior femoral recesses*—As the membrane extends posteriorly from both sides of the femur, recesses are formed between the posterior portion of both femoral condyles and the deep surface of the lateral and medial heads of gastrocnemius (Fig. 5). In the midline, the posterior capsular recess may be identified behind the PCL as an extension from the medial femorotibial compartment [6] (Fig. 6).

4. *Sub-popliteus recess*—A small pouch is seen between the lateral meniscus posteriorly and the popliteus tendon (Fig. 7a,b). In 10% of adults, the lining is continuous with the synovial membrane of the proximal tibiofibular joint (Fig. 7c).

5. *Other recesses*—A recess is frequently observed during arthrography superior to the posterior third of the medial meniscus (Fig. 8a). Inferior recesses are also seen beneath the lateral meniscus, both anteriorly (Fig. 7a) and posteriorly (Fig. 8b). Again posteriorly, a lateral synovial extension may be seen that has been implicated in iliotibial band syndrome [7] (Fig. 8c,d).

The synovial plicae

A plica is defined as a thin, vascularised fold of synovial tissue found in the joint lining and represents embryologic remnants of the synovial membrane. In the knee, the most commonly seen plicae are the infrapatellar plica, the suprapatellar plica and the mediopatellar plica. On MR imaging, synovial plicae are seen as low-signal intensity (SI) bands within the high SI joint fluid [2].

1. *Suprapatellar plica* is located at the margin between the suprapatellar bursa and the joint cavity (Fig. 9a). It runs obliquely downward from the synovium at the anterior aspect of the femoral metaphysis to the posterior aspect of the quadriceps tendon and inserts above the patella.
2. *Infrapatellar plica* (also known as ligamentum mucosum) is the most common plica in the knee. It has a fan-shaped arrangement with a narrow femoral origin in the anterior part of the intercondylar notch and then runs horizontally through the infrapatellar fat pad, attaching distally to the inferior pole of the patella (Fig. 9b).
3. *Mediopatellar plica* (also known as plica alaris or patellar meniscus) is by far the most commonly studied plica because of its clinical implications [8]. It arises from the medial wall of the knee joint and runs obliquely downwards, inserting into the synovium covering the infrapatellar fat pad. Sakakibara [9] classified mediopatellar plicae into four types on the basis of size. These include: type A, a cord-like

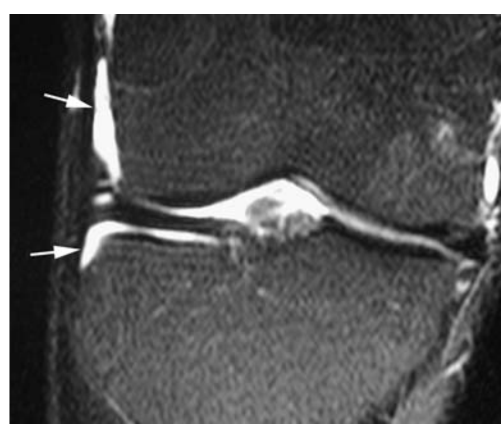

Fig. 4 Perimeniscal recesses. Coronal fat suppressed T2W FSE image showing fluid (*arrows*) above and below the lateral meniscal margin

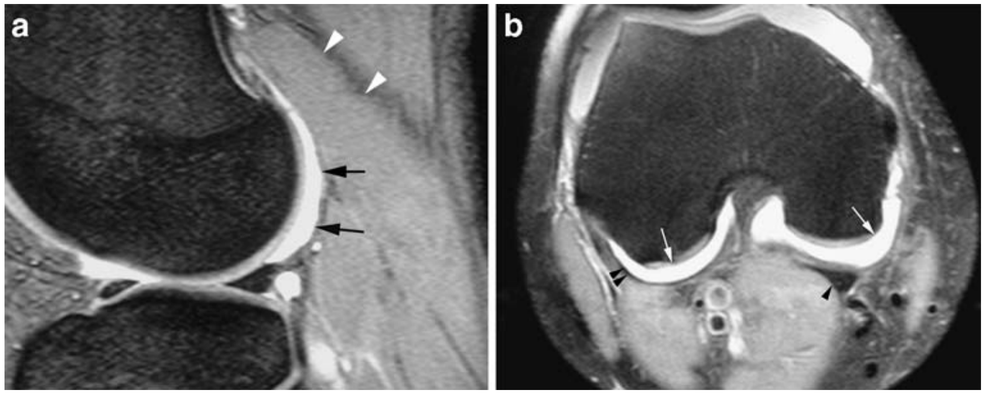

Fig. 5 Posterior recesses. **a** Sagittal T2*W GE image showing fluid (*black arrows*) in the recess deep to the lateral head of gastrocnemius (*white arrowheads*). **b** Axial fat suppressed PDW FSE image showing fluid in the sub-gastrocnemius recesses (*white arrows*), deep to the medial (*black arrowhead*) and lateral (*double black arrowheads*) gastrocnemius tendons

elevation in the synovial wall; type B, a shelf-like appearance that does not cover the anterior surface of the medial femoral condyle (Fig. 9c); type C, large with a shelf-like appearance covering the anterior surface of the medial femoral condyle (Fig. 9d) and type D, a plica with central fenestration. Types C and D have a tendency to impinge between the medial femoral condyle and the patella, thereby becoming symptomatic and sometimes even causing internal derangement of the knee joint. Types A and B are usually asymptomatic.

4. *Lateral patellar plica* is the least common plica of the knee, originating in the lateral wall above the popliteus hiatus and inserting onto the infrapatellar fat pad.

Synovial abnormalities of the knee joint

Joint effusion

The exact amount of fluid that may be present in a normal knee joint is not clear, although this fluid volume is never sufficient to distend the joint or to separate the synovial surfaces. MR examinations of the knee are very sensitive to the presence of small amounts of fluid (as little as 1 ml) [10]. Most commonly, effusions are located in the central portion of the knee joint (99%) (Fig. 1a) and suprapatellar pouch (76%; Fig. 2a) and occasionally around the cruciate ligaments (18–36%) [11] (Fig. 1b). This distribution of joint fluid is influenced by the size of effusion, the position of the knee during MR examination and the presence of synovial plicae. An antero-posterior measurement of 10 mm or less in the lateral aspect of the suprapatellar pouch is considered to be a reasonable threshold value for distinguishing a physiologic from a pathologic amount of joint fluid [12].

On MRI, effusion is of low SI on T1-weighted (T1W) and high SI on T2-weighted (T2W) images (Figs. 1, 4, 7). This appearance may be complicated in the presence of a haemarthrosis or synovial proliferative disorders. In acute traumatic knee disorders, the presence of a large knee effusion should prompt a careful evaluation of osteochondral fracture. Although, the absence of a large effusion in acute knee injuries is considered to be strong evidence against such a fracture, extra-capsular or capsulo-ligamentous injuries are still possible [12].

Fig. 6 Posterior recesses. Sagittal T2*W GE image showing fluid (*white arrow*) in the posterior capsular recess. Perforations in the capsule allow extra-articular extension of fluid collections (*arrowhead*) into the popliteal fossa

Haemarthrosis

Although commonly seen in the posttraumatic knee, haemarthrosis may result from a variety of articular abnormalities, including synovial haemangioma, pigmented villonodular synovitis (PVNS), bleeding disorders including haemophilia and various crystal deposition disorders.

In posttraumatic haemarthrosis of the knee, MRI is helpful in demonstrating ligamentous injuries as well as changes over a period of time. In acute cases (usually less than 12 h after injury), it may be difficult to differentiate between a haemorrhagic and non-haemorrhagic joint effusion, as both may have similar signal characteristics. A layering phenomenon may be seen with acute haemarthrosis, separating the serum (above) from the sediment (below; Fig. 10a). In sub-acute and chronic haemarthrosis,

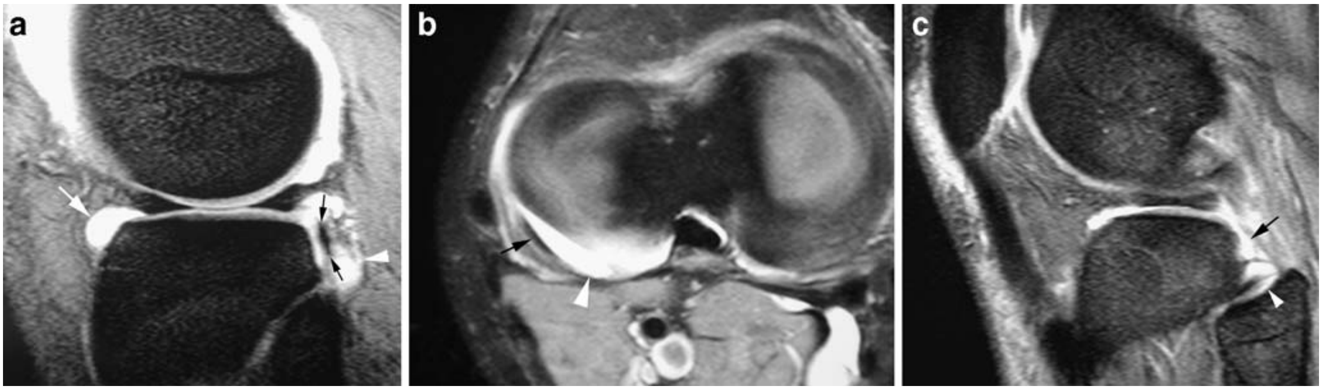

Fig. 7 Lateral recesses. **a** Sagittal T2*W GE image showing fluid (*white arrow*) in a recess antero-inferior to the lateral meniscus. Fluid is also present in the sub-popliteus recess (*white arrowhead*) surrounding the popliteus tendon (*black arrows*). **b** Axial fat suppressed PDW FSE image showing fluid in the sub-popliteus recess (*white arrowhead*) and the popliteus tendon (*black arrow*). **c** Sagittal T2*W GE image showing communication of fluid in the postero-lateral corner (*black arrow*) with the proximal tibio-fibular joint (*white arrowhead*)

effusions usually demonstrate high SI on both T1W and T2W images (Fig. 10b). With chronic haemosiderin deposition, the synovium shows low SI on T1W, T2W (Fig. 10c) and particularly gradient echo (GRE) images.

The presence of fat within an effusion (lipo-haemarthrosis) has diagnostic implications and is considered to be a strong indicator of intra-articular fracture, which may involve the tibial plateau, proximal fibula, patella or femoral condyles.

Fig. 8 Miscellaneous recesses. Sagittal fat suppressed PDW FSE image showing fluid (*arrow*) in a recess superior to the posterior third of the medial meniscus. **b** Sagittal T2*W GE image showing fluid (*black arrow*) in a recess inferior to the posterior third of the lateral meniscus. Coronal (**c**) and axial (**d**) fat suppressed PDW FSE image showing fluid (*arrow*) in a recess deep to the ilio-tibial band (*arrowheads*)

Fig. 9 Synovial plicae. **a** Sagittal T2*W GE image showing the supra-patellar plica (*black arrow*). **b** Sagittal PDW FSE image showing the infrapatellar plica (*arrows*) within Hoffa's fat pad. **c** Axial T2*W GE image showing a type B medio-patellar plica (*black arrow*). **d** Axial fat suppressed PDW FSE image showing a type C medio-patellar plica (*black arrow*)

Rarely, intra-articular fat may be present without any bony fracture and probably results from injury to other fat-containing structures including synovium, ligaments or even fat pads [13]. On MR imaging with the knee in a supine position, intra-articular fat appears as a floating band in the non-dependent layer with high SI on T1W and intermediate SI on T2W. The amount of fat in the synovial fluid is directly proportional to the severity of injury [14].

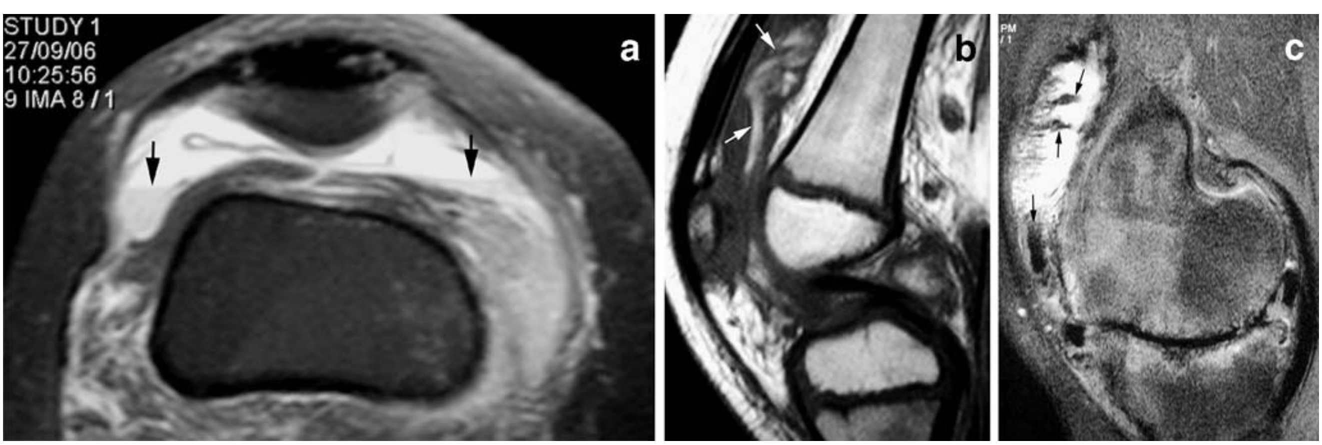

Fig. 10 Haemarthrosis. **a** Axial fat suppressed PDW FSE image showing fluid-fluid levels (*arrows*) in an acute haemarthrosis. **b** Sagittal T1W SE image showing a suprapatellar effusion with areas of hyperintensity (*arrows*) due to sub-acute haemorrhage. **c** Sagittal T2W FSE image showing hypointense synovial thickening (*black arrows*) in a patient with haemophilic arthropathy

Fig. 11 Synovial chondromatosis. Sagittal PDW FSE image showing extensive involvement of the posterior capsular recess by primary SOC, with trans-capsular extension into the popliteal fossa (*arrows*)

Synovial tumours and tumour-like lesions

Primary synovial chondromatosis

Primary synovial chondromatosis most frequently occurs in the knee joint, affecting men two to four times more commonly than women and presenting in the third to fifth decades of life. It is a disorder characterised by proliferative and metaplastic changes in the synovium. Synovial chondromatosis evolves in three distinct phases: an initial metaplastic phase with cartilaginous mass formation in the synovium; a transitional phase during which cartilaginous synovial nodules are detached forming free bodies in the joint; an inactive phase in which loose bodies remain dormant in the knee joint [15]. These cartilaginous nodules may become either calcified or ossified when the term synovial *osteochondromatosis* is employed.

As one would expect, the MRI findings in synovial (osteo) chondromatosis are largely dictated by the relative preponderance of synovial proliferation, loose body formation and the extent of calcification/ossification. Most commonly, MRI shows lobulated synovial masses with or without intra-articular loose bodies. When unmineralised, these masses show high SI on T2W images, whereas foci of signal void indicate mineralisation (Fig. 11). On GRE images, the signal voids become more conspicuous. Sometimes, these nodules may migrate into surrounding bursae depending on their continuity with the synovial space.

Pigmented villonodular synovitis

PVNS represents a benign, mono-articular synovial proliferative disorder, affecting young to middle-aged adults with the knee being the commonest location. It is characterised by hyperplasia of the synovial lining with sub-synovial infiltration by multinucleated giant cells, haemosiderin-laden macrophages, foam cells and fibroblasts. It may present in two forms—diffuse and localised, the latter also termed *nodular synovitis*. Nodular synovitis is typically not associated with effusion and most commonly affects the infrapatellar fat pad and pericruciate regions [16].

MR imaging reveals mass-like synovial proliferations with lobular margins. In the diffuse form, the entire synovium may be involved, whereas the nodular form usually shows a well-defined solitary nodule in the area of predilection (Fig. 12a). The SI is intermediate on T1W images but relatively low on T2W sequences, particularly gradient echo images, owing to the tendency of haemosiderin deposition from repeated haemorrhage (Fig. 12b). On intravenous gadolinium administration, PVNS typically demonstrates intense enhancement due to a rich vascular supply. Synovial sarcoma must be considered in the

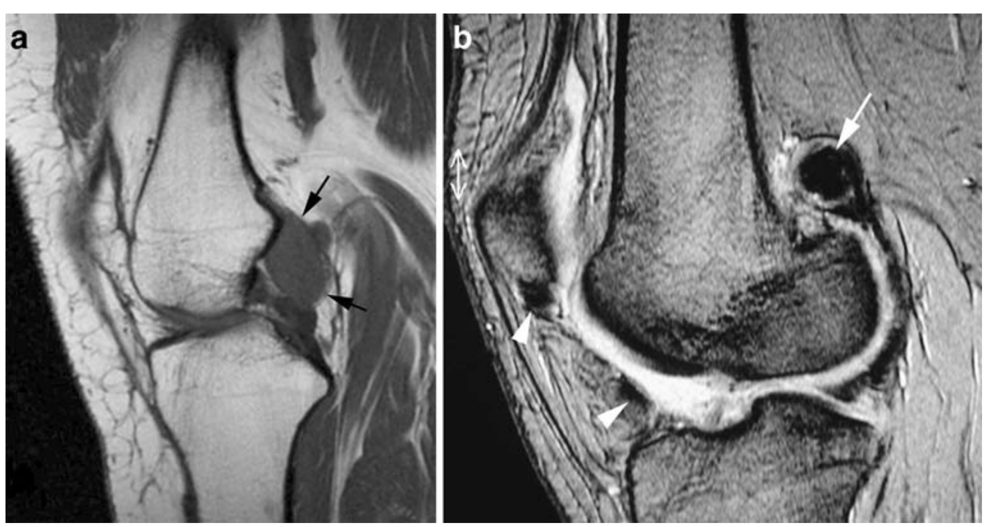

Fig. 12 PVNS. **a** Sagittal T1W SE image showing a well-defined, oval lesion (*arrows*) of nodular PVNS posterior to the PCL. **b** Sagittal T2*W GE image showing diffuse PVNS resulting in multifocal synovial hypointensity due to the paramagnetic effect of haemosiderin involving the gastrocnemius recess (*arrow*) and inferior central joint recess (*arrowheads*)

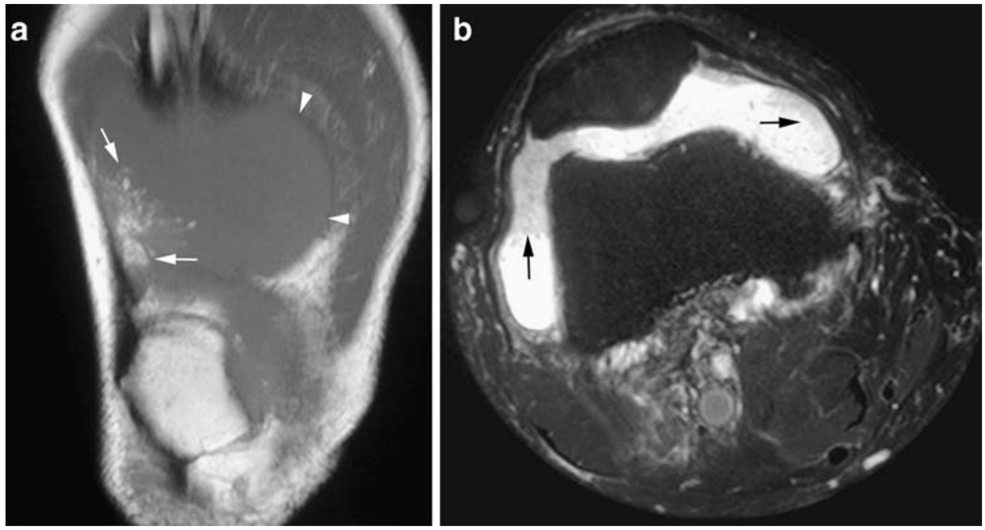

Fig. 13 Lipoma arborescens. Coronal T1W SE (**a**) and axial fat (**b**) suppressed T2W FSE images showing frond-like fatty synovial thickening (*arrows*) and associated joint effusion (arrowhead, **a**)

differential diagnosis of PVNS, as both entities may exhibit lobulated synovial masses, normal bone mineralisation and a normal-appearing joint. The features favouring a diagnosis of synovial sarcoma include the presence of tumour outside the joint capsule, scattered and irregular calcifications within the mass and associated bone destruction [17].

Diffuse and focal synovial lipomatous disorders

The synovial membrane of the knee may be involved rarely in fatty-proliferative disorders. Lipoma arborescens, which represents diffuse synovial involvement, should be differentiated from focal involvement by synovial lipoma. The former is characterised by diffuse sub-synovial deposition of fat and a villous appearance, associated joint effusion, synovial cysts and bone erosion, whereas the latter is a solitary localised mass of adipose tissue with a round or oval contour without synovial changes [18]. However, lipoma arborescens is a misnomer, as this condition represents 'villous lipomatous proliferation of the synovial membrane' rather than a true neoplasm, as suggested by Halel et al. [19]. It most commonly occurs secondary to osteoarthritis.

MRI findings are usually diagnostic and demonstrate a villous-like synovial mass with signal intensity similar to that of fat on all pulse sequences (high on T1W, intermediate on T2W and hypointense on fat-suppressed images) with associated joint effusion (Fig. 13). The absence of haemosiderin deposition is an important finding and helps to differentiate these lesions from PVNS. Lipoma arborescens predominantly affects the suprapatellar pouch, whereas synovial lipomas are most commonly found in the infrapatellar fat pad.

Synovial haemangioma

Synovial haemangioma is an uncommon benign lesion affecting children and young adults and is most commonly located in suprapatellar region of the knee joint. It may be pedunculated or diffuse and is classified on the basis of size and nature of the vascular wall as capillary, cavernous, mixed and venous [20]. MRI shows the extent of the lesion with variable signal characteristics. On T1W images, the lesions have a low or intermediate signal but show a high signal on T2W images corresponding with stagnant blood in vascular spaces. Small areas of signal void may be found due either to intravascular thrombosis or phleboliths.

Other tumours of the synovium are extremely rare and include chondroma and chondrosarcoma.

Cystic lesions of the synovium

Synovial cyst

Synovial cysts around the knee most commonly occurs in the popliteal region owing to a communication between the joint and normal posterior bursae. The most commonly involved bursa is the gastrocnemius–semimembranosus bursa located posterior to the medial femoral condyle and is termed a *popliteal* or *Baker's cyst*. This communication occurs through a transverse slit acting as a ball-valve mechanism. Occasionally, other bursae on the posterior aspect of the knee joint may be involved including the sub-popliteal bursa or a bursa between the lateral head of gastrocnemius and biceps femoris. Synovial cyst formation could be secondary to any degenerative, inflammatory, traumatic or neoplastic condition resulting in a chronic joint effusion.

MRI not only helps in the identification and localisation of the synovial cyst but also demonstrates cyst communication with the joint space, complications such as cyst rupture and associated internal derangement of the knee. On MRI, uncomplicated cysts typically show low SI on T1W and high SI on T2W images (Fig. 14). The possible complications of synovial cysts of the knee include rupture,

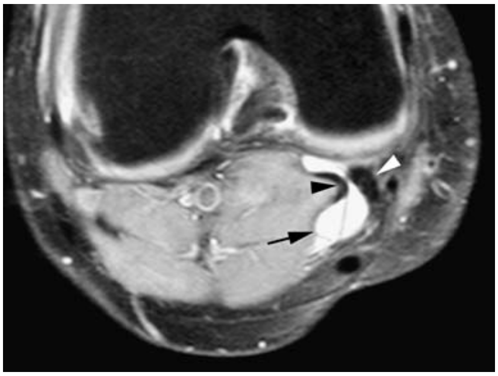

Fig. 14 Popliteal cyst. Axial fat suppressed PDW FSE image showing fluid (*black arrow*) in the bursa between the medial head of gastrocnemius (*black arrowhead*) and semimembranosus (*white arrowhead*) tendons

direct compression of the popliteal artery with resultant ischaemia, compression of adjacent nerves leading to entrapment syndromes, infection and haemorrhage [21].

Ganglion cyst

A ganglion cyst contains clear viscous fluid within a dense fibrous connective tissue wall without a synovial lining. Although various theories exists regarding the pathogenesis of ganglion cysts around the knee, most authors believe that they result from myxoid degeneration of connective tissue because they are usually located in areas of continuous physical stress such as joints, ligaments, periosteum and bone. Ganglion cysts in the knee are classified as intra-articular, extra-articular, soft tissue and intraosseous.

Intra-articular ganglion cysts of the knee are most commonly seen in association with the cruciate ligaments (Fig. 15a,b) and rarely with the infrapatellar fat pad (Hoffa's ganglion; Fig. 15c) [22]. On the other hand, extra-articular soft tissue ganglion cysts are typically located near the joint or at a variable distance from the joint capsule. On MRI, a ganglion cyst shows SI characteristic corresponding to fluid on all pulse sequences (Fig. 15). Various associated findings have been described on MR imaging of extra-articular soft tissue ganglion cyst, including the presence of a communicating channel with the joint cavity, pericystic oedema, periosteal reaction and nerve involvement [23]. A communication between various ganglion cysts of the knee and the joint cavity could be revealed on arthrography by performing delayed radiography after contrast medium injection [24].

Meniscal cyst

Meniscal cysts are thought to result from meniscal degeneration and trauma, leading to a tear of the meniscus into which synovial fluid can accumulate secondary to the 'pumping' effect of knee motion. MRI may show a lobular cystic mass communicating with a horizontal cleavage tear [21]. The vast majority of such cysts occur in a juxta-articular location. However, a tear of the posterior third of the medial meniscus may result in a cyst forming which extends within the joint posterior to the PCL. Although similar in MRI appearance to a PCL ganglion cyst, the presence of the meniscal tear communicating with the cyst confirms the diagnosis of a pericruciate meniscal cyst (Fig. 16) [25].

Arthridities and metabolic disease

Gout

Chronic tophaceous gout affects the knee joint diffusely, with urate crystal deposition in the capsule, the synovial membrane, the articular cartilage and the periarticular soft tissue. The synovium becomes inflamed and can enlarge across the degenerating cartilaginous surface. Cartilaginous sloughing as well as the tophaceous deposits themselves can cause filling defects within the joint capsule and prepatellar bursa. MRI clearly demonstrates the cartilaginous and synovial disease (Fig. 17), whilst the non-calcified gouty tophi are seen to

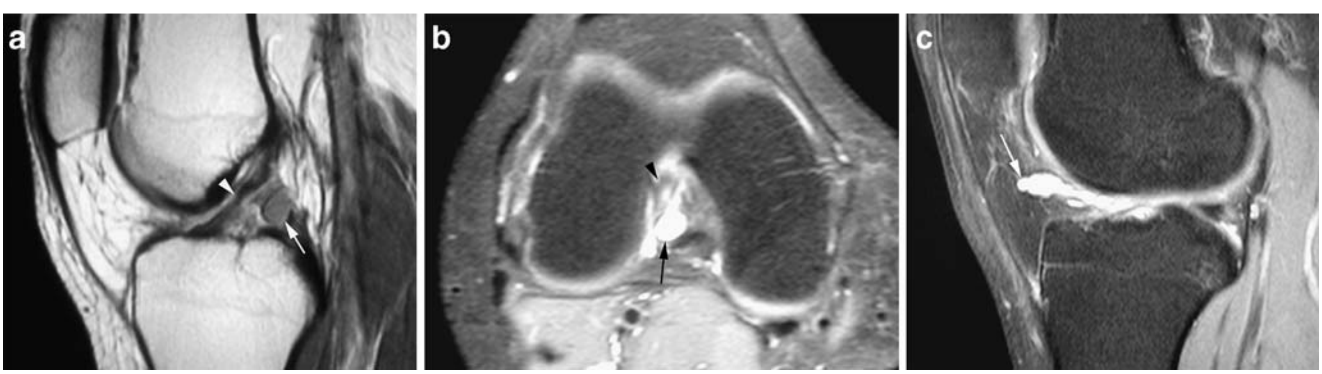

Fig. 15 Intra-articular ganglion cyst. **a** Sagittal PDW FSE and **b** axial fat-suppressed PDW FSE images showing a ganglion cyst (*arrows*) related to the ACL (*arrowhead*). **c** Sagittal PDW FSE FS image showing a Hoffa's ganglion (*arrow*)

Fig. 16 Pericruciate meniscal cyst. **a** Sagittal T2*W GE image showing a horizontal cleavage tear (*arrow*) of the posterior third of the medial meniscus. **b** Sagittal T2*W GE image showing extension of the cyst (*arrow*) posterior to the PCL (*arrowhead*). **c** Axial fat-suppressed PDW FSE image showing the cyst (*arrow*), the PCL (*white arrowhead*) and a communication (*black arrowhead*) from the cyst extending towards the medial meniscus

have low SI on both T1W and T2W images [26]. Variable enhancement of the inflamed synovium is seen following intravenous gadolinium administration.

CPPD and calcium hydroxyapatite crystal deposition diseases

In both conditions, crystal deposition can involve the synovium and capsule, although with calcium pyrophosphate dihydrate (CPPD), there is commonly preceding involvement of the articular cartilage with associated chondrocalcinosis. Cloud-like calcification of the synovial membrane may simulate idiopathic synovial osteochondromatosis on plain radiography. On MRI, synovial inflammation and calcification can be identified, along with intra-articular crystal debris.

Haemosiderosis

Haemosiderin granule deposition within synovium is commonly seen in haemophilia and haemochromatosis on gross pathological examination, but can only rarely be identified on MRI. The MR imaging characteristics of haemosiderin deposition are of low SI on all spin echo sequences (Fig. 10c) with accentuation on all gradient echo sequences. Various other disorders which can lead to haemosiderin deposition include PVNS, synovial haemangioma, neuropathic osteoarthropathy and chronic renal disease. A scoring system exists for the extent of joint involvement based on the amount of haemosiderin and other findings [27].

Amyloidosis

Amyloid deposition is seen to involve the synovial lining less commonly than articular cartilage, producing focal nodules or bulky masses. MRI allows assessment of the extent of the disease process, with the deposits having signal intensities between those of cartilage and muscle on all sequences [28].

Prosthetic wear

Following joint replacement, the wear from a metal hinge may result in the deposition of debris onto the synovial lining, causing an inflammatory synovitis. Metal debris, if present in large enough quantities, may be visualised either as diffuse opacity of the joint fluid or as a curvilinear line

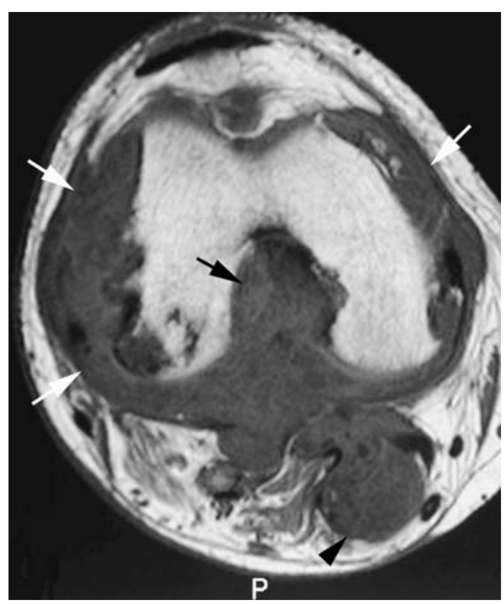

Fig. 17 Gout. Axial T1W SE image showing diffuse intermediate SI synovitis with associated bone erosion affecting the medial and lateral capsular regions (*white arrows*), the intercondylar notch (*black arrow*) and the gastrocnemius–semimembranosus bursa (*black arrowhead*)

outlining the synovium ("metal line" sign) on plain radiography [29]. At MR imaging, the thickened synovium shows low SI on all sequences [15].

Synovial rice bodies

Rice bodies are small white collections of collagen fibre, fibrin and amorphous material [30] which have an appearance resembling polished white rice. In addition, they may also contain foci of calcium apatite and calcium pyrophosphate dihydrate. Although commonly the result of rheumatological conditions (especially rheumatoid arthritis) [31], they have also been reported in osteoarthritis and tuberculosis [32]. On MRI, rice bodies are seen as multiple, small similarly sized filling defects within the synovial fluid that are isointense to muscle on T1W and slightly hypointense on T2W images.

Loose bodies

Any process, acute or chronic, causing articular disintegration can give rise to free or synovium-embedded loose bodies. This includes a wide variety of disorders such as osteochondral fracture, osteoarthritis, rheumatoid arthritis, gout, osteochondritis dissecans and osteonecrosis. Loose bodies derive their nutrition from synovial fluid and classically appear layered without recognisable trabeculae.

Although intra-articular loose bodies may be seen anywhere in the knee joint, focused examination of the suprapatellar pouch, popliteus tunnel (Fig. 18a), recesses beneath the menisci and the intercondylar notch (Fig. 18b,c), as well as any communicating cysts or bursae should prevent even the smallest loose bodies from being overlooked. Care must be made to search for multiple bodies (present in 30%) as well as the small bodies, which, especially if there is no accompanying joint effusion, may prove difficult to identify on MRI.

Meniscal fragments

Migration of a meniscal fragment into the intercondylar notch, a distant bursa or synovial recess is occasionally seen following traumatic or degenerative meniscal injury. The free body has the same MR signal characteristics as in situ meniscal tissue and thus may be difficult to identify if there is no significant accompanying joint effusion.

Plica syndrome

Plica syndrome is defined as a painful impairment of knee function, with the only finding that explains the symptoms being the presence of a thickened fibrotic plica [2]. It can be seen secondary to an injury such as a direct blow, repeated activity involving flexion–extension motion or a twisting force stretching the plica. The resultant oedema causes loss of normal elasticity and, subsequently, the plica becomes fibrotic and thickened. Repeated activity causes friction of the plica over the femoral condyle in extension and over the patella in flexion, resulting in bone erosion at these sites. Plica syndrome most commonly involves the medial plica. On MRI, the plica appears irregular and thickened and is often associated with a joint effusion.

Conclusions

As illustrated, the anatomy of the synovial spaces of the knee is complex. A thorough knowledge of these recesses will help the radiologist in identifying less common sites of synovial pathology. MRI is the best suited modality for synovial recess and bursal assessment, exquisitely demonstrating lesion extent, its complications and associated internal derangement of the knee. In many cases, the MR imaging signal characteristics are typical of a particular synovial abnormality and often allow a confident diagnosis.

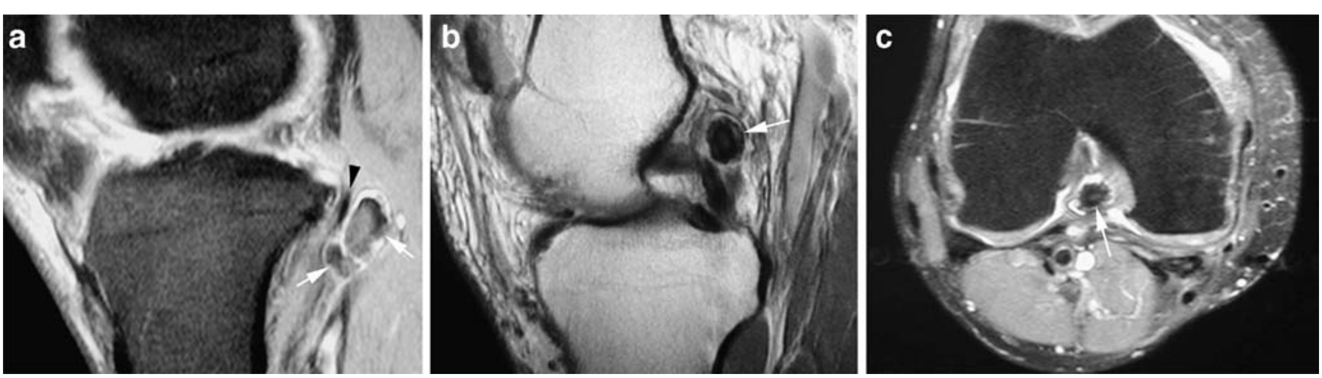

Fig. 18 Osteocartilaginous loose bodies. **a** Sagittal fat-suppressed PDW FSE image showing a loose body (*arrows*) posterior to the popliteus tendon (*black arrowhead*) in the popliteus recess. **b** Sagittal PDW FSE. **c** Axial fat suppressed PDW FSE images showing an osteocartilaginous loose body (*arrows*) in the posterior capsular recess

References

1. Aydingoz U, Oguz B, Aydingoz O, et al. Recesses along the posterior margin of the infrapatellar (Hoffa's) fat pad: prevalence and morphology on routine MR imaging of the knee. Eur Radiol 2005;15: 988–994.
2. Garcia-Valtuille R, Abascal F, Cerezal L, et al. Anatomy and MR imaging appearances of synovial plicae of the knee. Radiographics 2002;22: 775–784.
3. Patel SJ, Kaplan PA, Dussault RG, Kahler DM. Anatomy and clinical significance of the horizontal cleft in the infrapatellar fat pad of the knee: MR imaging. AJR Am J Roentgenol 1998;170: 1551–555.
4. Lee SH, Petersilge CA, Trudell DJ, Haghighi P, Resnick DL. Extrasynovial spaces of the cruciate ligaments: anatomy, MR imaging, and diagnostic implications. AJR Am J Roentgenol 1996;166: 1433–1437.
5. Kimura K, Takahashi Y. M. articularis genus. Observations on arrangement and consideration of function. Surg Radiol Anat 1987;9: 231–239.
6. De Maeseneer M, Van Roy P, Shahabpour M, Gosselin R, De Ridder F, Osteaux M. Normal anatomy and pathology of the posterior capsular area of the knee: findings in cadaveric specimens and in patients. AJR Am J Roentgenol 2004;182: 955–962.
7. Nemeth WC, Sanders BL. The lateral synovial recess of the knee: anatomy and role in chronic iliotibial band friction syndrome. Arthroscopy 1996;12: 574–580.
8. Boles CA, Butler J, Lee JA, Reedy ML, Martin DF. Magnetic resonance characteristics of medial plica of the knee: correlation with arthroscopic resection. J Comput Assist Tomogr 2004;28: 397–401.
9. Sakakibara J. Arthroscopic study on Iino's band (plica synovialis mediopatellaris). J Jpn Orthop Assoc 1974;50: 513–522.
10. Schweitzer ME, Falk A, Berthoty D, Mitchell M, Resnick D. Knee effusion: normal distribution of fluid. AJR Am J Roentgenol 1992;159: 361–363.
11. Kaneko K, De Mouy EH, Robinson AE. Distribution of joint effusions in patients with traumatic knee joint disorders: MRI assessment. Clin Imaging 1993;17(3): 176–178.
12. Kolman BH, Daffner RH, Sciulli RL, Soehnlen MW. Correlation of joint fluid and internal derangement on knee MRI. Skelet Radiol 2004;33: 91–95.
13. Graham J, Goldman JA. Fat droplets and synovial fluid leukocytes in traumatic arthritis. Arthritis Rheum 1978;21: 76.
14. Gregg JR, Nixon JE, DiStefano V. Neutral fat globules in traumatized knees. Clin Orthop 1978;132: 219.
15. Narvaez JA, Narvaez J, Ortega R, De Lama E, Roca Y, Vidal N. Hypointense synovial lesions on T2-weighted images: differential diagnosis with pathologic correlation. AJR Am J Roentgenol 2003;181: 761–769.
16. Williams AM, Myers PT. Localized pigmented villonodular synovitis: a rare cause of locking of the knee. Arthroscopy 1997;13: 515–516.
17. Dorwart RH, Genant HK, Johnston WH, Morris JM. Pigmented villonodular synovitis of synovial joints: clinical, pathologic, and radiologic features. AJR Am J Roentgenol 1984; 143: 877–885.
18. Dawson JS, Dowling F, Preston BJ, Newmann L. Case report: lipoma arborescens of the sub-deltoid bursa. Br J Radiol 1995;68: 197–199.
19. Hallel T, Lew L, Bansal M. Villous lipomatous proliferation of the synovial membrane (lipoma arborescens). J Bone Jt Surg Am 1988;70: 264–270.
20. Stout AP. Hemangio-endothelioma: a tumor of blood vessels. Ann Surg 1943;118: 445.
21. McCarthy CL, McNally EG. The MRI appearances of cystic lesions around the knee. Skelet Radiol 2004;33: 187–209.
22. Kim MG, Kim BH, Choi JA, et al. Intra-articular ganglion cysts of the knee: clinical and MR imaging features. Eur Radiol 2001;11: 834–840.
23. Kim JY, Jung SA, Sung MS, Park YH, Kang YK. Extra-articular soft tissue ganglion cyst around the knee: focus on associated findings. Eur Radiol 2004;14: 106–111.
24. Malghem J, Vande berg BC, Lebon C, Lecouvet FE, Maldague BE. Ganglion cysts of the knee: articular communication revealed by delayed radiography and CT after arthrography. AJR Am J Roentgenol 1998;170: 1579–1583.
25. Lektrakul N, Skaf A, Yeh L, Roger B, Schweitzer M, Blasbalg R, Resnick D. Pericruciate meniscal cysts arising from tears of the posterior horn of the medial meniscus: MR imaging features that simulate posterior cruciate ganglion cysts. AJR Am J Roentgenol 1999;172: 1575–1579.
26. Chen CKH, Yeh LR, Pan HB, et al. Intra-articular gouty tophi of the knee: CT and MR imaging in 12 patients. Skeletal Radiol 1999;28: 75.
27. Soler R, Lopez-Fernandez F, Rodriguez E, et al. Hemophilic arthropathy: a scoring system for magnetic resonance imaging. Eur Radiol 2002;12: 836.
28. Cobby MJ, Adler RS, Swartz R, Martel W. Dialysis-related amyloid arthropathy: MR findings in four patients. AJR Am J Roentgenol 1991;157: 1023–1027.
29. Weissman BN, Scott RD, Brick GW, Corson JM. Radiographic detection of metal-induced synovitis as a complication of arthroplasty of the knee. J Bone Jt Surg Am 1991;73: 1002–1007.
30. Wynne-Roberts CR, Cassidy JT. Juvenile rheumatoid arthritis with rice bodies: light and electron microscopic studies. Ann Rheum Dis 1979;38: 8–13.
31. Popert AJ, Scott DL, Wainwright AC, Walton KW, Williamson N, Chapman JH. Frequency of occurrence, mode of development, and significance or rice bodies in rheumatoid joints. Ann Rheum Dis 1982;41: 109–117.
32. Bucki B, Lansaman J, Janson X, et al. Osteoarthritis with rice bodies rich in calcium microcrystals. 4 cases with ultrastructural study. Rev Rhum Ed Fr 1994;61: 415–420.