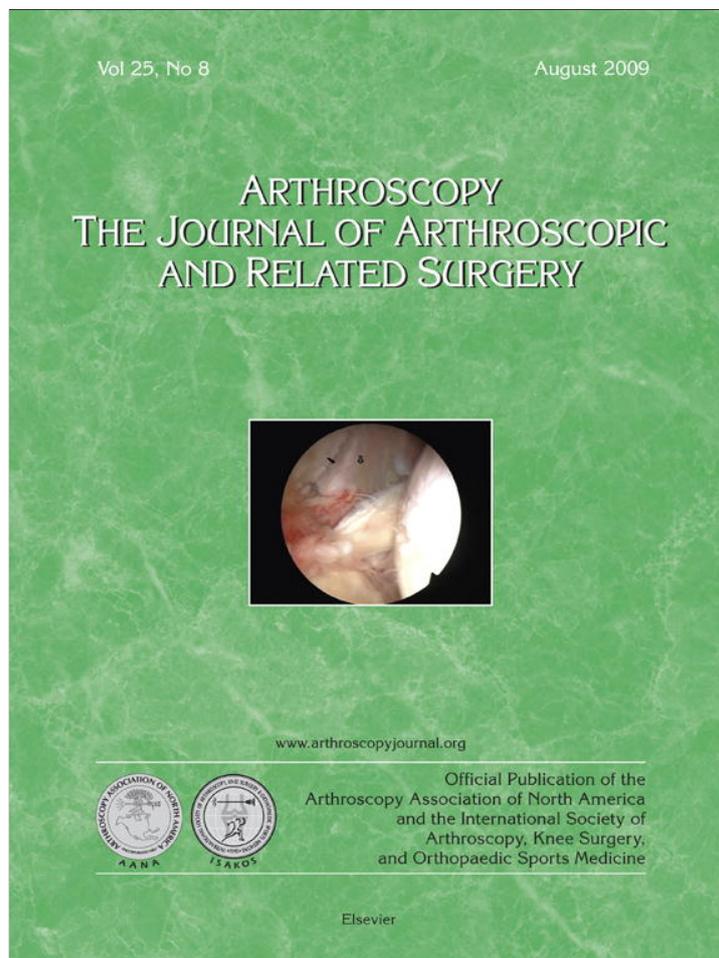


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## The Macroscopic Arthroscopic Anatomy of the Infrapatellar Fat Pad

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**Purpose:** Our purpose was to define the macroscopic anatomy of the infrapatellar fat pad (IFP) when viewed at arthroscopy and to document the common variations. **Methods:** Ninety-six consecutive patients between 8 and 50 years of age with no previous knee surgery or fat pad pathology underwent arthroscopic examination of the knee. The fat pad of each patient was observed and described regarding size, color, consistency, and the presence of lobules, villous synovium, and lingulae. **Results:** The macroscopic arthroscopic anatomy of the IFP was defined. Male fat pads were larger than female fat pads. Two separate parts were described—medial and lateral—with medial dominance being most typical. The specific normal anatomic appearance of each section was defined regarding size, color, consistency, and attributes. Ligamentum mucosum, as the separation limit between the sections, was found in most knees. **Conclusions:** The macroscopic anatomy of the IFP is described at arthroscopy performed for internal pathology of the knee. Two distinct parts were defined—medial and lateral—with medial dominance. A typical fat pad was yellow and included an infrapatellar lingula (85%), lobulation (65%), and villous synovium (65%). We found a ligamentum mucosum in 79% of cases. **Clinical Relevance:** Knowledge of the macroscopic anatomy of the IFP and variations will allow the accurate diagnosis of pathology of the fat pad, rather than being a diagnosis of exclusion. **Key Words:** Arthroscopic anatomy—Infrapatellar fat pad—Ligamentum mucosum—Lingual—Synovium.

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The infrapatellar fat pad (IFP) is a body of adipose tissue that occupies the space formed by the patella and patellar tendon, tibial plateaus, and the femoral condyles.<sup>1-3</sup> It may extend beyond the margins of the patellar tendon<sup>1</sup> and may be viewed as having both medial and lateral prominences.<sup>4,5</sup> The size, shape,

and volume of the fat pad are highly variable,<sup>2-4</sup> which is not widely appreciated.

Hoffa first described pathology of the IFP in 1904.<sup>1</sup> Since then, the existence of pathology in the fat pad as a cause of anterior knee pain has not been well accepted. A paucity of literature<sup>5</sup> on the subject has created a low level of knowledge of all aspects of the IFP, including anatomy. Anatomic studies to date have been based on cadaver dissections of a small number of knees<sup>1,2,4,6</sup> or on magnetic resonance imaging scans.<sup>7-10</sup> Consequently, the diagnosis of fat pad pathology is often made as a diagnosis of exclusion rather than a definition of a distinct pathologic process.<sup>11</sup>

There have been a number of published reports regarding primary pathology of the fat pad; however, these are mostly case reports<sup>12-20</sup> and have been non-specific regarding the normal anatomy of the fat pad. In order to obtain a complete understanding of pathology of the IFP, we must first develop an understanding of the normal fat pad anatomy. In the present study,

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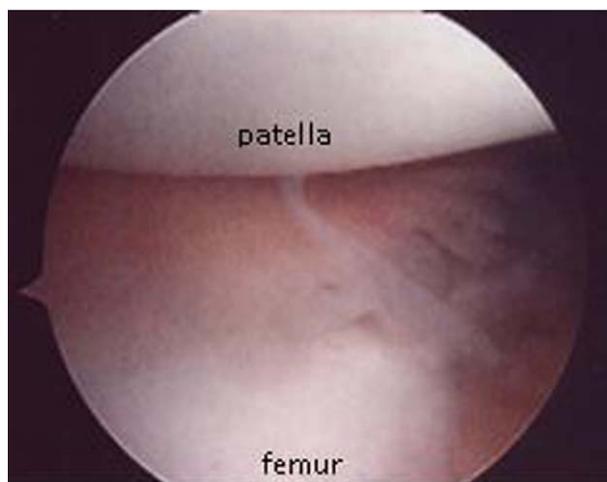
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**FIGURE 1.** Possible impingement within the patellofemoral joint. The knee is inflated with arthroscopic fluid.

we aim to document the macroscopic anatomy of the IFP and common anatomic variants during arthroscopy of the knee performed for unrelated pathology. Although this is not necessarily the “normal” anatomy of the IFP—because we are viewing it in an essentially abnormal environment—it is perhaps more clinically relevant; the fat pad will most commonly be assessed in the presence of unrelated internal derangement. We hypothesize that the usual anatomy of the IFP will be highly variable, and that attributes described in the literature as “pathologic” may in fact be common findings.

## METHODS

Over the 6-month period from October 2002 to March 2003, 96 consecutive patients underwent arthroscopy of the knee, during which careful observation and description of the appearance of the IFP was recorded. Of them, 67 were male and 29 female with an average age of 33.9 years. Forty-six right knees and 50 left knees were examined. All arthroscopies were performed by the same surgeon (H.M.). The inclusion criteria were patients undergoing arthroscopy of the knee for unrelated pathology who were 18 to 50 years of age, had undergone no previous ipsilateral knee surgery, those who had agreed to the study and provided informed consent, and those in whom appropriate vision of the IFP was achieved at arthroscopy. Although we agree that there is no standard definition of the appearance of a pathologic fat pad, patients treated for fat pad pathology at arthroscopy were

excluded from this study. Fat pad pathology was diagnosed when the constitution was harder than usual and not easily compressible with the arthroscopic probe.

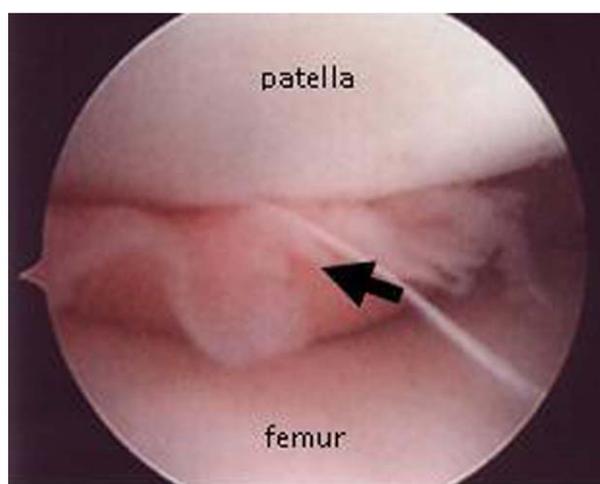
Fat pad observation was done through inferolateral and inferomedial portals consistent with standard clinical practise using a Dyonics (Smith & Nephew Dyonics, Andover, MA) arthroscope and standard arthroscopic procedure (including white balancing).

Impingement of the fat pad within the patellofemoral joint was suspected when the fat pad or a lingua appeared to extend superiorly towards and into the patellofemoral joint. When this was the case, a superolateral arthroscopic portal was used to best view the patellofemoral joint as the knee was extended. Impingement was identified if part of the fat pad was entrapped or “impinged” within the patellofemoral joint on extension. This was assessed with the knee both inflated with fluid (Fig 1) and at normal fluid levels (Fig 2).

The relevant data were recorded for both the medial and lateral aspects of the fat pad, the border between the two being defined as the ligamentum mucosum or, when absent, the center of the fat pad. The ligamentum mucosum itself was classified as complete if sharing a synovial envelopment with the anterior cruciate ligament or incomplete where separate (Fig 3).

During arthroscopy, fat pads were observed, documented, and classified according to size, color, and consistency. The presence of lobules, villous synovium, and/or lingula was recorded in each case.

The size of the fat pad was classified as large, medium, or small. A large fat pad was defined as



**FIGURE 2.** Impingement of the medial lingual (black arrow) within the patellofemoral joint.



FIGURE 3. The ligamentum mucosum (black arrow) with no attachment to the anterior cruciate ligament synovium (incomplete).

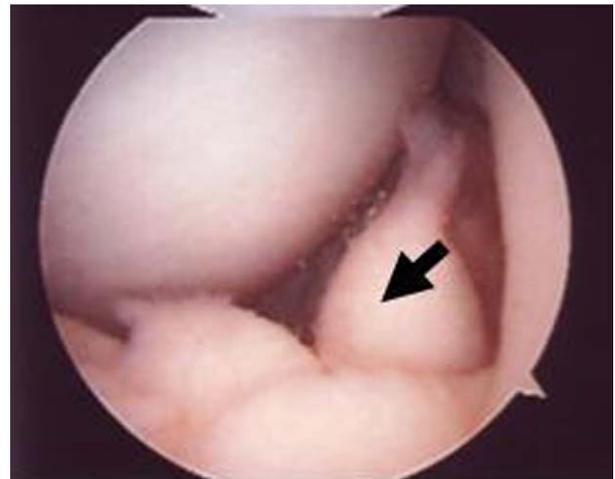


FIGURE 5. Lateral lobulation (black arrow).

extending beyond the margins of the patellar tendon and occupying much of the anterior joint space. A medium fat pad extended to, or beyond, the margins of the patellar tendon but with limited projection into the joint. Small fat pads extended to the border of the patellar tendon and did not project into the joint. Figure 4 shows a small fat pad viewed through a superolateral portal. Dominance refers to whether the medial or lateral component of the fat pad was larger. Fat pad color was recorded as yellow, reddish, or white. Constitution of the fat pad was determined by palpation with an arthroscopic probe to determine



FIGURE 4. A typical small fat pad (black arrow) with no lobulation.

firmness, with a normal fat pad being soft and quite movable. A fat pad of abnormal constitution was hard and resisted movement when pressure was applied by the probe (these subjects were excluded from the study).

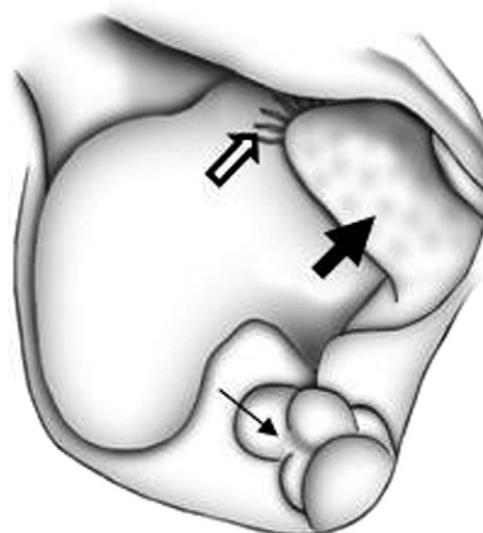
Lobulation was identified as grape-like nodules extending from, but continuous with, the fat pad (Fig 5). Villous synovium was defined as finger-like projections originating from the synovium of the fat pad (Fig 6). An infrapatellar lingula was identified if a segment of the fat pad immediately inferior to the patella projected into the joint (Fig 6). This was previously identified and named by Tsirbas et al.<sup>21</sup>



FIGURE 6. Large villous synovium (black arrow) along the free edge of a medial lingual (open arrow).

**TABLE 1.** Results and Description of Fat Pad and Intra-articular Knee Pathology (N = 96)

	Total (n)	Percentage
Gender		
Male	67	69.79
Female	29	30.21
Side		
Right	46	47.92
Left	50	52.08
Presenting pathology		
Anterior cruciate ligament tear	19	19.79
Posterior cruciate ligament tear	0	—
Medial meniscus	26	27.08
Lateral meniscus	9	9.38
Medial femoral condyle lesion	17	17.71
Lateral femoral condyle lesion	9	9.38
Medial tibial plateau lesion	17	17.71
Lateral tibial plateau lesion	4	4.17
Patellofemoral chondromalacia	29	30.21
Synovitis	26	27.08
Loose body	4	4.17
Plicae	4	4.17
Medial synovial plica		
Present		
Small	29	49.15
Medium	16	27.12
Large	14	23.73
Pathologic	3	5.08
Medial fat pad		
Size		
Small	18	18.75
Medium	40	41.67
Large	38	39.58
Impingement	3	3.13
Lobulation	62	64.58
Infrapatellar lingua	82	85.42
Villous synovium	62	64.58
Color		
Yellow	82	85.42
Pink	14	14.58
Lateral fat pad		
Size		
Small	35	36.46
Medium	44	45.83
Large	17	17.71
Impingement	0	—
Lobulation	83	86.46
Infrapatellar lingua	14	14.58
Villous synovium	47	48.96
Color		
Yellow	84	87.50
Pink	12	12.50
Ligamentum mucosum		
Present	76	79.17
Complete	7	7.29
Dominance	67	69.79
Medial fat pad		
Lateral fat pad	19	19.79
Equal	10	10.42



**FIGURE 7.** An impression of a typical fat pad (lateral view) showing a medial lingual (black arrow) with villous synovium (open arrow) and lateral lobulation (small arrow). The ligamentum mucosum has been omitted for ease of viewing.

Intra-articular knee pathology, the purpose of the arthroscopy, was recorded. Pathologies included: ligamentous lesions, meniscal tears, chondral lesions, loose bodies, synovitis, plicae, and patellofemoral maltracking. Patellar tracking was assessed with the knee deflated and was considered normal when the patella engaged the central trochlea groove of the femur at or before 10° of knee flexion. Mild maltracking was identified if the patella engaged between 10° and 30° of flexion, was considered moderate if it was engaged between 30° and 40°, and was considered severe if it was engaged at more than 40° of flexion.

The data obtained were analyzed using the  $\chi$ -square or Fisher exact tests where appropriate. Alpha value was determined as  $\alpha = 0.05$ .

### RESULTS

Our results include the observation and documentation of 96 fat pads in 214 patients. One hundred and eighteen patients were excluded. The results are summarized in Table 1. Analysis of the results allows the description of a usual IFP (Fig 7) as seen at arthroscopy, composed of two separated sections: medial and lateral. The medial section is usually yellow (85.4%) in color and medium (41.6%) or large (39.6%) in size; an infrapatellar lingua is present in 85.4% and some degree of lobulation is found in 64.6%. Villous synovium was found in 64.6%, often along the free edge of

the lingula. As with the medial side, the lateral fat pad is usually yellow (87.5%); however, its size is medium (45.8%) or small (36.5%) with a small degree of lobulation (86.5%), often close to the ligamentum mucosum. Villous synovium was present in 49.0% and infrapatellar lingula was present in 14.6%. The medial aspect of the fat pad is mostly dominant (69.8%). The border separating the sections, the ligamentum mucosum, is present in 79.2% of knees and is usually separated from the anterior cruciate ligament synovium (92.7%).

Statistical analysis was performed; however, assessment is difficult because of the small numbers involved in some subgroups and the subjective nature of the data. In addition, the statistical analysis does not contribute to our hypothesis more than the descriptive analysis already presented. Perhaps most interesting is that there was no statistical difference in the fat pads between patients of different age groups or fat pad dominance, and the only significant difference regarding gender is that male medial fat pads were significantly larger than female medial fat pads ( $P = .006$ ).

## DISCUSSION

Few published data in the English literature describe the normal anatomy of the IFP, most of which mention the anatomy while investigating fat pad pathology. Under-representation in the medical literature has created a low level of knowledge of both normal and pathologic fat pad appearance; in most cases, the diagnosis of fat pad pathology is still made as an exclusion, rather than as a defined pathologic process. To our knowledge, no previous study has investigated IFP either with direct visualization by arthroscopy or in an extensive number of patients.

The IFP is a body of adipose tissue that occupies the space formed by the patella and patellar tendon, tibial plateaus, and the femoral condyles.<sup>1-3</sup> Our results have confirmed previous authors' assertions that the fat pad may be viewed as having both medial and lateral components,<sup>4</sup> that the fat pad may extend beyond the margins of the patellar ligament,<sup>1</sup> and that the size, shape, and volume of the fat pad vary considerably.<sup>2,4</sup>

In addition, we have both expanded on the previous data regarding the normal anatomy of the IFP and identified possible inaccuracies with the current description of a pathologic fat pad. Some authors stated that villous synovium,<sup>1,22,23</sup> fat pad hypertrophy,<sup>1,22-24</sup> and synovitis<sup>1,23</sup> are pathologic features. Our results show, however, that these are common findings viewed at arthroscopy for unrelated pathology and

may be normal variants. In their report, Tsirbas et al.<sup>21</sup> suggest that a large infrapatellar lingula may become impinged within the patellofemoral joint. If present (in the setting of patellofemoral pain), they suggest that a lingula should be surgically excised. However, in our series, an infrapatellar lingula was quite common (86% medial; 15% lateral) and presumably normal. We also noticed that, with knee flexion, the lingula usually retracted inferiorly away from the patellofemoral joint, decreasing the possibility of impingement.

The most common portal for arthroscopic examination of the knee, the anterolateral portal, usually penetrates the fat pad. It is generally agreed that arthroscopy of the knee may cause fat pad damage,<sup>2,10,25</sup> although the clinical significance of this is uncertain.<sup>26</sup> For minimizing this complication, another arthroscopic method is suggested: the initial incision is made and the arthroscope is inserted to the capsule in the usual manner. The arthroscope is then advanced to the patellofemoral compartment with the knee in extension, placing the arthroscope superior to the fat pad. Consequently, trauma to the fat pad is reduced and the arthroscope is positioned above the fat pad for easier visualization of the knee joint. Minimization of fat pad trauma should also be considered when creating subsequent portals, especially inferomedial portals. We emphasize using a needle to guide portal placement, thereby avoiding damage to the fat pad.

We have also observed that the arthroscope (and other instruments) occasionally causes swelling of the fat pad during an arthroscopic examination. We suggest that examination of the fat pad be performed at the commencement of the procedure, thereby avoiding visualizing an iatrogenic edematous fat pad.

If fat pad involvement is suspected from the clinical and initial arthroscopic examinations, a superolateral portal should be used. In our experience, visualization of the fat pad is best achieved through this portal, and features of the fat pad and its relationship with the patellofemoral joint may be assessed. [Figure 8](#) shows a typical fat pad viewed through a superolateral portal.

If impingement of the fat pad within the patellofemoral joint is suspected, this should be reassessed at normal fluid levels after draining the knee. The knee should be flexed while arthroscopically visualizing the patellofemoral joint; flexion may retract the IFP, avoiding impingement into the patellofemoral joint ([Figs 1 and 2](#)).

A number of limitations are associated with our study. First, although a large number of fat pads were observed, some of the subgroups created during anal-



**FIGURE 8.** View of the fat pad from the suprapatellar portal. Note the medial lingual (black arrow) with villous synovium (open arrow).

ysis contained low numbers. This significantly affected any statistical analysis attempted; however, it did not impact the overall descriptive analysis. Second, because of the nature of an invasive procedure, no “normal” controls were examined, which has obvious implications for any assumption of a “normal” fat pad. While it would be ideal to know the precise macroscopic appearance of the normal fat pad, ethical considerations prevent us from operating on significant numbers of nonsymptomatic knees. It must be acknowledged, however, that the great majority of fat pads will be observed at arthroscopy for unrelated pathology, as in this study. Therefore, it is also valuable—and perhaps more valuable—to know the appearance of the IFP in this common setting.

Perhaps the greatest assumption of this study is the exclusion of patients diagnosed with and treated for primary fat pad pathology. Although we fully acknowledge that there is no standard accepted definition of the pathologic fat pad, it was felt that the inclusion of patients treated for fat pad pathology significantly weakened a study designed to determine the appearance of a usual, or normal, fat pad. Given the large number of subjects involved, we hope that any bias regarding diagnosis is not reflected in the results. We also acknowledge that the data collected were subjective. Because of the irregular appearance and variability of the fat pad, it was not practical to

measure other attributes, such as size. If this had been attempted, many other factors could have combined to decrease the reliability of the results, such as the irregular shape and compressibility of the fat pad, the presence of lobules, the accuracy of the measuring device, and the ability to use such a device via arthroscopic portals. It must also be recognized that specific tools to measure the size of the fat pad or its segments are unlikely to be used during standard knee arthroscopy, making any results obtained from these tools less clinically useful.

These limitations notwithstanding, a large number of patients with other unrelated pathologies were examined in this study dealing with the macroscopic anatomy of the IFP as observed under direct vision during arthroscopy. This enabled us to put a classification suggestion for the usual appearance of the IFP, upon which pathologic processes could be cautiously recognized and studied.

## CONCLUSIONS

The macroscopic anatomy of the IFP is described at arthroscopy performed for internal pathology of the knee. Two distinct parts were defined—medial and lateral—with medial being dominant. A typical fat pad was yellow and included an infrapatellar lingula (85%), lobulation (65%), and villous synovium (65%). We found a ligamentum mucosum in 79% of cases.

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