The Synovial Folds of the Patellofemoral Joint: A Dynamic Study

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The synovial folds of the patellofemoral joint have been studied in five fresh cadaveric knees through a window cut in the patella. When the knee is extended, the superior part of the patellar articular surface lies on the synovium lining the supracondylar fat pad of the femur, which has a distal leading edge and a distal excursion of 2 to 3 mm. As the knee flexes, the contact area of the patella on the femur sweeps superiorly, and the inferior articular surface is covered by the alar folds of the infrapatellar fat pad which face towards one another, and the midline of the joint. On flexion beyond 90° the alar folds move away like a curtain opening, to face away from one another. The synovium lining the infrapatellar fat pad then lies on the medial facet of the patella.

Key words: dynamics, patella, synovium

INTRODUCTION

Most anatomical descriptions of the patellofemoral joint are based on prosections of preserved knees, which are therefore static and in extension. The synovial folds are hardened and do not conform to their natural state. The synovial folds are visualized in the living joint during arthroscopy or when an arthrogram is performed, but in these procedures the introduction of fluid into the knee changes the normal shape of the synovium.

Goodfellow, Hungerford, and Zindel (1976) showed that the contact area between the articular surfaces of the patella and the femur varies according to the position of the knee. In full extension only the inferior margins of the medial and lateral facets of the patella are in direct contact with the trochlea of the femur. As the knee flexes, the contact area on the patella sweeps superiorly so that at 90° flexion the superior part of both the medial and lateral patellar facets is in contact.

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with the trochlea. With further flexion the patella articulates with the inner borders of the medial and lateral condyles of the femur. During this phase the odd (or extreme medial) facet is in contact with the medial condyle, and the lateral facet with the lateral condyle. The medial facet is not in articular contact.

It was noted at that time (Goodfellow, personal communication) that in transverse sections of fresh frozen knees, wherever the articular surfaces of the patellofemoral joint were not in direct contact, the gap was filled intimately by soft tissue, i.e., fat lined by synovium. This is a feature of many synovial joints (Williams et al., 1989) and in the knee can be confirmed by magnetic resonance imaging.

Wiberg (1941) demonstrated that the patella has a synovial fringe, like a crown, around it. This fills the triangular gap between the edge of the patella and the patellar ligament, quadriceps tendon, and the parapatellar expansions (Fig. 1). This paper is concerned with the other synovial folds that fill the gaps in the contact areas of the patellofemoral joint and how they behave during flexion and extension of the knee.

**MATERIALS AND METHODS**

Five fresh frozen cadaveric knees were obtained from three normal males aged 18, 19, and 22 years. From the patella of each a square window was removed with an osteotome. Care was taken to preserve the margins of the patella because of its synovial attachments. A plaster of Paris mould of the excised portion of the patella was formed and from this a clear resin cast was fashioned. The cast was then inserted into the windowed patella and the edges sealed with bone wax. The knee was then mounted on a rod inserted into the medulla of the tibia. When the specimen had thawed, a canvas patch was sewn to the cut end of the quadriceps muscle. On this ties were placed and linked to a single string which was passed over a pulley and loaded with 2 lb weight, with the intention of reproducing the tone of the quadriceps muscle. The joint was then aspirated with a 21G needle and 20 ml syringe until no more air could be removed. This attempted to recreate the negative pressure in the knee.

The movement of the synovial folds was observed through the resin window, and video-recorded, as the knee was taken from full extension to full flexion and back.

![Fig. 1. Diagrammatic sagittal section of the patella to demonstrate the synovial fringe (after Wiberg, 1941). quads = quadriceps tendon.](image)
RESULTS

The superior part of the patellofemoral joint is filled by the supracondylar fat pad, which consists of the fat that lies on the anterior surface of the distal femur, covered by the synovium that forms the posterior surface of the suprapatellar bursa. The fat pad has a leading edge, which disappears if fluid is introduced into the joint (Fig. 2).

In full extension, over 90% of the articular surface of the patella rests on the supracondylar fat pad. As the knee flexes the leading edge of the fat pad moves distally for 2 to 3 mm over the trochlear surface of the femur. In the first 30° of knee flexion the patella glides over the supracondylar fat pad, which is thereafter in contact with the quadriceps tendon. When the knee extends from 30° flexion, as the patella glides proximally over the femur, the leading edge of the supracondylar fat pad moves proximally on the trochlea, thus avoiding becoming trapped between the patella and the femur. This action occurs passively.

![Diagram showing the supracondylar fat pad and its leading edge](image)

**Fig. 2.** a: Diagrammatic sagittal section of the femur demonstrating the supracondylar fat pad. b: Diagrammatic section showing the loss of the leading edge of the supracondylar fat pad in the presence of an effusion.
Figure 3 shows that the supracondylar fat pad’s leading edge extends further distally on the medial side than on the lateral. This conforms with the less prominent medial femoral condyle.

The inferior part of the patellofemoral joint is filled by the infrapatellar fat pad and its alar folds. During knee flexion, as the contact area on the patella sweeps superiorly, a gap appears under the lower patellar facets which is filled by the alar folds. Figure 4 shows that during this phase (from 30° knee flexion) the alar folds face towards one another and the midline of the joint, and not away from one another, as they are usually illustrated. As knee flexion increases beyond 90°, the infrapatellar fat pad is forced between the alar folds, which move like an opening curtain away from the midline of the joint, and adopt their usually observed posture of facing outwards, away from one another. The medial facet of the patella then comes to lie on the infrapatellar fat pad, whilst the lateral facet is in contact with the lateral condyle of the femur, and the odd (or extreme medial) facet of the patella is in contact with the medial condyle of the femur, as shown by Goodfellow et al. (1976). Again the movements of the alar folds are passive. The presence of fluid in the knee forces the alar folds to stay in their outward-facing position.

Fig. 3. a: Photograph and b: diagram showing the supracondylar fat pad as seen through the window in the left patella (acrylic resin cast removed). The knee is in 10° flexion.

Fig. 4. a: Photograph and b: diagram showing the alar folds of the infrapatellar fat pad facing medially, as seen through the window in the left patella (acrylic resin cast removed). The infrapatellar fold can be seen in the intercondylar notch. The knee is in 80° flexion.
DISCUSSION

The synovial fat pads are known to be flexible and to occupy the potential spaces in a synovial joint as these change in shape and volume during movement (Williams et al., 1989). This study confirms this for the patellofemoral joint and describes the position and movement of the relevant fat pads. Superiorly this is the supracondylar fat pad, and inferiorly the alar folds of the infrapatellar fat pad, until greater than 90° of flexion, when the medial facet of the patella lies on the synovium of the infrapatellar fat pad.

Because an effusion abolishes it, the leading edge of the supracondylar fat pad has not been fully appreciated before. This leading edge overlies the upper part of the trochlear groove of the femur and moves distally for 2 to 3 mm on the femur during the first part of knee flexion. This movement has to occur very rapidly as the knee can move from fully flexed to fully extended, and back again, in less than a second. In this study all synovial movements occurred passively, probably under the influence of the negative intra-articular pressure. Presumably the articularis genu muscle is needed to pull the supracondylar fat pad superiorly during forced extension to avoid the latter being caught between the patella and the femur, when the knee is moving at a rapid rate.

The other interesting finding of this study is the position of the alar folds of the infrapatellar fat pad. The infrapatellar fat pad is attached to the patellar ligament, and therefore to the extensor apparatus of the knee. This means that during knee movement the infrapatellar fat pad must stay in the same position relative to the patella until, at greater than 90° flexion, it is forced proximally by the decreasing volume in the intercondylar notch. However we know that as the knee flexes a gap develops under the lower part of the patella. Since this cannot be filled by the infrapatellar fat pad, it is filled by the alar folds. It has been shown that they face inwards towards one another, from 30° to 90° knee flexion. Their position in knee extension was not directly observed. Beyond 90° knee flexion the alar folds were observed to move away from one another as the infrapatellar fat pad came to occupy the intercondylar space. Thus as the knee flexes and extends the alar folds “open” and “close” like a curtain (or perhaps a windscreen wiper), pivoting on their anchorage to the infrapatellar fold. The inward-facing position of the alar folds is abolished by an effusion.

This study also shows that during full movements of the knee, all of the patellar articular cartilage is swept by synovium, an action which may serve a number of functions, such as joint lubrication or cartilage nutrition.

“Windowing” the patella has allowed the movements of the synovial folds of the patellofemoral joint to be observed and shown this to be different from that previously described for the supracondylar fat pad and the alar folds of the infrapatellar fat pad. This is because this technique has allowed the synovial folds to be studied without being disturbed by the presence of fluid.

REFERENCES