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ROENTGENOGRAPHIC AND ANATOMIC STUDIES ON  
THE FEMOROPATELLAR JOINT

With special reference to chondromalacia patellae

BY

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INTRODUCTION

Many theories have been advanced as to the cause of dislocation of the patella, and these etiologic factors will be discussed in some detail later in this communication. At present, I shall merely remind readers that the most widely accepted theories assume the presence of some congenital malformation. In particular, aplasia of the lateral femoral condyle has been suggested, and it was in order to attempt to clear up, with the aid of roentgenography, the relation of the femoral condyles to the patella, in dislocation of the patella, that I took up the studies to be described in the following chapters. A roentgenologic examination of the femoral condyles signifies in reality the acquirement of a knowledge of the femoropatellar joint.

A competent estimation of pathologic conditions always necessitates a knowledge of normal relations, and as no detailed investigations have previously been made on the normal anatomy of the femoropatellar joint, the first step was obviously to examine the typical relations between the patella and the femur. My investigations consisted not only of an examination of autopsy specimens, but also of a roentgenologic study of healthy subjects. I unfortunately found it impossible to avoid devoting a fair proportion of the space to a description of normal conditions.

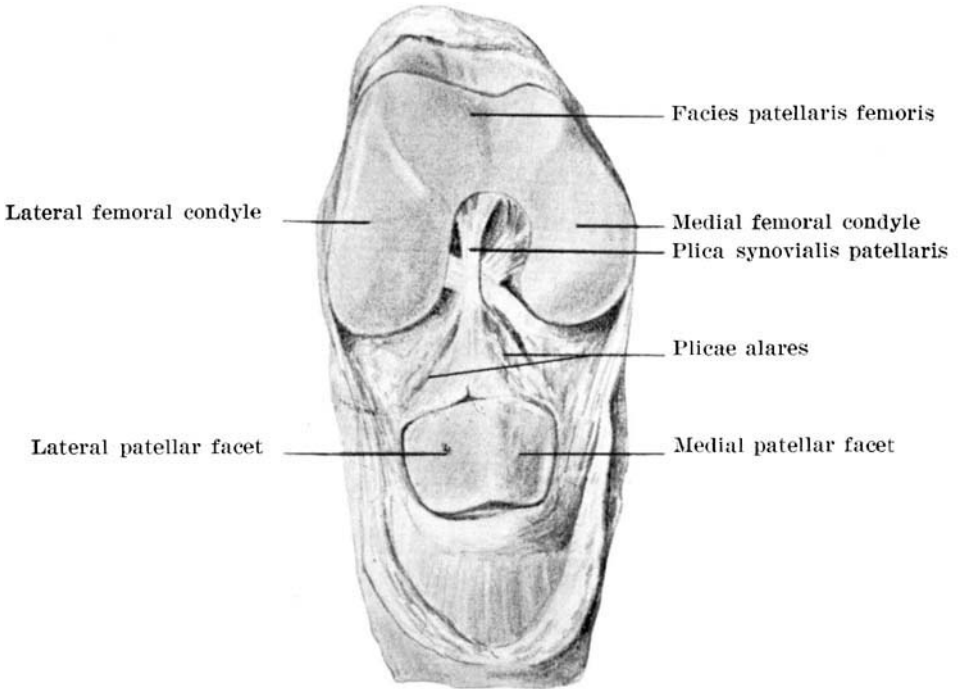
As one certain projection was found most satisfactory in obtaining the desired views of the femoropatellar joint, this was used subsequently for the roentgen examinations at the Orthopedic Clinic. Not only were subjects suffering from dislocation of the patella photographed by means of this projection, but other diseases were also included. A total of 158 joints from 101 patients were photographed. Chondromalacia was the main subject of interest, but the complication of osteo-arthritis was also added as a sub-group.

### STUDIES ON NORMAL CONDITIONS

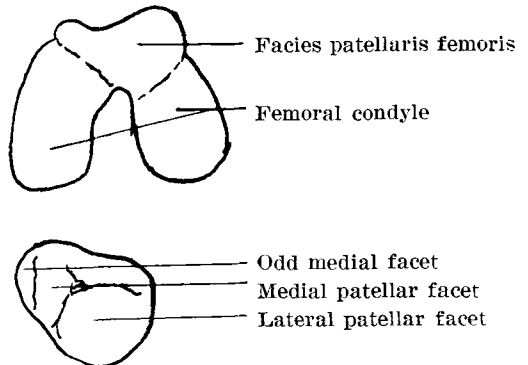
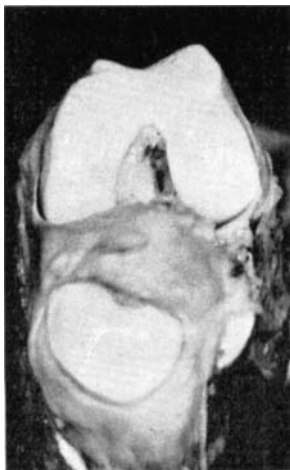
In view of the extensive investigations carried out on joints in the past few years, and the attention that has been paid to the arthrographic method, it is surprising that the femoropatellar joint has failed to arouse interest. The description in *Fick's* text-book on anatomy, published in 1904, is still one of the most detailed available on the normal anatomy of the joint in question, and the account given hereinafter is based on his statements.

The part of the articular surface of the femur which is opposed to the patella is crescentic and includes the anterior part of the distal epiphysis. It is concave mediolaterally and convex proximodistally and is continuous with the more distal area with which the tibia articulates. The articular surface of the lateral femoral condyle projects further forward than that of the medial, and extends further up on the condyle (figs. 1 and 2). Opinions vary regarding the thickness of the cartilage in the femoral part of the femoropatellar joint, but in any case it is thickest in the middle.

The articular surface of the patella is in the main an exact cast of the femoral articular surface. Thus, it is divided into two concave areas—the medial facet and the larger lateral facet—by a ridge that fits into the groove on the crescentic facet of the femur (fig. 1). A close examination reveals that the articular surface is divided into not less than seven different facets, namely, an odd medial strip-shaped facet, and two inferior, two midd-



*Fig. 1.* Anterior aspect of the knee joint.



*Fig. 2.* Autopsy specimen of the knee joint, showing the patellar facets.

le, and two superior paired facets. The medial ridge separating the medial and lateral articular surfaces of the patella varies in different individuals. It is usually convex, and here is found the thickest cartilage of the body; this may be from 5.4 mm. to 6.4 mm. in thickness. In other parts, according to *Fick's* statements, the patellar cartilage is relatively thin.

When the knee is extended or flexed the position of the patella in relation to the femur changes to a considerable degree; on the other hand, its relation to the tuberosity of the tibia does not alter. The displacement in relation to the femur may amount to from 5 to 7 cm. The gliding movement executed by the patella towards the femoral condyle takes place around an approximately transverse axis, and besides this movement a slight, lateral displacement occurs in acute flexion. Since the articular surface of the patella is of approximately the same size as the femoral surface with which the patella articulates, it is obvious that the patella in its movements must pass beyond the boundaries of the femoral articular surface, and this is what actually happens in both extension and flexion.

In the extended position of the leg, the superior part of the patella lies above the crescentic surface of the femur and rests upon the subsynovial pad of fat situated in this area. The inferior part of the patella comprising the two lowermost facets, the "extension facets", is in congruence with the upper part of the crescentic facet. In proportion as the knee is flexed, the articular surface of the patella comes further into contact with that of the femur, but by degrees this contact again decreases until, in extreme flexion, only the two uppermost patellar facets, the "flexion facets", face the femur. In the midway position between these two extremes, the two articular surfaces are in closest contact, and the ridge on the patella is then best engaged with the concavity of the crescentic facet. In the position of maximal flexion the patella sinks in to a certain extent between the two femoral condyles, and simultaneously there takes place a slight lateral displacement of the knee cap.

Other text-books of anatomy furnish practically identical descriptions of the anatomic relations in question, though not

in such detail. There are a few variations. Thus, *Corning*, and later *Lanz* and *Wachsmuth*, stated that when the knee is in extreme flexion the patella is displaced laterally to such a degree that it may be separated from the medial femoral condyle by a broad hiatus.

Although the alar folds are not part of the femoropatellar joint as such, I should like to point out one fact in connection with them. It is generally stated rather hazily that they extend as two folds from the infrapatellar fatty pad towards the patella, filling up the pockets between the patella and the femoral condyles. The impression given is that they never reach higher than to the inferior part of the patella. In this respect, the anatomical description furnished by *Lanz* and *Wachsmuth* forms an exception, since in one of their cross-sections of the knee joint, made close to the base of the patella, the alar folds also are seen to be cut, a circumstance indicating that it was the intention of the authors to show that the folds extend upwards as far as to the base of the knee cap.

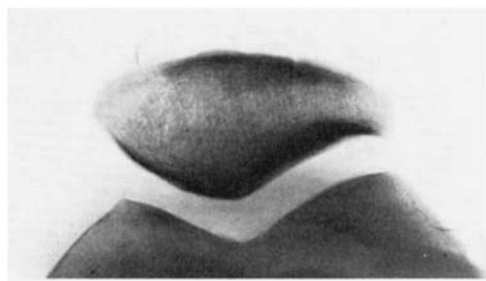
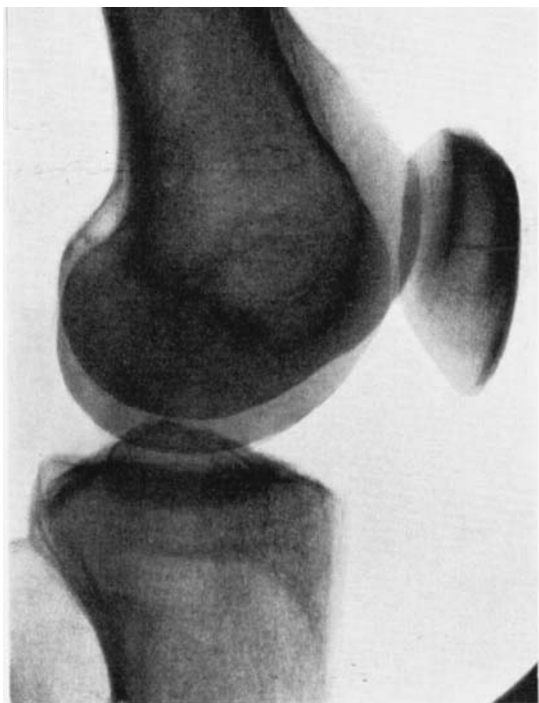
Roentgen anatomy is an excellent aid in complementing examinations on the joints, and in the case of the femoropatellar joint it is invaluable, seeing that the roentgenographic method must be solely relied upon when dealing with this joint. The routine views of the knee joint obtained by frontal and lateral projection are obviously insufficient for a study of the femoropatellar joint; in fact, they provide practically no information on the subject. An axial projection of the patella, on the other hand, is extremely informative. This type of projection was first mentioned by *Sattogast*, and it has since been extensively used for studies on the patella, but has been neglected as regards the femoropatellar joint. As far as I have seen in the literature, *Jaroschy* was the only worker to use it. As a rule, when the patella alone is to be examined by axial projection, the photograph is taken with the knee in the easiest position for the purpose, namely, extreme flexion. The usual technical procedure is to stand the patient on a stool with the knee acutely flexed and the roentgen plate below the knee. Another method is for the patient to lie prone, with the knee in extreme flexion and

the roentgen plate above the knee. When the femoropatellar joint is to be projected free, on the other hand, a knowledge of the anatomy of the knee joint makes it obvious that the picture must be taken with the knee only slightly flexed, since the femoral articular surface in the femoropatellar joint comprises principally the frontal part of the articular condylar surfaces.

Thus, when the idea was conceived of making roentgenograms of the femoropatellar joint in dislocation of the patella, the first task was to determine the most suitable angle of flexion of the knee joint for the purpose of obtaining a free view of the femoropatellar joint. As a beginning, a number of subjects, clinically symptom-free, were selected for examination. Frontal, lateral and axial pictures were taken of one knee flexed at different angles. As no variations of importance were noted among these different subjects, I have reproduced the pictures from only one of them, a man of thirty-five.

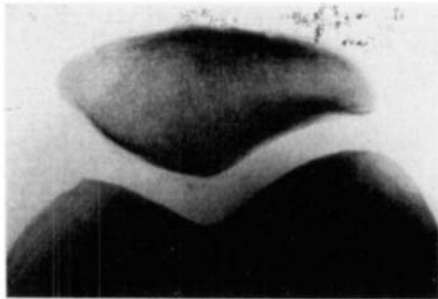
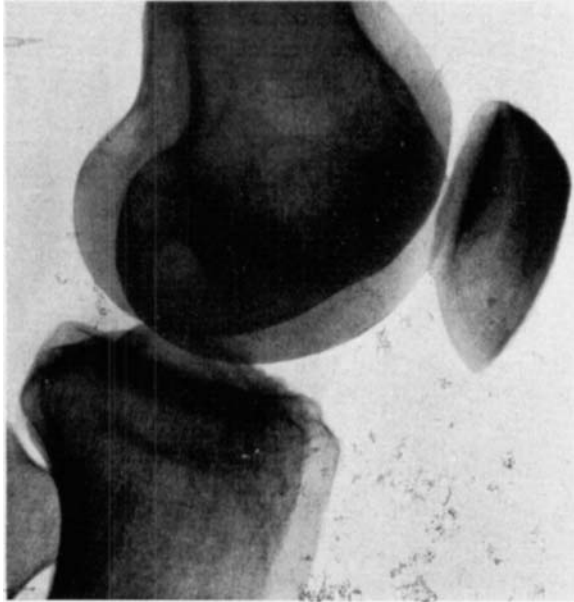
The knee was roentgenographed at five different angles of flexion, 20, 40, 60, 90 and 115 degrees. The reason why a beginning was made with an angle of 20 degrees was that it is obviously impossible in practice to obtain a free view of the femoropatellar joint with the leg in complete extension. Nor would a roentgenogram taken on the knee in this position have been of any value, since, according to the indications of normal anatomy, when the knee is fully extended the main part of the patella is situated over the articular surface of the femur, and there could thus have been no question of a free projection of the femoropatellar joint.

The pictures taken at the two lowest angles of flexion tally well with one another (figs. 3 a and 3 b). It is easy to distinguish how the lateral femoral condyle juts in advance of the medial condyle. According to *Böhm*, this difference in level amounts to 7 mm., that is to say, the lateral femoral condyle should project a distance of 7 mm. in front of the frontal plane through the medial femoral condyle. The articular surface of the lateral condyle is slightly broader than that of the medial, judging from the skeletal parts. The patella has been projected free longitudinally so that the articular surface has been caught at



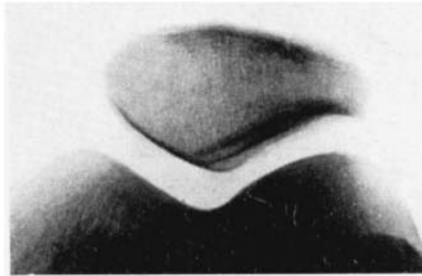
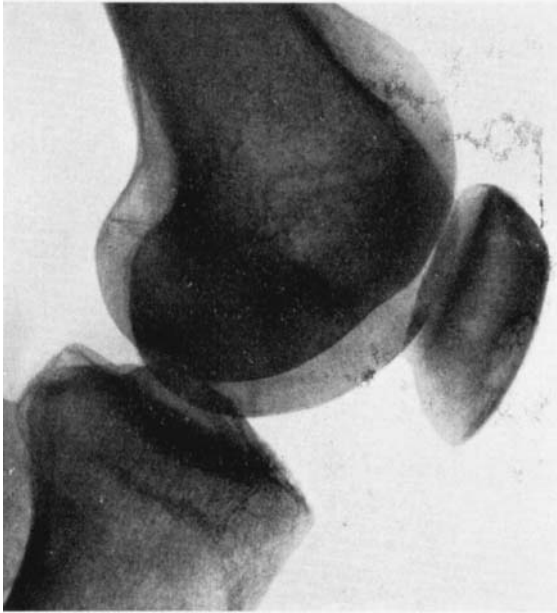
*Fig. 3 a.* Normal knee joint flexed at 20°. Lateral and axial views.

a tangent. In agreement with the anatomical description, the lateral facet is slightly concave and is congruent in its extent with the lateral femoral condyle. The medial part of the patella, on the other hand, appears convex in its entirety, and further-



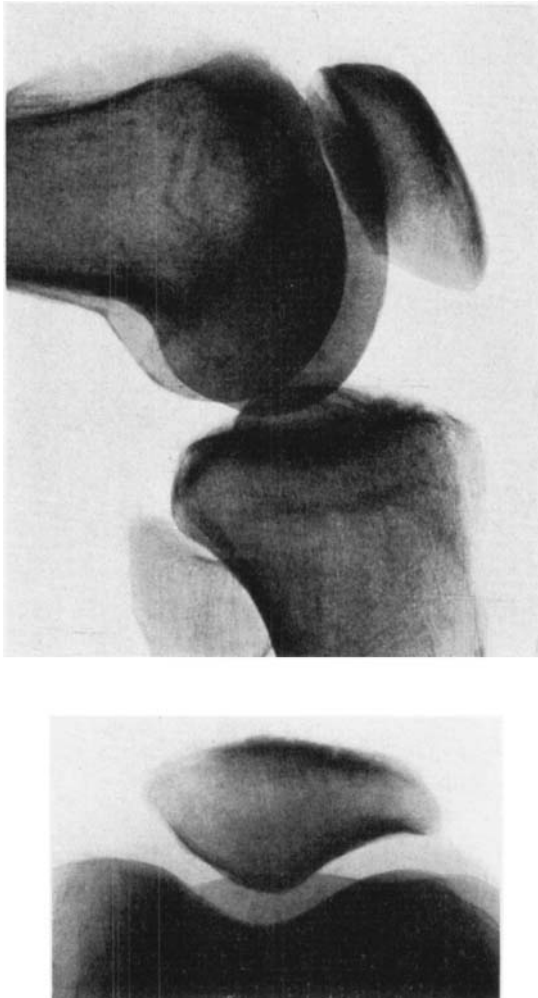
*Fig. 3 b.* Normal knee joint flexed at 40°. Lateral and axial views.

more, seems to project over the femoral condyle on this side. The ridge on the patella corresponds well with the groove between the femoral condyles, and the height of the joint cavity is even along its whole length. In the picture taken with the knee flexed at 60 degrees (fig. 3 c), the relations have already begun to alter slightly, and the two femoral condyles now appear approxi-



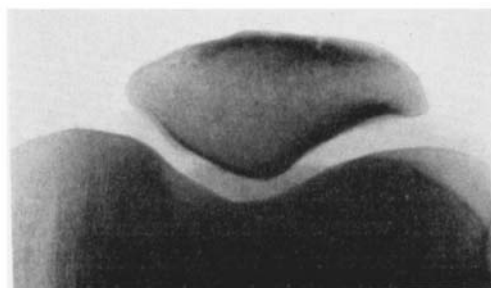
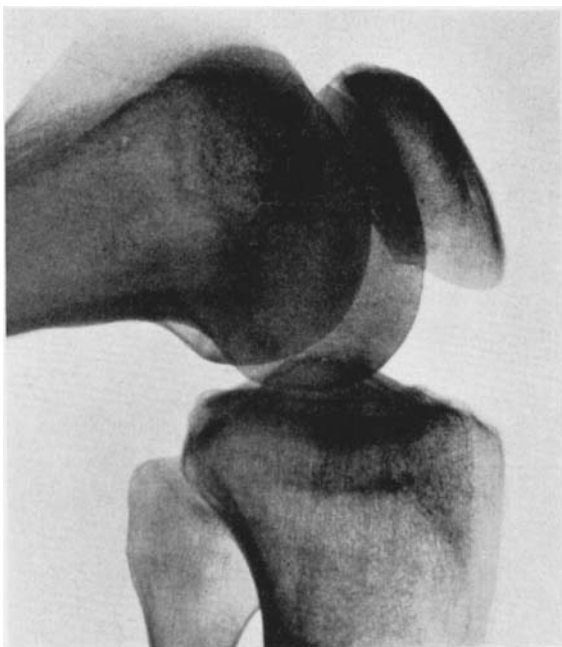
*Fig. 3 c.* Normal knee joint flexed at 60°. Lateral and axial views.

ately equal in size. The medial articular surface of the patella seems to articulate more broadly with the femoral condyle. The height of the joint cavity is maintained as in the previous positions. When the angle of flexion is increased to 90 degrees the picture changes (fig. 3 d). The external borders of the femoral condyles are more rounded than in the previous views, and the groove in the centre is broader. The articular contact looks un-



*Fig. 3 d.* Normal knee joint flexed at 90°. Lateral and axial views.

changed but the space between the femur and the patella is undoubtedly lower. At 115 degrees, the latter condition is further accentuated (fig. 3 e), and the joint cavity has narrowed. This is not because the height of the articular cartilage has diminished in reality but because the ridge of the patella

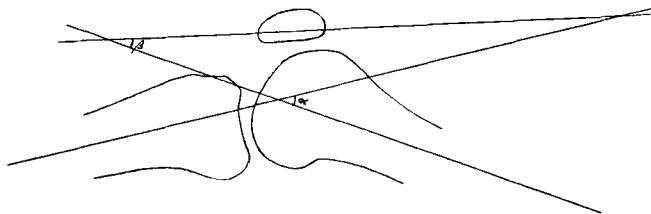


*Fig. 3 e.* Normal knee joint flexed at 115°. Lateral and axial views.

sinks in between the femoral condyles. (This is explained later on on page 378). As a result of the extreme flexion the anterior border of the tibia is seen to be projected free between the condyles.

Of course, the above-mentioned angles are not in any way

identical with the angle of incidence at which the femoropatellar joint is met by the central ray from the roentgen-ray tube. They merely refer to the positions of the knee from which it is most convenient to gain a free view of the femoropatellar joint (see fig. 4). The object is to take an axial projection of the patella, and as far as possible, therefore, the rays must travel parallel with the articular surface of the patella. Thus, the adjustment must always be made by the eye.



*Fig. 4.* Diagram of the axial projection.  
 $\alpha$  = angle of flexion.  
 $\beta$  = angle of incidence.

In connection with my investigations, to which I shall return later on, a number of postmortem specimens were used, and to complement my studies on normal conditions I photographed some of these in various positions of flexion. There was of course no anatomic difference between these two types of knees.

The specimens were taken from young subjects aged 27 and 30 years, in whom it was possible to ascertain that no pathologic changes had been present in the joint. About 15 cm. of the femur and 10 cm. of the tibia were included in the specimens, and from the fleshy parts were taken the entire capsule, the ligamentum patellae and the tendon of the quadriceps muscle together with the musculature up to the level of the sawn-off leg. Before the specimens had had time to dry, it was possible, by keeping the quadriceps tendon extended, to retain the patella in its normal position at different angles of flexion.

In order to be able to examine the angle values between 40 and 60 degrees with a greater degree of certainty, the pictures

were taken with the knee flexed at five angles that differed slightly from those used for the other pictures.

These pictures gave results very similar to those obtained from the living subjects. Thus, at angles of flexion ranging from 20 degrees, at which an axial projection is first practicable, up to 50 degrees, the appearance of the femoropatellar joint remains practically unchanged, while after that, in proportion as



*Fig. 5.* The patient's position on the examination table.

the angle increases, a change in form takes place until the femoropatellar joint can no longer be projected free, since the projection then reaches so far down on the femoral condyle that the articular surface of the tibia is included.

We therefore chose an angle of about 40 degrees for our roentgenographic studies on the femoropatellar joint. It was difficult to keep to this angle with exactitude, but small variations are of no consequence.

Our technical method followed that described by *Knutsson*.<sup>1)</sup> The patient lies on his back on the examination table, with the flexed knee supported by cushions (see fig. 5). For technical reasons, the roentgen-ray tube is situated above the patient's head since it is otherwise difficult to obtain a sufficiently small angle of incidence. The plate is placed on blocks directly below

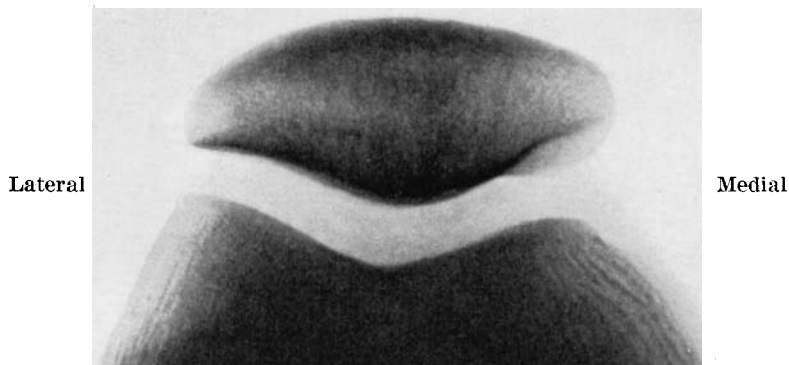
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<sup>1)</sup> See the article by F. Knutsson in *Acta radiol.*, vol. XXII, fasc. 3, 1941.

the knee. It should be noted that as the longitudinal axis of the patella seldom lies in the same direction as that of the leg, the projection must generally be directed slightly from the inner side of the leg.

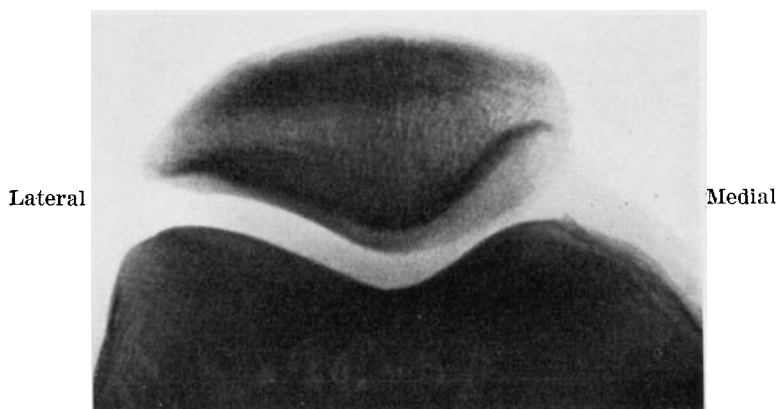
I have already mentioned that in my studies on the femoropatellar joint I did not confine my investigations to dislocations of the patella but roentgenographed also cases of other diseases. A number of joints were therefore included which, while exhibiting such defects as injuries to the meniscus, and contusions, must be regarded as normal as far as the femoropatellar joint was concerned. These have also been used as material for my studies on the normal appearance of the femoropatellar joint. A total of 25 joints have been examined, distributed over 18 subjects, and of these, 8 were subjected to arthrographic examination.

As might be expected, much variation in shape was exhibited by the patella, and the size also varied in different individuals. On an average, the knee caps of my male subjects were larger than those of the females. The femoropatellar joint duplicated the form of the patella on the whole, but on the roentgenograms the patella came out more strikingly and it was the latter that dominated the picture. The patella has therefore been taken as the basis for the type classification that I use in the remainder of this communication. It was possible, in fact, to distinguish three different types as regards the shape of the patella, judging by the position of the ridge in relation to the patellar borders, or in other words, depending upon the size relation between the medial and lateral patellar facets. In a number of instances, the ridge was seen to be situated approximately in the centre of the patella, so that the medial and lateral facets were equal in size, as in case 2013/41 (fig. 6). The femoral articular surface, as I stated earlier in this chapter, followed the form of the patella, and the lateral part was only slightly wider than the medial. In the second type, the ridge was situated slightly towards the medial border of the patella, and the medial facet was smaller than the lateral. Case 1467/41 is an example of this type (fig. 7). The cases in which the ridge was displaced

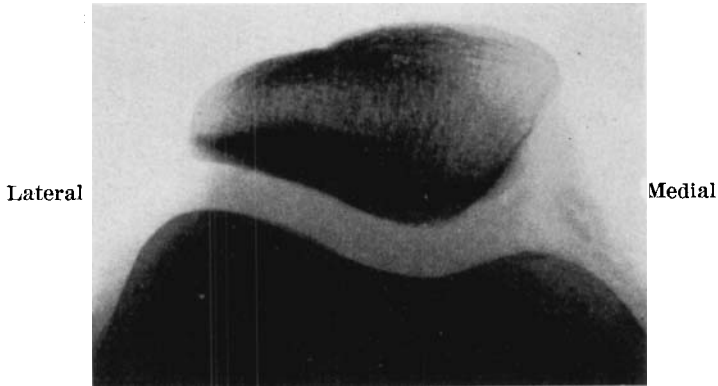


*Fig. 6.* Case no. 2013/41. Normal type no. I.

medially to such a degree that there was hardly any room left over for the medial facet, with the result that the latter sloped steeply forward and medially, constituted the third type. (See case 5117/40, figure 8). In the two last-mentioned types there was a certain parallelism between the patella and the articular surfaces of the femur, so that in type III the medial articular surface of the femoral condyles was considerably smaller than that in type I. In other words, in congruence with the patellar ridge the groove between the two condyles in these instances was situated further toward the medial aspect. Of course, the



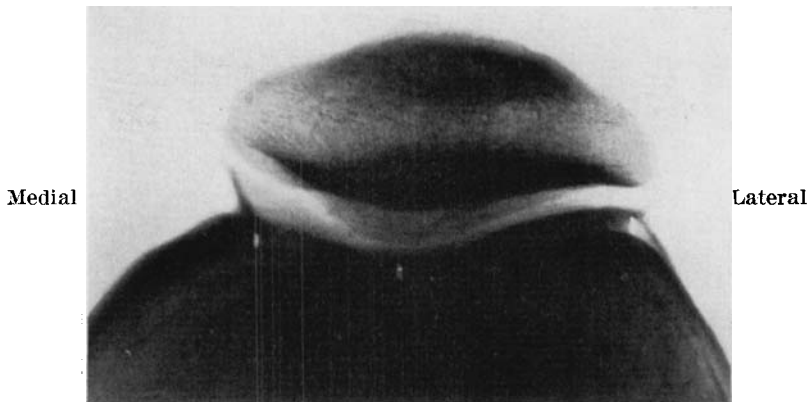
*Fig. 7.* Case no. 1467/41. Normal type no. II



*Fig. 8.* Case no. 5117/40. Normal type no. III.

transition between these three types was gradual, but in general there was no difficulty in differentiating between them.

This classification was based wholly upon the roentgen pictures, that is to say, upon the appearance of the skeletal parts, and thus nothing definite could be said about the appearance of the articular surfaces of the cartilage in these cases. In order to endeavour to clear up this question, I subjected eight normal knees to arthrographic examination. Difficulty was experienced in obtaining a clear view of the femoropatellar joint



*Fig. 9.* Case no. 1549/38. Arthrogram obtained with axial projection. Type II.

on the arthrograms, owing to the fact that the contrast medium showed a tendency to accumulate in the suprapatellar bursa, and that in an axial projection it covered the contrast fluid in the joint cavity. However, it was sometimes possible to obtain a good picture by compressing the suprapatellar bursa (see figure 9, case 1549/38).

The joint cavity comes out as a streak of contrast, while the



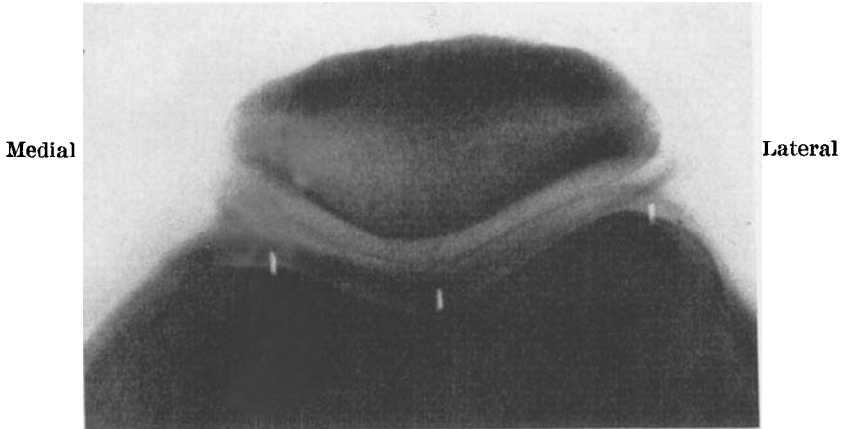
Fig. 10. Case no. 236/41. Arthrogram obtained with axial projection. Type II.

contrast-free channels opening from both directions into the cavity are in all probability capsular folds constituting a direct continuation upwards of the alar folds, which in *Lanz* and *Wachsmuth's* opinion also, may be considered as extending up to the base of the patella.

I have not succeeded in obtaining completely typical examples of the three different types, and I must therefore be content to indicate the type to which different cases most closely approximate. It will be easily observed from figure 10, which is an example of type II inclining towards type III, that only a small proportion of the whole articular surface falls to the medial facet, while in figure 11, which most closely resembles type I, the proportional distribution between the two facets is much more evenly balanced. On the whole, therefore, the skeletal

form and the cartilaginous articular surface may be said to be in congruence with one another.

To summarize the results obtained from my anatomic and roentgenographic studies on the femoropatellar joint, it may be said that the joint may be projected free most satisfactorily



*Fig. 11.* Case no. 2363/41. Arthrogram obtained with axial projection. Type I.

when the knee is flexed at 40 degrees. With respect to the form of the patella, three type groups may be distinguished. In all normal subjects the patella is congruent with the articular surface of the femur in the roentgen pictures.

#### THE FEMOROPATELLAR JOINT IN DISLOCATION OF THE PATELLA

As I pointed out in the previous chapter, my studies on the femoropatellar joint were made for the purpose of ascertaining the appearance of the lateral femoral condyle in dislocation of the patella. A number of workers have advanced different theories—to be discussed later in this section—to prove that a congenital malformation in the development of the lateral femoral condyle is the root of the trouble.

In order to obtain a clear conception of this theory of origin,

it must be studied in comparison with others, and furthermore it is necessary to examine the variations in position exhibited by the patella in the normal condition and in different types of luxation.

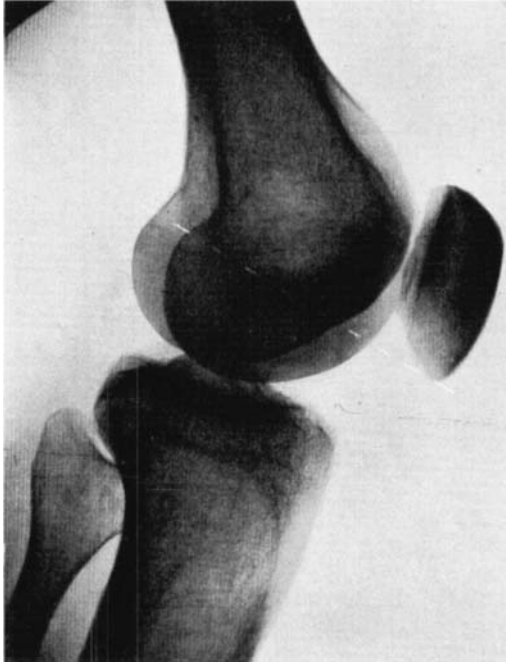
Even when normal, the patella shows much variation in its position, both in the lateral direction, and upward and downward. When the leg is extended, and while the quadriceps musculature is relaxed, the apex of the patella should be on a level with the joint cavity, but as the muscles are stretched the patella is displaced upward about a thumb's breadth. This was called by *Payer* "the play of the patella". In order to determine the height of the patella roentgenographically a lateral view is always most valuable. *Boon* and *Itt* has described a fairly complicated method for determining whether the position should be regarded as normal or abnormal. A simpler method of measurement has been suggested by *Blumensaat*. If the faint sclerotic line produced by the inner boundary of the femoral condyles is extended (fig. 12), it should meet the apex of the patella when the knee is flexed at 30 degrees.

A congenital, abnormally high position of the knee cap, usually bilateral, is found in many cases of Little's disease. Osteo-myelitis of the femur has been suggested as the cause of an acquired elevated position of the patella. The condition is sometimes found also in polio-myelitis and in Schlatter's disease. An abnormally low patella has also been reported in cases of polio-myelitis, chiefly due to paralysis of the quadriceps muscle.

Difficulty is sometimes experienced in determining whether the position of the patella laterad is to be regarded as normal, as a frontal projection slightly out of line is all that is needed to cause the patella to deviate from the median line. In all probability, the normal position laterad may vary within certain limits, and it may therefore be hard to differentiate between this type of lateral displacement and a true subluxation. *Blumensaat* considered that in a normal lateral displacement the entire articular surface of the patella contacts with the femoral condyle, while in subluxation the patella rests on the

convexity of the femoral condyle, generally on the lateral condyle.

If luxations of the patella are grouped according to the nature of the dislocation, a distinction may be made among



*Fig. 12.* A normal case. With the knee flexed at  $30^{\circ}$ , the apex of the patella is on a level with a line drawn through the sclerotic line marking the inner boundary of the femoral condyles.

those resulting from a change in position around a vertical or around a horizontal axis. Of these, only the vertical changes in position are of any practical significance, and even among the latter, certain types are extremely rare; these are torsive luxation, in which the patella has twisted at an angle of 90 degrees so that one border rests in the groove of the femoropatellar joint, and inverse luxation, in which the patella lies with its articular surface anteriorly. From a practical standpoint, the

most important group comprises that in which a lateral dislocation has taken place. Depending upon the extent to which the articular surfaces of the patella and of the femoral condyles have lost contact with one another, the classification subluxation or total luxation may be applied.

The last-named types of luxation may be due to various etiologic factors, and the basis for classification that seems the most favoured is that first mentioned by *Soliero*, and later modified by *Wiemuth* and *Dünkeloh*, and others.

1. Congenital luxations,
2. Acquired luxations, among which a differentiation may be made between traumatic and pathologic types.

As regards torsive and inverse dislocations, as well as the extremely rare horizontal luxations, these are invariably traumatic, and the various etiologic theories therefore chiefly relate to the lateral dislocations.

I should like to emphasize the difficulty of making a definite distinction between a congenital and an acquired luxation of the patella. As a rule, a trauma, however slight, is required to occasion the first luxation even when the constitutional element is present, and it would thus seem as if it is only the intensity of the trauma that should be the deciding factor when determining whether the dislocation is congenital or acquired. The usual practice is to assume that, if nothing indicating a congenital disturbance is observed, the luxation is acquired. ...

Discussion centres mainly about two theories regarding the origin of congenital luxation of the patella. According to the first, maldevelopment of the lateral femoral condyle is the essential cause, while according to the second, it is an abnormal traction on the part of the vastus lateralis muscle.

The first theory is favoured by a number of authors, among them *Smith*, *Stokes*, *Servier*, *Canton* and *Appel*, who believe defective development of the femoral condyle to be congenital, while other workers disagree with this, arguing that malformation of a femoral condyle should be regarded not as a cause but rather as an effect of a dislocation of the patella. In their opin-

ion, the continuous friction caused by a luxating patella retards the normal development of the lateral femoral condyle. In opposition to this argument it has been alleged that in *that* case it should not be possible to find a low femoral condyle in permanent luxation, where the abrasive element is absent.

The second theory refers to an abnormal traction on the part of the vastus musculature. Some authors, such as *Böhler*, have pointed out that as a result of defective development of the vastus medialis, the vastus lateralis gets the upper hand, causing the gradual appearance of a luxation. *Duchenne's* test supported this view. By means of electric stimulation of the vastus lateralis on fresh cadavers he succeeded in producing a dislocation of the patella laterad. *Böhler* otherwise regarded the vastus medialis as merely an adductor for the quadriceps musculature which in itself possesses tractive power in a lateral direction. Other workers who favour this theory of muscular traction cite as a reason for faulty muscular action an insufficient inward torsion of the femur during the period of growth (*Dreesman*), or an abnormal rotation occurring on flexion of the knee joint (*Hohlbaum*).

*Blumensaat* said that in the matter of their fundamental cause it was undoubtedly difficult to make such a clear discrimination that it was possible to decide with certainty whether luxations were congenital. It is an established fact, however, that maldevelopment of the lateral femoral condyle is observed in luxation of the patella.

A total of 13 patients in whom either luxation or subluxation had been clinically diagnosed were available for examination. Among these subjects 25 knees were roentgenographed (the healthy side in one patient was overlooked by mistake). Four of them exhibited bilateral luxations, and altogether there were 17 dislocated and 3 subluxated knees.

In my classification of the normal material into three groups, the shape of the patella was used as a basis.

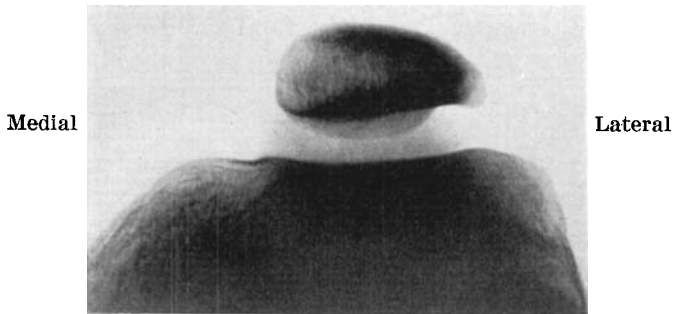
If the roentgen pictures of the femoropatellar joints in these thirteen luxated and subluxated cases are compared, it will be seen that on most of them there are evidences of a considerable

deviation from the normal appearance; both the femoral condyles and the patella evince changes in form. On the basis of these developmental inconsistencies it is possible to classify the material into three groups, with the reservation, of course, as in the previous classification, that no definite demarcations can be drawn between them, since the transition from one type to another is gradual, as it always is when skeletal variants are placed into groups.

The first category (group I) consists of the cases exhibiting the greatest changes (2 patients and 4 knees), and as the criterion for this type I took the total levelling-off of the articular surfaces of both femur and patella. Case 9621 may be regarded as an example of this group. From his earliest years the patient had been troubled by repeated dislocations of the right knee. The left knee had only showed tendencies to luxate, or more exactly expressed, to subluxate. As far as was known, there had been no injuries to the knee. The right knee was operated upon in June 1938 by the method usually employed at the Orthopedic Clinic in luxations of the patella. Plastic surgery was done according to Krogus' operative method and the tuberosity of the tibia together with the insertion of the ligamentum patellae were chiselled off and shifted distally and medially. This will be termed "the Krogus combination method" in the remainder of this communication. The amount of the shift must be determined in each individual case, but 1 to 1.5 cm. in each direction is generally sufficient. In the case under discussion, however, the capsule was so relaxed that a shift of 2 cm. both distally and medially was considered necessary. At the operation the femoral condyles were seen to be completely cylindrical and consequently contained no groove for the patella on the patellar surfaces. After six months there was a recurrence, and the patient was operated upon again in May 1939. This time, a more radical measure was adopted. The lateral femoral condyle was elevated by chiselling into the bone from the lateral aspect and filling in the carved-out area with bone chips. The width of the patella was also reduced to enable it to fit more exactly into the new-formed groove between the condyles. Un-

fortunately, no axial view of the right knee was taken before the operation, but judging from the history of the operation the appearance of the right side must have tallied well with the axial picture of the left side (see fig. 13). On the latter the articular surface of the femur is absolutely plane, and the patella lacks all signs of a central ridge.

Case 2155/38 provides a second instance of group I. This patient also had suffered from early childhood from repeatedly recurring bilateral dislocations, and here also nothing was



*Fig. 13.* Case 9621. Axial view of the left knee.

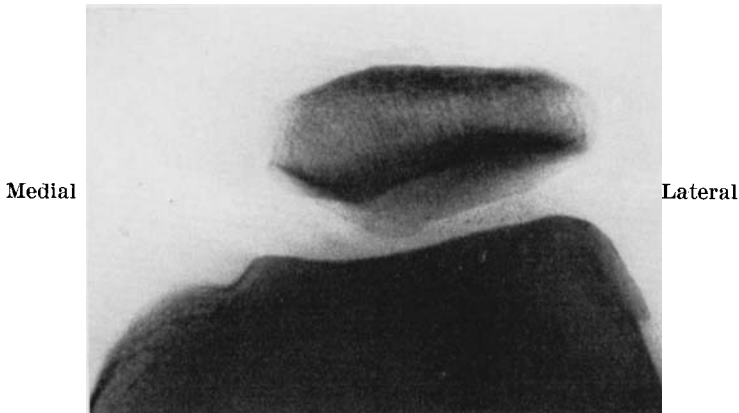
known of a trauma in the past. Both knees were successfully operated upon by the Krogus combination method.

In this patient also, the articular femoral surface was totally planed down and the patella practically level with only slight traces of ridge formation (figs. 14 and 15).

The transition from group I to group II is smoothly continuous, as I stressed earlier in the chapter, but in the second group I have placed the cases displaying a too level patella, or maldevelopment of the lateral femoral condyle with or without a plane patella. Nine patients comprise my group II, and as an example I will cite case 1322/41. Since the age of ten this patient had suffered discomfort from bilateral dislocations which occurred without previous injury. The roentgen pictures (figs. 16 and 17) reveal that the lateral femoral condyle is without doubt abnormally low and the sub-division of the patella into two facets is also faulty. The first of these conditions may be



*Fig. 14.* Case 2155/38. Axial view of the right knee.



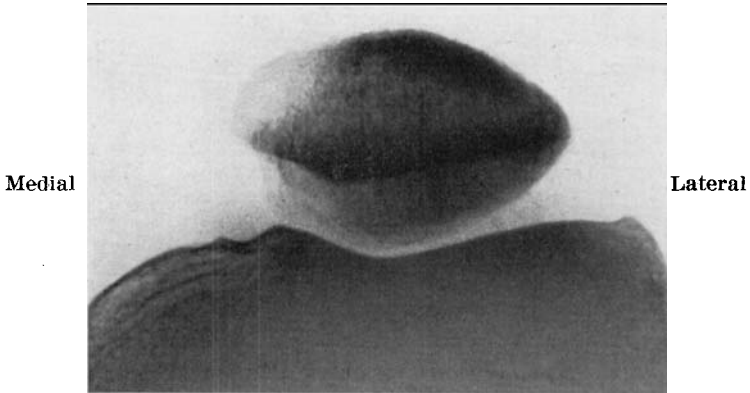
*Fig. 15.* Case 2155/38. Axial view of the left knee.

described by saying that the groove between the femoral condyles has become shallower than is normal. Verification of this was obtained during the operation on the left knee, of which figure 17 a is an illustration.

Case 16672 is another representative of group II. The lateral femoral condyle is relatively well-developed but the posterior surface of the patella is strikingly level (see figs. 18 and 19). As in the last-mentioned case, the patient began to suffer from



*Fig. 16.* Case 1322/41. Axial view of the right knee.

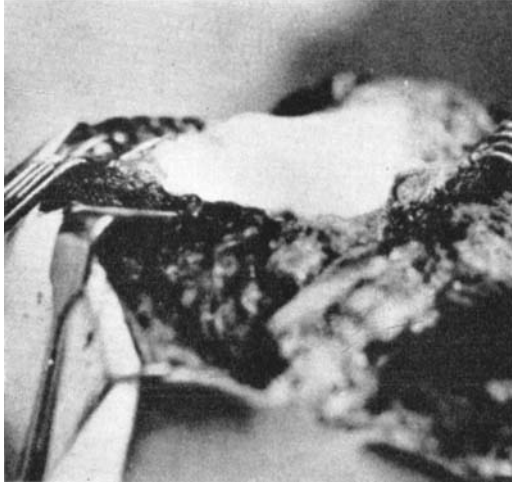


*Fig. 17.* Case 1322/41. Axial view of the left knee.

dislocations at the age of ten, and could recall no injuries to the knee. The dislocations only occurred on the left side, a rather surprising circumstance seeing that this knee was slightly better developed than the right. The patient refused any surgical intervention, and in view of his relatively advanced age—45 years—no attempt was made to alter his decision. But two other patients classified under group II were operated upon.

It was necessary to make a special subdivision of the second

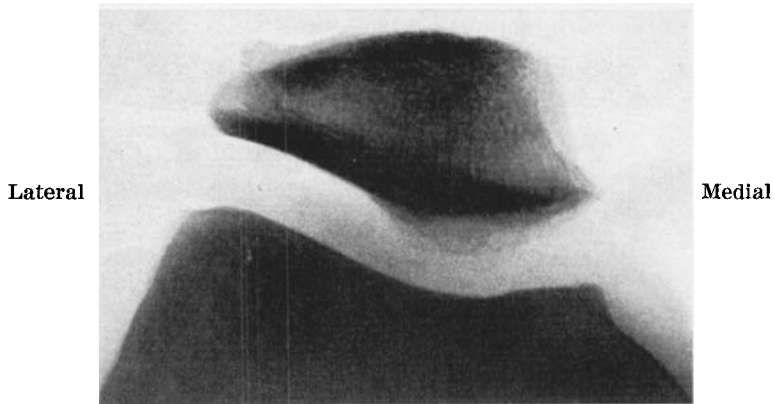
group to allow for the cases which, because of the appearance of the femoral condyles, should be classified in group II but which exhibit a completely normal patella in a position of permanent luxation (group II a). Two identically similar cases were encountered. From figure 20 relative to case 873/39, as well as from the photographs from the operation (fig. 21), it



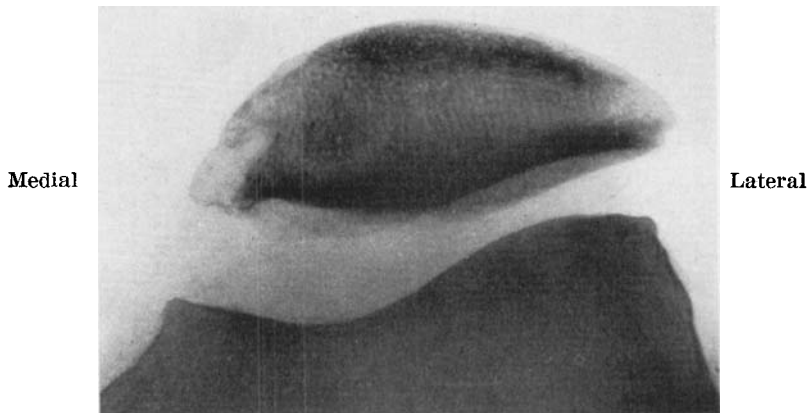
*Fig. 17 a.* Photograph taken during operation on the left knee.

will be noted that the lateral femoral condyle is lower than it should normally be. The patella, situated on the external aspect of the lateral femoral condyle, is normal in shape. The right knee was quite normal. The patient in question was operated upon in April 1939, the Krogius combination operation being performed. Despite the fact that the lateral part of the capsule was left open after the intervention, in order to avoid a strain laterad, a redislocation of the patella appeared again after a short interval, and by February 1941 the entire knee cap was found to be situated on the lateral surface of the femoral condyle.

As regards the femoropatellar joint in the cases previously mentioned, my experience has been that the patella and femoral



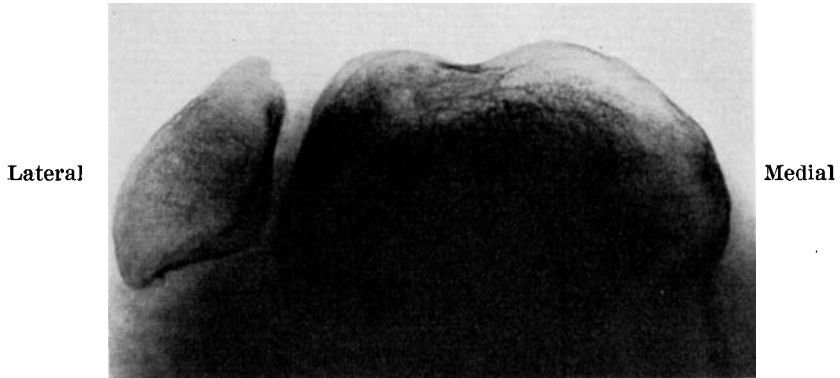
*Fig. 18.* Case 16672. Axial view of the right knee.



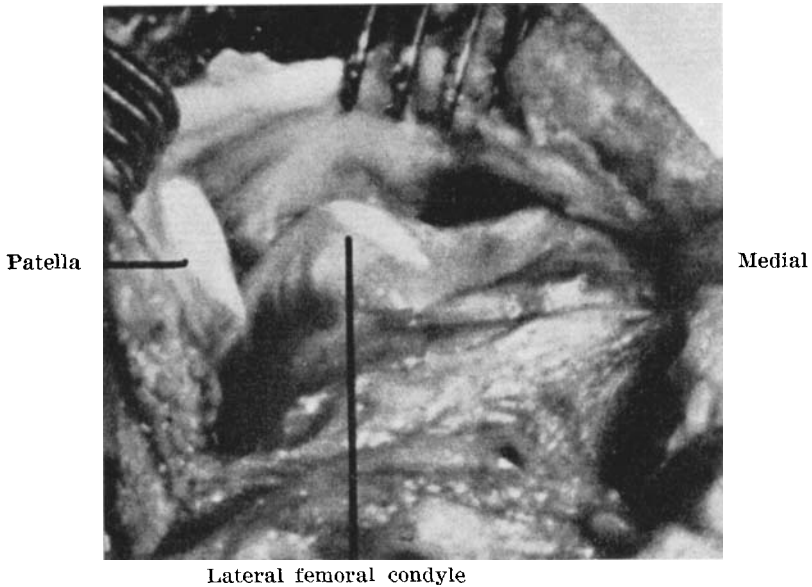
*Fig. 19.* Case 16672. Axial view of the left knee.

condyles have, as it were, kept pace in development, and that consequently the term dysplasia of both knee caps and condyles could be used to describe them, but in the cases under discussion it is only the condyles that exhibit maldevelopment.

Just as the transition between groups I and II was gradual, so it is also between groups II and III, but there are undoubtedly cases in which, despite the fact that the development of the femoral condyles is quite normal, fully developed luxations are



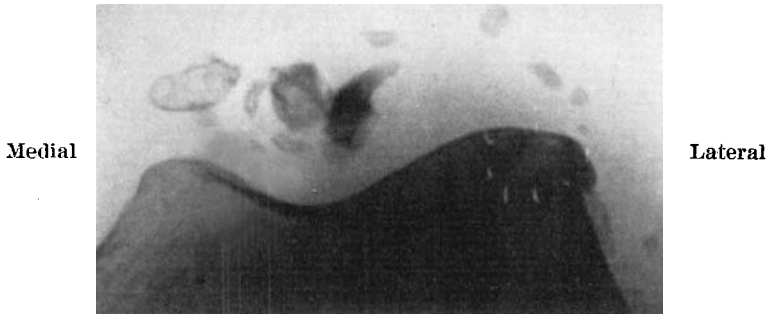
*Fig. 20.* Case 873/39. Axial view of the left knee.



*Fig. 21.* Case 873/39. Photograph taken during operation on the left knee.

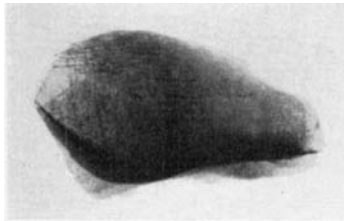
nevertheless present (group III). This group is represented by two of my cases, of which I will cite no. 3406/40 (fig. 22). The first dislocation had occurred as a result of a violent trauma. Unfortunately, no axial view of the luxated knee was obtained

before the operation, but since it was a question of the articular surface of the femur the roentgen picture taken after the operation in October 1940 furnishes a good impression of the appearance of the articular surface. This is to all appearances



*Fig. 22.* Case 3406/40. Axial view of the left knee after operation.

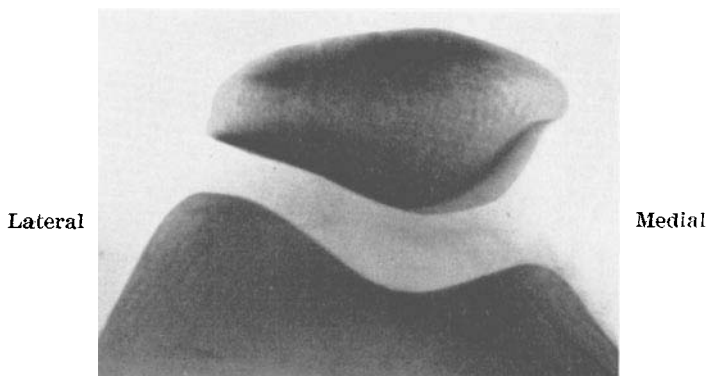
normal and agrees well with pictures of the other knee (fig. 24). The patella also, roentgenographed after removal (fig. 23), coincides with the healthy side and is of normal shape. This case gives rise to a number of reflections connected with operative therapy. At operation the patella was found to be affected with advanced chondromalacia, and as figure 22 illustrates, the dome



*Fig. 23.* Case 3406/40. Roentgenogram of the excised patella.

of the lateral femoral condyle, as a consequence of the protracted friction caused by the luxations, has also become the seat of changes in the shape of subchondral cyst formations in the bone. Everything pointed to the fact that, unless the abrasive

action could be relieved by some means, the lesions already present would continue to advance. We therefore reverted to a method of operation previously employed by a number of workers in dislocations of the patella, namely, excision of the patella (*Fowler 1871, Chaput 1908, Lorenz 1914*). Since the femoral part of the femoropatellar joint was normal, we hoped that this would act as a guiding groove for the remaining ligamentum



*Fig. 24.* Case 3406/40. Axial view of the normal right knee.

patellae and the quadriceps tendon, and this assumption proved later to be correct. Since the operation the patient has suffered no further dislocations and has had little discomfort with the knee.

In view of the success gained with this patient it would seem as if a return to the old method of removing the patella in luxations of the patella might be justified. However, it is only cases exhibiting normally developed patellar surfaces on the femur (group III) that would seem suitable for such an operation.

When the articular surface is plane (group I) it must necessarily be more difficult for a patella left in position to become dislocated beyond the border than it is for a relatively soft quadriceps tendon. In the former event, the lateral displacement must be more advanced before the levering force on the patella is sufficient to produce a dislocation. In the latter, the luxation

begins as soon as the quadriceps tendon reaches the edge of the patellar surface of the femur.

Case 4459/40, in which there was present a permanent bilateral subluxation, should be classified under group III with a strong leaning towards group II a. This subluxation may be considered as genuine in contrast to other, secondary types to which I shall return in a later chapter when dealing with the



*Fig. 25.* Case 4459/40. Axial view of the left knee.

complication of osteo-arthritis. Figure 25 illustrates that the patella rides on the lateral femoral condyle, and through the severe friction that has obviously resulted, the cartilage in the femoropatellar joint has been disintegrated; the pressure has even been so great that the lateral condyle has become compressed. It is uncertain whether the case should be grouped as type II or type III, since it is quite possible that before the start of the attrition the condyle may have been normal in height; but bearing in mind another similar case, I am inclined to place it in group III. In case 1193/41 (fig. 26), a subluxation is also in question, but in this instance the cartilaginous attrition had not advanced so far, and it was possible to see that the lateral femoral condyle was normal in height. Nor did the form of the patella deviate in any degree from the normal. This supports my supposition that the lateral femoral condyle also in case 4459/40 was probably of normal height. Of course, a case of

this kind must be regarded as practically hopeless from an operative standpoint. The only likely measure might be a removal of the patella.

Thus, my investigations on the femoropatellar joint in luxation of the patella proved that considerable variation in the form of the femoral condyles is possible. Furthermore, a number of other deductions may be drawn from the material.



*Fig. 26.* Case 1193/41. Axial view of the left knee.

Firstly, as regards etiology, I am in agreement with *Blumensaat*, that it is extremely difficult to reach definite conclusions regarding individual cases. Seeing that the majority of my patients in groups I and II exhibited maldevelopment of the lateral femoral condyle, there should be every reason to believe that a constitutional factor is at the bottom of a luxation. The theory of the congenital element receives added support when the condition is bilateral and when, as in the patients from group I, it has been present since early childhood. In these instances an eventual trauma is of little significance, since the cylinder-shaped patellar surface of the femur provides such poor support for the patella that a luxation is a natural consequence. The fact that dysplasia of the femoral condyle is present in the patients of group II, despite permanent luxation of the patella, also strengthens the assumption that a congenital factor

is in question rather than a secondary result from a luxating patella, as has been suggested by some workers.

In group III, on the other hand, in which the articular surfaces are completely normal, we must resort to other explanations to account for the dislocation, and when we find, as in my case 3406/40, that a violent trauma was the liberating factor, there is some justification for supposing a trauma to be the cause of the luxation also in other cases of type III. A congenital malformation *may* of course be present in these instances, and defective traction of the vastus musculature is the most likely possibility that comes to mind, but any of the more complicated methods of origin might equally be the explanation.

My classification into groups may possibly prove useful also from a practical standpoint. I believe that when patients are thought to belong to group III and display advanced cartilaginous changes in the patella, removal of the patella is strongly indicated, as by this measure the joint is spared much attrition in the future.

#### CHONDROMALACIA PATELLAE

From observations made on other joints, in particular the hip joint, we know that an increased stress, brought about by the fact that the normal pressure in the joint is borne by an abnormally small articular surface, constitutes a powerfully disposing condition for the appearance of osteo-arthritic changes, which undoubtedly generally start with degenerative chondral lesions. The dysplastic acetabulum is a typical example of this derangement.

In the previous chapters we have learned what variation the femoropatellar joint may display, not only in luxation of the patella but also in the normal state, and judging from the anatomic description it may be presumed that, in certain positions of the joint at least, there exists a certain incongruity between the articular surfaces of the patella and of the femoral condyles. It is therefore natural to wonder whether this dis-

cordance may not sometimes occasion an increased strain on the articular surfaces resulting in cartilaginous attrition, and more especially it is the problem of chondromalacia that enters our mind in this connection.

It is not my intention to undertake a detailed symptomatologic description of chondromalacia patellae; I mean chiefly to discuss the different theories that have been advanced regarding the etiologic aspect. The first mention of the disease was made by *Büdinger*, who believed that it originates from injuries in the cartilage caused by a trauma. In one patient, who was operated upon following an injury, he observed a subchondral hematoma in conjunction with cartilaginous fissure formation. Other workers also favoured the traumatic theory, although some of them made reservations. Thus, *Läwen* considered that while a trauma is the cause in many instances, in others the disease may arise without any known injury. From the beginning, therefore, much uncertainty was apparent in the attempts to account for chondromalacia patellae, and since a definite trauma could not be proved in all cases the suggestion was made that it need not necessarily be a question of a single definite trauma but rather perhaps of many small injuries (sometimes occurring in childhood) overlooked or forgotten by the patient (*Aleman* and *Axhausen*). However, there are reports on unmistakable cases in which no trauma preceded the appearance of chondromalacia patellae.

Hence, in the earlier accounts, a trauma, either in the form of an isolated injury or of many small ones, was accorded the chief significance respecting the origin of the disease. It should be mentioned, however, that some authors entertained the possibility of other factors likely to have contributed to the origin of these degenerative cartilaginous changes, and *Läwen*, in particular, emphasized that a mechanical element very probably plays a role, either in the form of increased strain or, indirectly, through reduced power of resistance on the part of the cartilage. The latter circumstance might be due to various endogenous factors such as a derangement in the synovial chemism. According to *Läwen*, also, some significance may be attached to

the constitutional element, an assumption he based upon the fact that the affection can occur in such young subjects.

The only worker who has discussed conditions of stress in the knee joint as the possible cause of chondromalacia patellae is *Öwre*. In his exhaustive study on the disease he makes the following statement. "When examining for the presence of crepitation it must be remembered that not every part of the surface cartilage comes in contact with the facies patellaris femoris during the movement employed. Thus it frequently happens that no crepitation is perceived on active flexion, while this sign may be distinctly noted on active extension. This circumstance depends, as the author has found, upon the different anatomical relationships assumed by the patella during these two movements. On active flexion its lateral facet lies against the facies patellaris of the lateral femoral condyle, while on active extension its medial facet lies against the facies patellaris of the medial femoral condyle."

*Öwre* asserted also that the articular surfaces of the patella are utilized to a different degree during the phases of flexion and extension of the joint. Thus, on flexion, the lateral facet receives the greater stress, while on extension, which he believed takes place more actively than the movement of flexion, the medial facet is subjected to greater pressure than the lateral. He did not state, however, how he reached this conclusion.

A number of other observations made by *Öwre* are worthy of mention. From his postmortem examination on 124 knee joints he noted that the greatest thickness of cartilage occurs on the medial patellar facet immediately adjoining the ridge. In this region, therefore, the cartilage probably receives the least nutriment, and in consideration of the previously mentioned intense pressure against the medial facet when the knee is in extension, it is quite likely that degenerative changes arise more easily here.

Chondromalacia patellae starts as an edematous swelling of the cartilage, which, according to *Öwre*, arises first on the medial facet, whence it gradually spreads (see fig. 27). The subsequent cartilaginous streaking and degeneration is also simi-

larly located. When the affection has reached the border of the patella, this occurring first in the inferior medial area, small osteophytes appear on the bone.

*Øvre* reasoned that the relation between the cartilaginous surfaces of the patella and the femoral condyles might play some part in the origin of chondromalacia patellae, and also that the location of the changes in question might be explained by an uneven contact between the articular surfaces. However, he did not provide convincing proof to support his statement.



*Fig. 27.* Diagram made by *Øvre*, showing the localisation of chondromalacia in the patella.

*Silfverskiöld*, in his article on chondromalacia patellae, contended that in a number of cases the patella is probably displaced laterally to an abnormal extent. His observations were based on cases from which axial views of the patella were obtained.

Thus, although the likelihood that an uneven contact between the articular surfaces might lead to degenerative chondral changes has been entertained by some authors, no one has attempted directly to demonstrate this element in chondromalacia patellae. On the other hand, experimental examinations on the articular contact have been carried out in order to endeavour to explain the origin of osteo-chondritis dissecans, or at least the factor causing the liberation of the diseased focus.

*Burchardt*, for instance, believed he had proved that the medial border of the patella under certain circumstances, e.g. when the knee is flexed at a sharp angle and the lower leg is rotated inward, is capable of producing an impression on the cartilage at the spot where osteo-chondritis dissecans charac-

teristically arises. He also demonstrated mathematically that the muscular force normally at the disposal of the knee joint suffices to bring about such an injury.

*Schmidt* also made certain inferences from axial views he took of the patella. He observed that, in a knee with 90 degrees of flexion, the patella contacts more intimately with the lateral femoral condyle when the lower leg is rotated outward and with the medial condyle when the leg is rotated inward. At an angle of 90 degrees the superior border of the patella is on a level with the condylar areas where osteo-chondritis dissecans arises, and through active outward or inward rotation any focus of the latter disease present could thus be liberated.

None of the above-mentioned workers, however, has made a direct study of the relationships of the articular surfaces (the cartilage surfaces) under normal conditions, a matter that is obviously extremely important when estimating the significance of different contacts between the articular surfaces.

In order to attempt to increase our knowledge of the contact between the articular surfaces in the femoropatellar joint as well as of the articulation between the patella and the femoral condyles, I made additional investigations to complement my studies on normal anatomy described in the first chapter.

#### *Experimental pathologic investigations.*

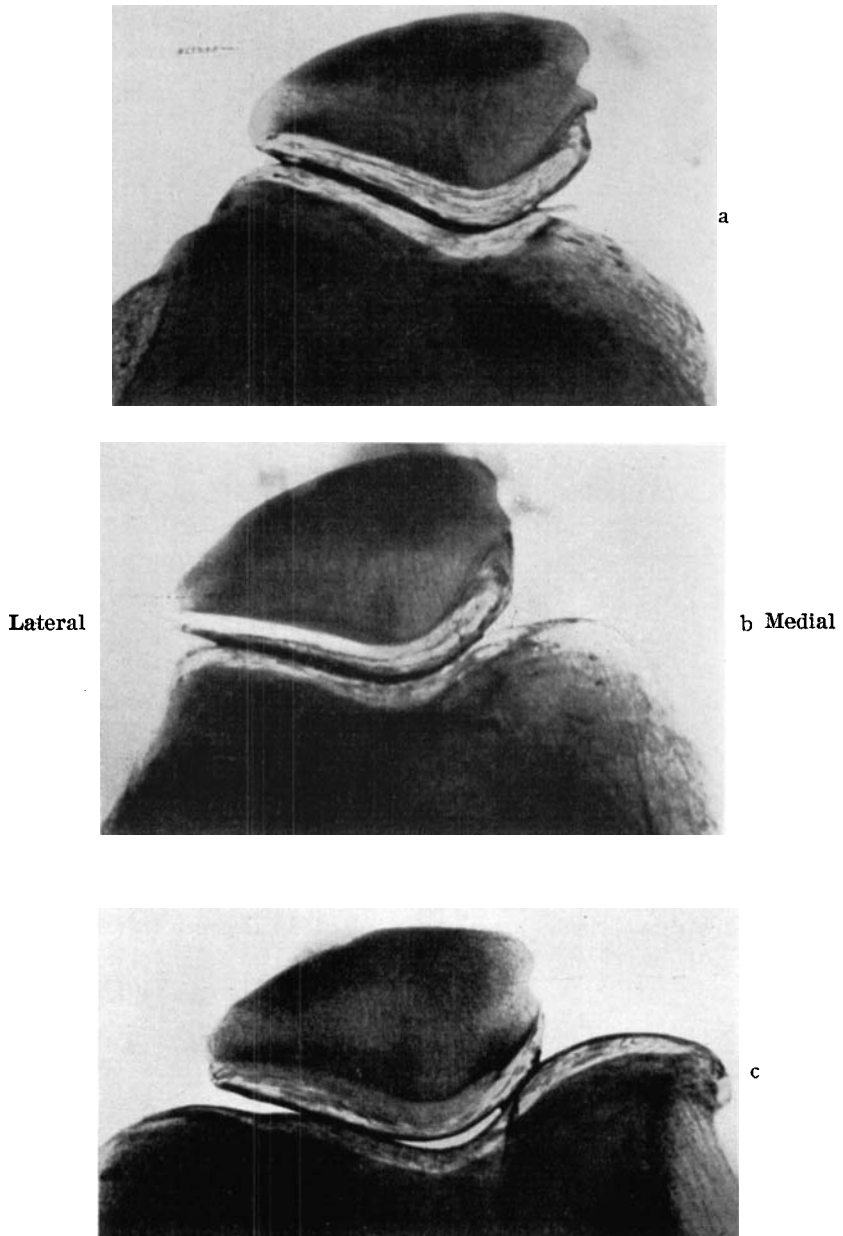
The material consisted of fresh postmortem specimens<sup>1)</sup> of the same type as those used for the roentgenographic studies on normal conditions. In order to bring out the cartilage surfaces on the roentgen picture, it was necessary to paint them with a contrasting agent, and red lead proved the most suitable for the purpose. The joint was opened by cutting through the capsule laterally and loosening the quadriceps muscle. Both the patella and the femoral condyles were painted with a thin layer of red lead. To make the red lead stick to the cartilage, which

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<sup>1)</sup> I desire to tender Professor F. Henschen my sincere thanks for the valuable assistance he gave me in procuring the specimens.

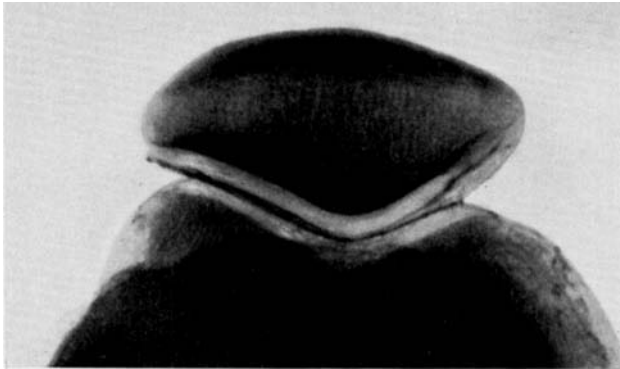
was slippery and sticky with synovia, it was necessary to cleanse the articular surfaces with alcohol and ether. When the contrast medium was dry, the patella was again brought into contact with the patellar surfaces of the femur with the joint flexed at definite angles, and the tendon of the quadriceps muscle was stretched so that the patella might be kept in place in the normal manner. The knee joint was then roentgenographed on the same principle as that employed for the living material.

The first specimen was taken from a man of thirty. Macroscopically, there was nothing unusual about the articular surfaces. On figure 28 a, which illustrates the knee flexed at 20 degrees, it will be seen that the contact between the articular surfaces of the cartilage is good. It is remarkable, however, that the lateral facet opposes the lateral femoral condyle along practically its entire length. The ridge of the patella fits well in the groove on the patellar surfaces of the femur, but the medial patellar facet contacts with the femur over only a small area close to the ridge. This agrees with the arthrographic findings from the normal knee, in which the contact with the medial facet in cases of this type (II) was relatively small compared with that facing the lateral facet. On the picture it is also possible to see channels such as we saw on the arthrograms. The specimen was then flexed at 40 degrees. This could not be done while the patella was in touch with the patellar surfaces of the femur, since the red lead would have been scraped off, a circumstance to which I shall return shortly. The patella was therefore raised and the joint flexed at 40 degrees, whereupon the patella was replaced in position. The roentgenogram then taken (fig. 28 b) revealed that the medial facet is now in somewhat broader contact with the patellar surfaces of the femur. The relations are otherwise identical with those in figure 28 a. As the flexion became sharper the contact between the medial facet and the femur broadened but the pictures show nothing else of interest. It is only when the angle of flexion is increased to 80 or 90 degrees that the picture changes (fig. 28 c). As soon as the intercondyloid fossa comes into the picture the patella loses its contact with this interlying section between the femoral



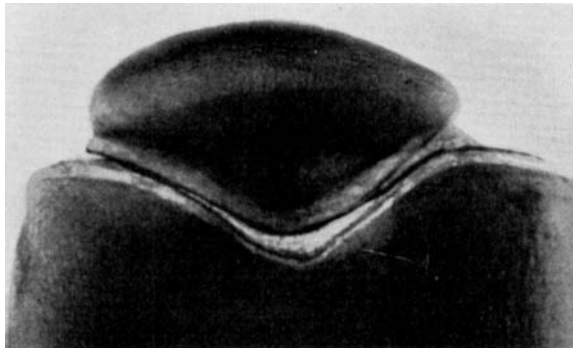
*Fig. 28.* Red lead preparation from a man of 30.  
a = flexed at  $20^{\circ}$ . b = flexed at  $40^{\circ}$ . c = flexed at  $90^{\circ}$ .

condyles and contacts only with the facets. Owing to its convex form the medial facet has a smaller articular contact surface than the lateral, but even the latter partially loses contact.



Lateral

Medial



*Fig. 29.* Red lead preparation from a woman of 29.

a = flexed at 40°.

b = flexed at 90°.

Another specimen was relative to a woman of twenty-nine, and here too the articular cartilage was unaffected, grossly. In figure 29 a the knee is flexed at 40 degrees and the picture accords well with figure 28 a. Thus, the lateral facet contacts broadly and the medial facet only with the part bordering on the ridge. At 90 degrees (fig. 29 b) a hiatus has arisen between

the patellar ridge and the femur corresponding to the intercondyloid fossa. The external part of the medial patellar facet is now in contact with the femoral condyle.

A further specimen that was roentgenographed gave results very similar to the two just described.

I mentioned earlier in the chapter that if a knee joint treated

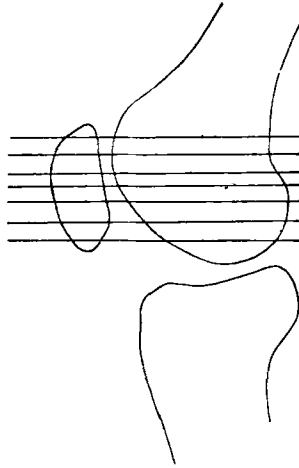


Fig. 30. Drawing illustrating the method employed in cutting frozen sections.

with red lead is flexed, the red lead is flaked off as the flexion increases. This affords another means of studying the contact between the articular surfaces during movements in the joint. We find that at the lower angles, from 20 to 50 degrees, contact is present with the lateral facet and with a small part of the medial facet, but it is *closest of all with the ridge*. After 50 degrees, the pressure on the ridge lessens and the facets take over more of the strain while from about 70 degrees upward the pressure on the ridge is still less. It disappears entirely at 90 degrees, when there is no further contact. These angles of flexion should not be regarded as arbitrary; some variation is apparent but it nevertheless keeps within a 10 degree limit.

Still a third method was adopted in investigating the

mechanics of the femoropatellar joint. Autopsy specimens, taken in exactly the same way as the previous ones, were fixed on a wooden stand which was capable of flexing the joint at different angles. To keep the patella in position the quadriceps musculature was fixed to the femur; since the joint had not been opened the negative pressure in the joint was thus maintained, and contributed towards holding the patella in its place. The specimens were preserved in a refrigerator for several days until they were thoroughly frozen and were then cut into sections varying in thickness from 0.5 cm. to 1 cm. The direction of cut was horizontal and at right angles to the surface of the patella (see fig. 30), since the aim was to examine how the contact was distributed between the different parts of the patella, and the femur.

Twenty-five specimens were examined by this method. Since we wanted to leave the joint unopened we were unable to study the appearance of the cartilage beforehand; it was thus not possible to select suitable knee joints, we had to take them as they came. There was consequently great variation in the age of the subjects, but for natural reasons the major part of the material related to old subjects. The material is assembled in the following table.

TABLE I.  
*Specimens.*

Case No.	Sex	Age in years	Position of joint	Type of patella	Chondr. patellae
1.	♂	21	extension	II	0
2.	♂	37	extension	II	0
3.	♂	50	30° of flex.	II	+
4.	♂	79	30° of flex.	II	+
5.	♂	35	45° of flex.	I	+
6.	♂	30	45° of flex.	II	+
7.	♂	61	45° of flex.	II	+
8.	♀	49	90° of flex.	II	+
9.	♂	53	90° of flex.	II	+
10.	♀	25	115° of flex.	II	0
11.	♂	66	90° of flex.	II	+
12.	♂	49	115° of flex.	II	+

Case No.	Sex	Age in years	Position of joint	Type of patella	Chondr. patellae
13.	♀	79	115° of flex.	II	+
14.	♀	65	90° of flex.	II	+
15.	♂	22	115° of flex.	I	0
16.	♂	17	90° of flex.	I	0
17.	♂	45	90° of flex.	III	+
18.	♀	59	90° of flex.	II	+
19.	♀	28	115° of flex.	II	+
20.	♂	25	125° of flex.	II	0
21.	♀	46	140° of flex.	II	+
22.	♀	36	115° of flex.	II	+
23.	♂	64	115° of flex.	II	+
24.	♀	59	115° of flex.	II	+
25.	♂	74	90° of flex.	II	+

It will be noted that very few of the subjects displayed completely unaffected cartilage; in the majority far-advanced cartilaginous changes were present. Greatest interest is naturally attached to those exhibiting chondromalacia in the incipient stage, since in these cases the original form of the articular surface is maintained intact, making it possible to gain a clear conception of how the contact had appeared. In well-advanced chondromalacia the contact is not as it was originally, owing to the reduced height of the cartilage.

The specimens were fixated in different positions, i.e. two in extension, two at 30 degrees of flexion, three at 45 degrees, eight at 90 degrees, eight at 115 degrees, one at 125 degrees and one at 140 degrees. It is obvious that only a general idea of the mechanism of the articular contact may be gained by this means, seeing that different specimens must represent different positions. There is no other choice, however, as the same specimen cannot be examined in different positions other than by inspection, which is not so exact as the section method. I shall return later in this chapter to one case in which an inspection of the movements of the joint provided information on a number of interesting features.

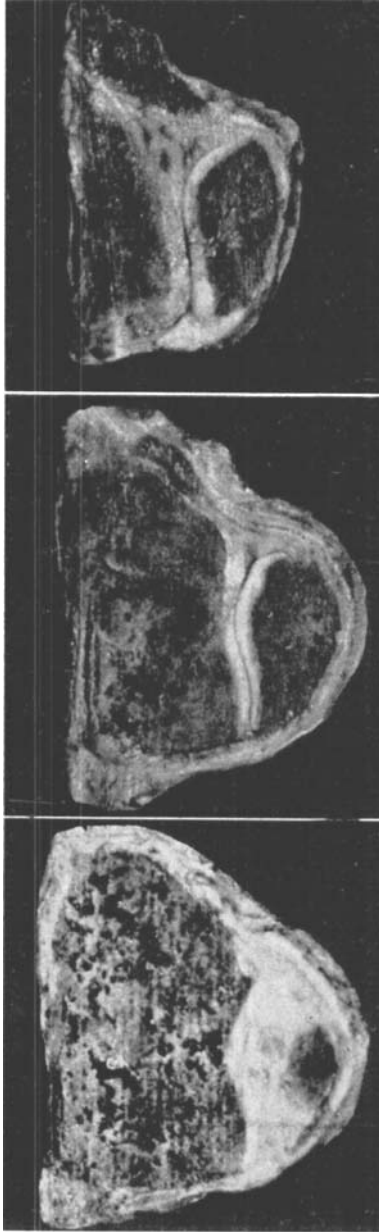
As the specimens had softened during the sectioning they

were again frozen and then photographed. Space does not permit of a description of all the specimens and I have therefore selected a number of typical cases. Before I proceed to a discussion of them I should like to make a few general remarks on the entire material.

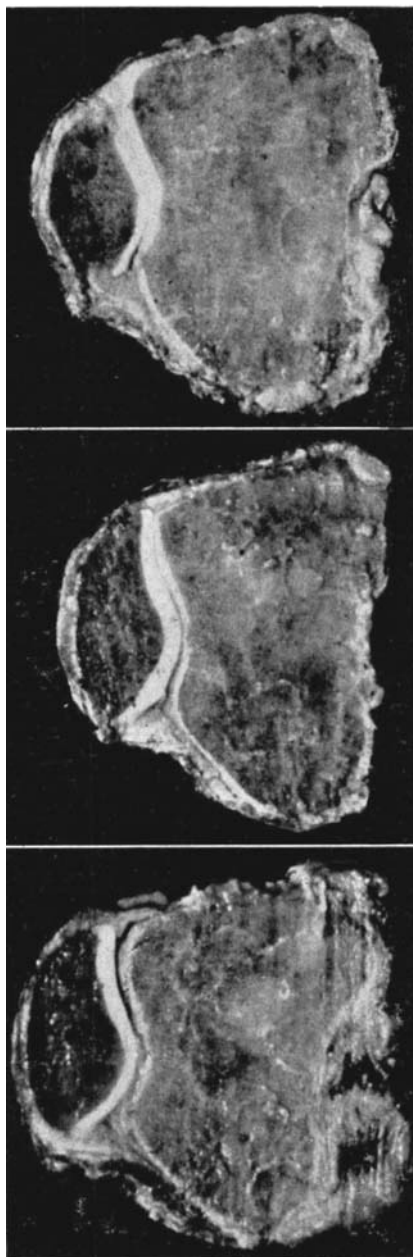
As in the case of the roentgenologic appearance of normal material, it was possible to group the specimens under review on a similar principle. From the sections, a good idea may be formed of the shape of the patella as it appears on a horizontal section, and this shape tallies also with the roentgen picture. Three specimens were classed as belonging to group I, twenty-one to group II, and one to group III.

Coming now to a review of the material, the first specimen (no. 2, fig. 31) is an example of a joint in extension, relative to a man of thirty-seven. On view 31 a the section runs in the exact centre of the patella. The part of the femur that rests against the patella is not covered with cartilage. This fact does not come out quite clearly on the photograph. The white area is subsynovial fatty tissue which has this appearance on a frozen section. The patella must therefore be situated very high up, as has also been described in the chapter on normal anatomy. On view 31 b, in which the section was cut 1 cm. lower down, cartilage is now present on the anterior surface of the femoral condyles (the patellar surface), and the contact is good between the articular surfaces of the patella and of the femur, though it rests chiefly on the lateral part. Furthest toward the medial aspect the odd facet is distinguished, delimited from the rest of the medial patellar facet. In the third section, 31 c, only 1 cm. lower down on the patella, the contact between the articular surfaces is completely broken, and only the apex of the patella has been included in the picture; the interlying space between the patella and the femoral condyles is filled up by the infrapatellar pad of fat.

This case illustrates that in extension the contact is relatively small, comprising only the lower part of the knee cap, or the "extension facets". There is no sign of chondromalacia, and the case may be classed as type II.



*Fig. 31. Specimen 2. Man of 37. Extended knee.*



*Fig. 32.* Specimen 4. Man of 79. Knee flexed at 30°.

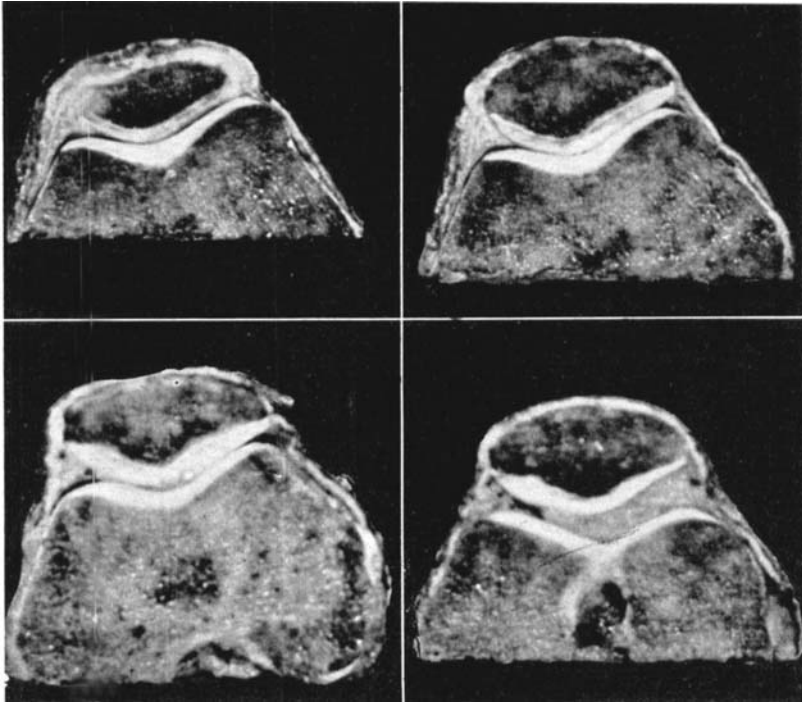
The second specimen (no. 4, fig. 32) is a joint flexed at 30 degrees. The subject was a man of seventy-nine.

The first section, 32 a, is from the middle of the patella, and here, as in the previous case, there is no cartilage on the femur. On the ridge there are traces of chondromalacia extending on to the medial facet. On section 32 b, 1 cm. further down, cartilage is noticed on the femoral condyles and the contact between both medial and lateral facets is good. It is also possible to see the ridge separating the odd medial facet from the remainder of the medial articular surface of the patella. The chondromalacia extends out to the median ridge. The third section, 32 c, shows continued good contact, although the lateral condyle does not occupy such a large proportion of the contact as in the first two views. There are no longer any evidences of chondromalacia. The section was cut 1 cm. below 32 b, and a section made 1 cm. lower no longer contained portions of the patella.

In this case also, the contact between the articular surfaces may be regarded as relatively small, and the "extension facets" are those mainly engaged. The case has been placed in group II.

The next angle of flexion was 45 degrees, and the specimen representing this position derives from a man of thirty-five (no. 5, fig. 33). On the first section, 33 a, which was cut 1 cm. below the base of the patella, it will be noted that even here there is good contact between the articular surfaces. While both the facets share almost equally in the contact, the lateral takes the greater share. Section 33 b was cut 0.7 cm. lower down on the patella and hardly differs from view 33 a. The next section, 33 c, was taken still another 0.7 cm. further down. The contact between the articular surfaces is still good and on the ridge signs of chondromalacia are visible. View 33 d illustrates a section 0.7 cm. lower, and here there is no longer any contact between either the medial or lateral facets and the femur. If section 33 c is examined from the posterior aspect we find that the contact between the patella and the femoral condyles occurs first on the medial facet. Evidences of chondromalacia are no longer present.

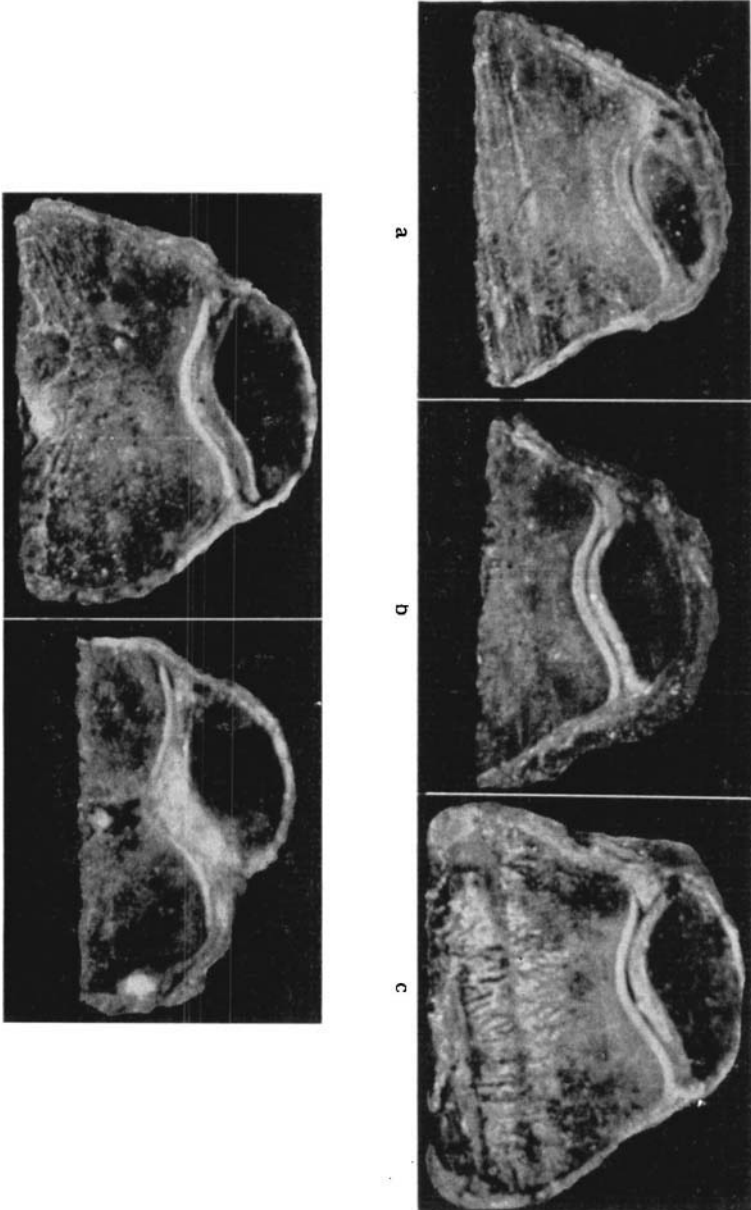
In this case, the contact between the articular surfaces is



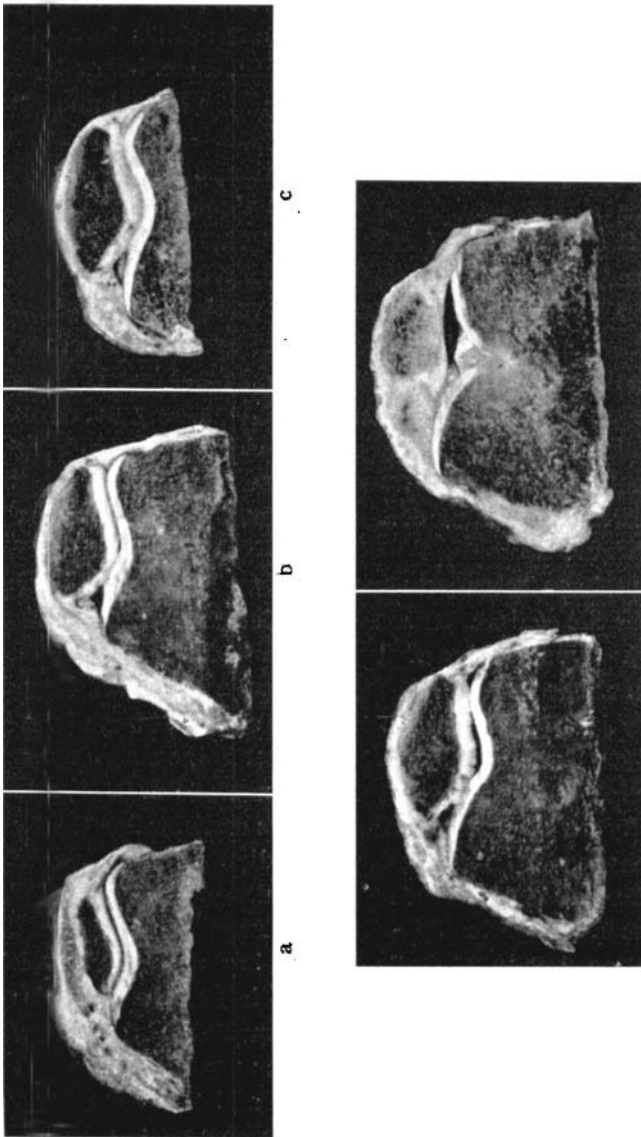
*Fig. 33.* Specimen 5. Man of 35. Knee flexed at 45°.

much broader lengthways on the patella than it was in the two previous specimens. This is to be expected, seeing that in a knee with 45 degrees of flexion the articular surface of the femoral condyles (the patellar surface) is also involved. Possibly, from view 33 d, in consideration of the complete lack of contact between the articular surfaces one might believe that the patella had been dislocated in the specimen and that the picture does not represent normal conditions, but the position is undoubtedly fully correct. The contact in the superior parts of the patella is so broad that the inferior parts could not possibly be forced in against the femoral condyles, and the intervening space has instead been filled up by the infrapatellar fatty pad. The case comes under group I.

We shall soon see that as the flexion becomes more acute,



*Fig. 34.* Specimen 6. Man of 30. Knee flexed at 45°.



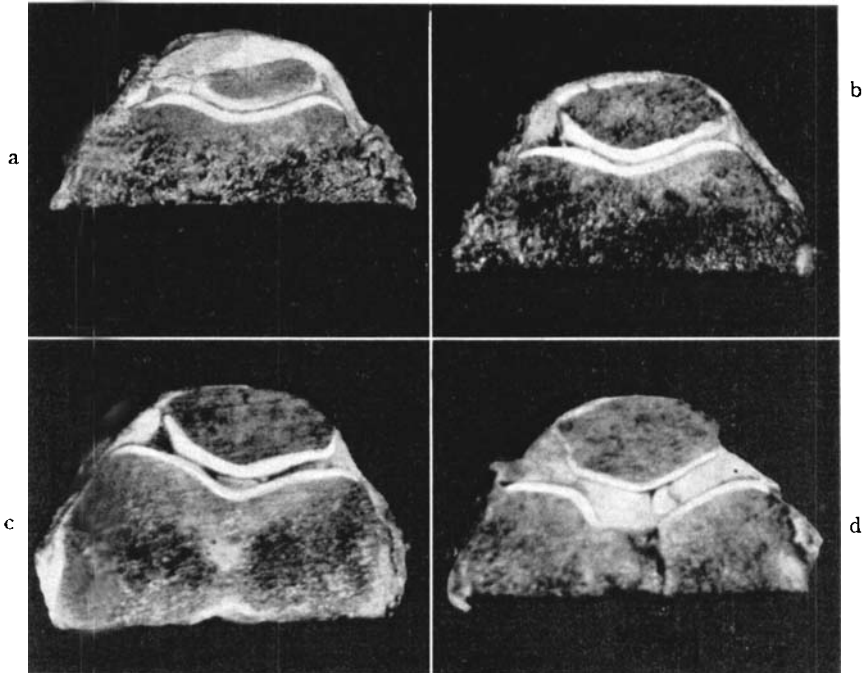
*Fig. 35. Specimen 9. Man of 53. Knee flexed at 90°.*

more interest is attached to the contact of the articular surfaces. I therefore thought it wise to describe one more specimen of a knee with 45 degrees of flexion. This one relates to a man of thirty (no. 6, fig. 34). On the first section, 1 cm. below the base of the patella, 34 a, the contact between both lateral and medial facets of the patella and the femur is good. It is broadest, however, on the lateral part. The next section, 34 b, 0.5 cm. lower, reveals that the contact between the articular surfaces is now broader. Section 34 c, 0.7 cm. below 34 b, does not differ to any degree from the latter. A change has taken place in section 34 d, cut 1 cm. below 34 c. Owing to vestiges of blood on the patellar cartilage the points of contact are not too clear, but it is nevertheless evident that the lateral facet has lost contact while the medial is still in touch, although only over a small area. Precisely at this point of contact changes due to incipient chondromalacia are to be discerned. On the next section, 34 e, 0.5 cm. lower, there is no contact whatever between the patella and the femur.

The specimen belongs to group II, and as in the last-mentioned case the contact between the articular surfaces is broader than in the lower angles of flexion.

The next specimen is the first example of a knee flexed at 90 degrees (no. 9, fig. 35). On the first section, 35 a, which was taken 0.5 cm. below the base of the patella, the contact between the articular surfaces is good. On the next, 35 b, 0.5 cm. lower, it is chiefly the lateral facet that makes contact, but the medial is also engaged. Chondromalacia is distinguished, embracing mainly the medial facet but also extending to the ridge and the lateral facet. On section 35 c, 0.7 cm. lower, there is practically no alteration, but in 35 d the contact begins to disconnect opposite the ridge. The chondromalacia is manifest and is particularly marked on the spot where the medial facet rests against the medial femoral condyle. On the last section, 35 e, 0.6 cm. lower, the contact between the patella and the femur is wholly disconnected, but the medial facet lies nearest the femur. The specimen is classed as group II.

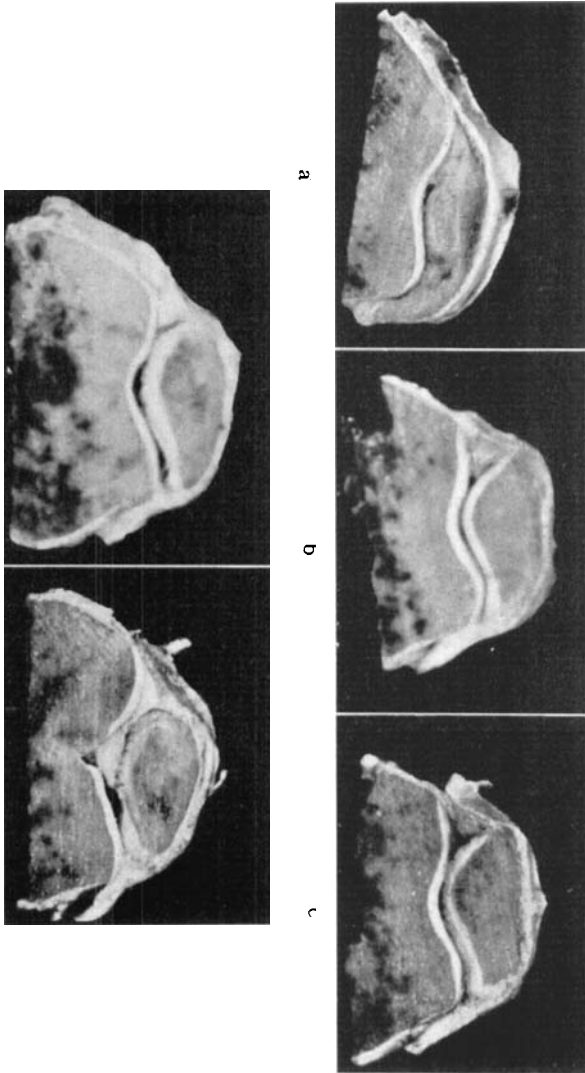
Another specimen (no. 16, fig. 36) flexed at 90 degrees



*Fig. 36.* Specimen 16. Man of 17. Knee flexed at 90°.

shows good contact on the first section, 36 a, cut 0.5 cm. below the base of the patella. The contact is also good on the next section, 36 b, 0.7 cm. lower. On the third section, 36 c, 0.7 cm. lower, the contact is being released and the depression between the condyles has increased, indicating that the intercondyloid fossa is being approached. However, the medial facet still contacts at a spot closely adjoining the ridge relative to the odd medial facet. The last section, 36 d, which lies 0.8 cm. lower, reveals that the patella is no longer in contact with the femur. No chondromalacia was observed in this case, probably due to the youth of the patient—17 years. The specimen belonged to group I.

I include a third specimen (no. 25, fig. 37) from the series flexed at 90 degrees. On the first section, 37 a, 0.5 cm. below the base of the patella, there is good contact, and on the next, 37 b,



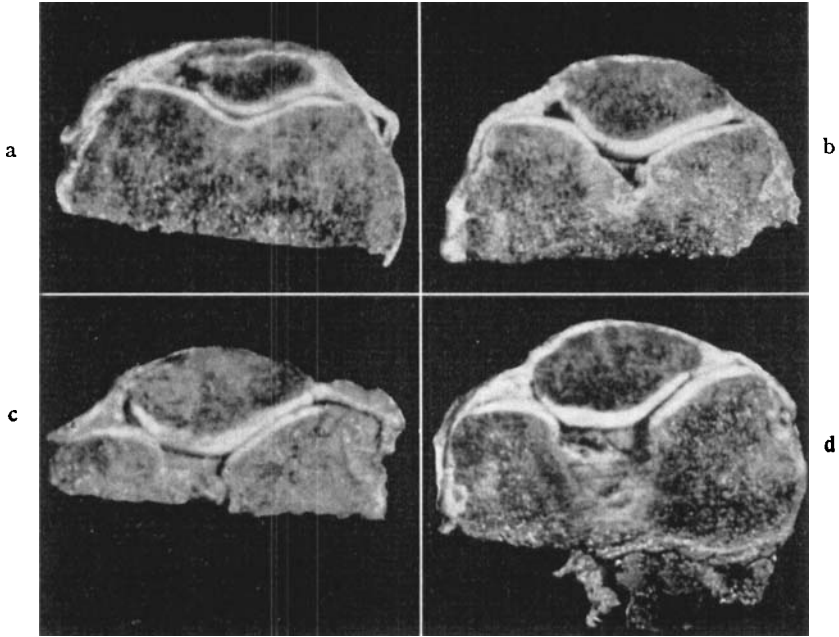
*Fig. 37. Specimen 25. Man of 53. Knee flexed at 90°.*

0.7 cm. lower, the relations have not appreciably altered. On the third section, 0.5 cm. lower, the contact has begun to slip in the central part of the patella. On the ridge, and encroaching upon the medial facet there is an incipient chondromalacia. On section 37 c, 0.6 cm. lower, the contact opposing the central part has still further loosened; the supporting area is mainly against the medial facet, where the ridge that demarcates the odd medial facet from the other part of the articular surface of the patella is clearly apparent. The malacia is still diffused. The last section, 37 d, was cut 0.7 cm. lower, and there is no longer contact between the articular surfaces. The specimen may be grouped as type II.

Thus, from these three specimens with 90 degrees of flexion we learn that the contact with the median ridge disappears approximately opposite the centre of the patella, reckoned in a longitudinal direction; this is due to the intercondyloid fossa. Furthermore, the contact on the medial facet has shifted outward, so that the contact surface lies at the ridge adjoining the odd medial facet, a circumstance illustrated beautifully by the second specimen at 90 degrees (fig. 36).

The next angle of flexion taken was 115 degrees. This position, as well as that at 90 degrees, is in my opinion the most interesting from the standpoint of the contact surfaces in the femoropatellar joint, since it is in the articular contact surfaces in these positions that the greatest alterations may be observed. I reproduce pictures of two specimens.

The first relates to a man of forty-nine (no. 12, fig. 38), and the uppermost section 38 a was cut 1 cm. below the base of the patella. Here the contact between the two facets is good, slightly broader on the lateral. We see also that the difference in level between the medial and lateral femoral condyles is no longer as marked as in the previously mentioned specimens. This is of course due to the fact that when the section finally meets the patella the latter is no longer in contact with the superior parts of the femoral condyles, the true femoropatellar joint, but only with the inferior part, the part that in reality constitutes the supporting surface for the tibia and where,



*Fig. 38.* Specimen 12. Man of 49. Knee flexed at 115°.

according to the normal anatomy, there exists no difference in level between the condyles. On section 38 b, taken 0.7 cm. lower down, the intercondyloid fossa already comes out very clearly. The contact thus comprises only the medial and lateral facets, and the broadest contact is found on the lateral facet, while on the medial side the facet and the condyle oppose one another only with convex surfaces. At this spot also, initial chondral malacia of the patella is observed. Section 38 c, 0.8 cm. lower, shows practically the same picture as 38 b, with the difference, however, that the point of contact on the medial patellar facet has shifted further toward the medial aspect (toward the border of the patella). The cartilage in this area is morbidly soft on this section also, and one has the definite impression that the malacic cartilage is impressed by the femoral condyle. On 38 d we can see that the medial part of the medial facet is demarcated from the other part by a little ridge, evidently the ridge some-

times seen between the odd facet and the remainder of the medial patellar facet. If this picture is compared with 38 c it will be noted that the impressed area is exactly opposite the place for this ridge.

This specimen, which belongs to group II, illustrates what an essential difference this position of flexion displays, as regards the contact between the patella and the femur, in comparison with, for instance, the specimen in the extended position. It is now the *upper* part of the patella that answers for the contact, i.e. the "flexion facets". The lower part of the patella has no contact whatever with the femoral condyles, a fact that is confirmed when we continue cutting the sections. Even at 0.7 cm. lower down, the contact is completely disconnected, and a further fact is evident, the lateral condyle is situated furthest from the femur, a circumstance that is already visible on view 38 d, on which we find that the contact between the lateral condyle and the patella has begun to loosen.

The second specimen in this series (no. 15, fig. 39) derives

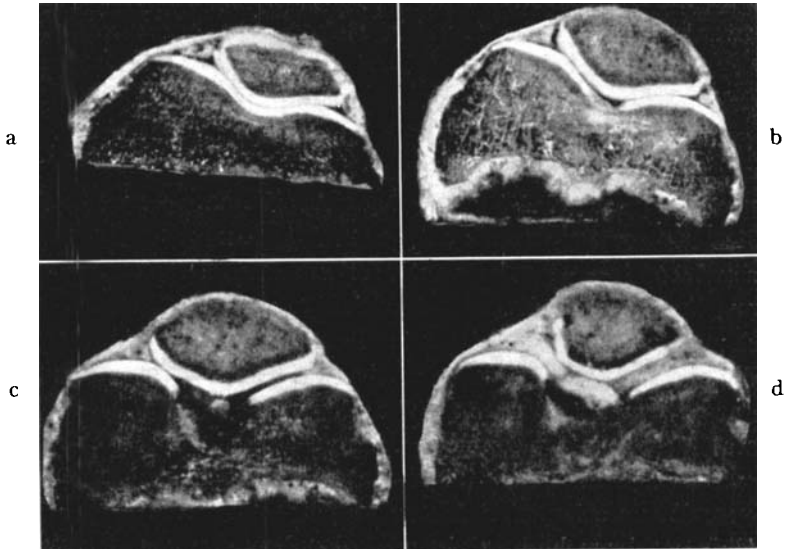
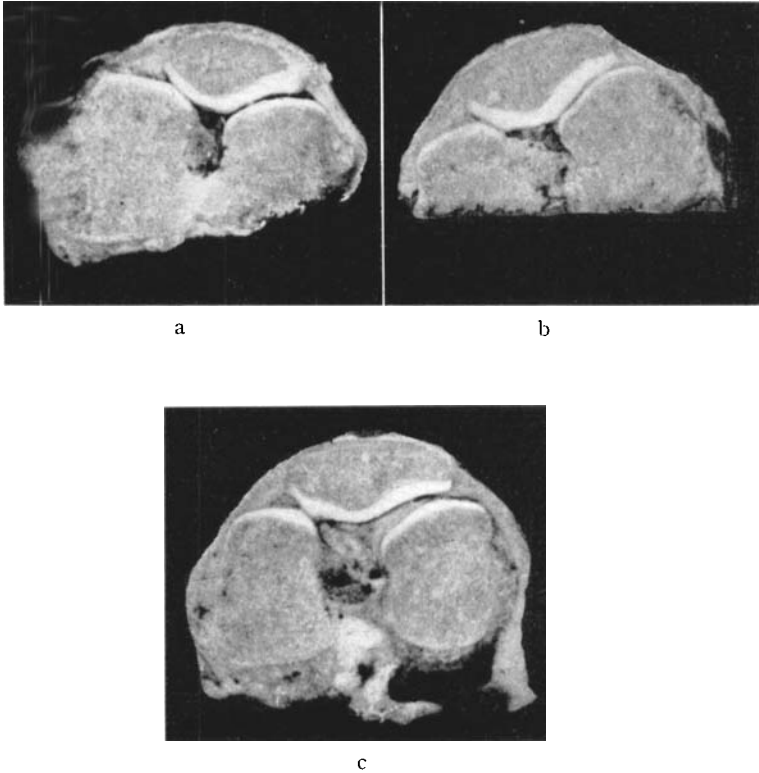


Fig. 39. Specimen 15. Man of 22. Knee flexed at 115°.

from a man of twenty-two, and may be classed under group I. Section 39 a lies 1 cm. below the base of the patella, and we can distinguish that there is good contact between both the facets and the femur. The medial facet also in this case takes a fair proportion of the articular contact surface. On the next section, 39 b, 0.8 cm. lower, the contact is still good and the intercondyloid fossa is beginning to appear. On section 39 c, 0.7 cm. lower, the intercondyloid fossa is already broad, so that almost half of the middle section of the patella no longer has any point of contact; furthermore, the lateral facet shows a tendency to lose contact and only the medial facet is in touch, opposing the convex surface of the femoral condyle with a convex surface. Here also we can see traces of the ridge that separates the odd facet from the articular surface in general. On the last section, 39 d, 0.5 cm. lower, the contact has been lost with the medial facet also. There is no chondromalacia present in this case.

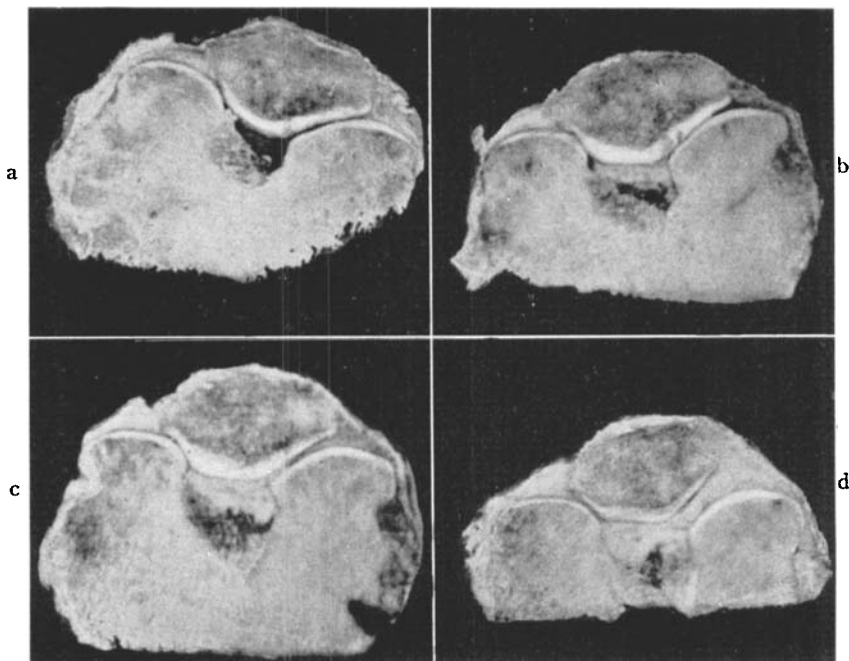
In order to make my study more complete, I examined several specimens in other positions of flexion, namely, 125 degrees and 140 degrees. The first of these (no. 20, fig. 40) relates to a man of twenty-five. Even on the first section, 40 a, cut 1 cm. below the base of the patella, the intercondyloid fossa comes out very clearly, owing to the extreme flexion of the joint. The contact is good between both the medial and lateral facets and the femoral condyles, but we can observe clearly that it is in particular the lateral facet that constitutes the supporting surface while the medial opposes a convex surface to the equally convex femoral condyle. On the next section, 40 b, that lies 0.9 cm. lower, the contact between the articular surfaces is practically unchanged, and an odd facet is clearly distinguishable on the medial aspect, marked off from the other part of the articular surface by a ridge. On the third section, 40 c, 0.7 cm. lower, the lateral facet has lost contact, and on the medial facet it is just the ridge adjoining the odd medial facet, already observed on the previous section, that forms the point of contact.

This specimen had no signs of chondromalacia and may be placed in group II.



*Fig. 40.* Specimen 20. Man of 25. Knee flexed at 125°.

The first section cut from my last specimen (no. 21, fig. 41) lies 1 cm. below the base of the patella. Here the intercondyloid fossa is even clearer than in the last-mentioned case (fig. 40). There is contact between both medial and lateral facets, chiefly the lateral, and on the medial there is contact between two convex surfaces, as in the previous specimen. There is a mild chondromalacia on the lateral facet closely adjoining the median ridge and opposite the innermost border of the femoral condyle where the cartilage ends. On the next section, 41 b, 0.8 cm. lower, there is still good contact with the lateral facet while on the medial facet the contact surface has moved further out towards the border and it looks very much as if it is just the odd medial



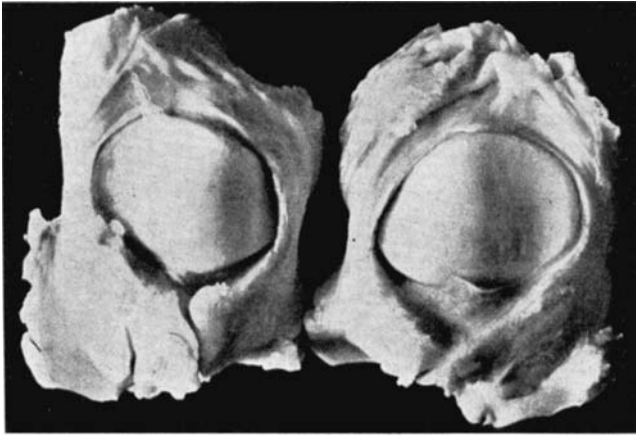
*Fig. 41.* Specimen 21. Woman of 46. Knee flexed at 140°.

patellar facet that makes the contact. This facet is marked off also from the rest of the articular surface by a clearly defined ridge. The chondromalacia close to the median ridge is still present. Section 41 c, 0.6 cm. lower, reveals that the lateral facet is beginning to lose contact, and the medial touches as in the previous section. There is no sign of chondromalacia. The last section, 41 d, was cut 0.7 cm. lower, and the medial facet is seen to be only just in contact with the femoral condyle.

This specimen belongs to group II, and we find that as in the lastmentioned case, it is only the "flexion facets" of the patella that are in contact with the femoral condyles when the joint is flexed at this extreme angle. Even in the sections taken from a joint at 115 degrees of flexion we could observe how the patella may sink in between the femoral condyles, and this is still more pronounced in the position of extreme flexion under

discussion. When a section such as 41 c is studied we realise without difficulty the reason why the "joint space" is lower than in the smaller angles of flexion, where the thickness of the cartilage on the ridge of the patella determines the height of the joint cavity.

Reviewing these autopsy specimens, it is possible to draw



*Fig. 42.* A photograph of the back of the patella.  
(Taken from a paper by Øwre.)

a number of general conclusions in addition to the particular observations made in each separate case. Thus, the two channels that are formed between the patella and the femoral condyles, one on the medial and one on the lateral side, are invariably found to be filled with fleshy tissue, and these folds evidently constitute the continuation upward of the alar folds. In figure 42, which is taken from *Øwre's* communication, the alar folds are seen to continue on both sides of the patella in the sub-synovial folds of fat, separated from the patella by a deep "moat". The latter is also easily distinguishable on the arthrograms, due to the fact that it becomes filled with the contrast medium and appears as a ring around the patella. The channel on the medial side is especially striking, and the synovial fold present here is obviously identical with the fold described by

*Lanz* and *Wachsmuth* as the alar fold. Where these alar folds end is a matter for discussion. The general view seems to be that they reach no further than to the inferior part of the patella. The transition from this inferior part to the continuation in the subsynovial folds of fat on the sides of the patella is so indistinct, however, that I am inclined to agree with *Lanz* and *Wachsmuth* that the alar folds extend as far as to the base of the patella, in which case they also embrace it.

As regards the thickness of the patellar cartilage, my material was not sufficiently comprehensive to allow me to draw definite conclusions, especially as we cannot include the cases in which chondromalacia has already appeared, since we are not then dealing with normal conditions. The cases of most interest are those exhibiting only slight degenerative chondral changes. The place where the patellar cartilage is thickest seems to vary. It is not always the median ridge nor the median facet adjoining this ridge; in some instances, it is the ridge adjoining the odd facet. I have been unable to find convincing proof that the distribution of cartilage on the patellar facets has any direct connection with the different types of knee caps. Possibly, more extensive material consisting of normal knees, or knees manifesting slight degenerative cartilaginous changes, might give a positive result. The collection of such material would undoubtedly require much time, however, seeing that suitable cases are few among the ordinary postmortem material.

I stated earlier in this chapter that the frozen section method is incapable of illustrating how *one and the same* joint appears in different positions of flexion, and that we can only obtain by this means a general conception of the articular function. By combining the picture of the section with the thickness of the section it is also possible to form an idea of what proportion of the articular surface of the patella is in contact with the articular surface of the femur. The *whole* patella is obviously never in contact with the femur at once, and the broadest contact seems to occur in the intermediate positions. The fact that the contact surfaces vary when the joint is in different positions of flexion is proved very plainly. Thus, in extension, only the

inferior part of the articular surface of the patella (the "extension facets") rests against the femur, while in extreme flexion it is instead the superior part of the patella (the "flexion facets") that contacts with the femoral condyles. In extension, or at a low angle of flexion (30 degrees), both the medial and the lateral facets contact well with the articular femoral surface, the lateral taking the greater proportion; this we were able to observe in the studies on normal conditions with the aid of red lead preparations and arthrographic examinations. When we follow the section series from extension to acute flexion, the most significant feature that comes to light is that the contact surface on the medial patellar facet moves gradually further out toward the border of the patella until in extreme flexion it is situated right at the border itself. Furthermore, from about 90 degrees and upward, we find that convex articular surfaces on the patella and the femoral condyles oppose one another on the medial aspect. It is true that the entire contact is not supported by the medial part of the patellar facet alone, not even in the most extreme positions of flexion, and that the lateral facet and partly also the uppermost part of the patella bear a proportion of the stress. In any event, the pressure on the small contact area that is available when two convex articular surfaces are opposed must be considerably greater than when there is a broad contact in complete congruence. Besides this, if *Öwre* is correct in his assertion that when the knee is extended the medial facet must bear the main proportion of the stress, and that the movement of extension takes place with greater force than that of flexion, then these elements also form an additional strain on this small contact surface. I am therefore inclined to believe that this may be the reason why chondropathic changes are found chiefly on the medial patellar facet. To illustrate this last statement, I refer to the specimen relating to figure 38. On views 38 c and 38 d the contact is practically at the border of the patella, and in addition a convex surface of the facet opposes a convex surface on the condyle, i.e. the point of contact is very small. In my opinion,

therefore, the fact that an incipient chondromalacia occurs just at this spot is no chance circumstance.

Another feature deserves mention, since it undoubtedly constitutes a further factor making for strain on the cartilage. This refers to the ridge delimiting the odd facet from the rest of the patella, mentioned in the description of some of the specimens (figs. 36, 38, 40, 41). As already stated, the contact surface of the medial patellar facet moves gradually further out toward the border as the angle of flexion increases, and at a certain stage, therefore, this ridge must be passed. At the moment of passing the stress is concentrated on a very small area, a fact that, in theory, might produce chondral friction. I was lucky enough to encounter a specimen that splendidly confirmed my assumption. This was the third of the specimens treated with red lead in my studies on normal anatomy.

The odd medial patellar facet in this case was well-developed, and the ridge separating it from the medial facet was clearly defined. Although the subject was only twenty-one there was present on this ridge pronounced cartilaginous softening manifesting yellowish discoloration, in other words, an unmistakable, incipient chondromalacia. As far as was possible, I examined the articular contact surface of this specimen in joint movements and an interesting fact was noted. From extension up to a flexion of about 80 degrees there was contact between both medial and lateral facets and the opposing femoral condyle, and between the ridge and the patellar surface, but from 80 degrees upward there was a change. The lateral facet maintained contact but on the medial part of the patella the stress slid over to the odd facet. This transition did not take place with an even, gliding movement; the ridge was passed with a little jerk in the patella which at the same time was laterally displaced. Although I attempted to obtain pictures of the joint at the exact moment when the passage over the ridge occurs, I was unsuccessful, due probably to the fact that it is not a position of rest but a momentarily occurring transition. On figure 43, however, we may discern imperfectly the position when the ridge adjoining the odd facet is in contact with the femoral condyle.

The examination of the autopsy specimens brought out that the stress on the contact surface of the medial patellar facet is not by any means equal to that on the lateral. On the latter the surface is concave and is adapted to the convex surface of the condyle, and as long as a contact exists between these two surfaces, it is broad. When the contact disconnects from the lateral part of the patella, it appears to take place along the



*Fig. 43.* A red lead preparation showing the contact between the medial femoral condyle and the ridge adjoining the odd medial patellar facet. a = the odd medial facet coated with red lead. b = indicates the ridge adjoining the facet. The contrast on the articular surface of the ridge crosses that on the articular surface of the medial femoral condyle.

whole surface at once. On the medial side, on the other hand, convex articular surfaces oppose one another in the more acutely flexed positions, and this fact, in my opinion, is conducive to cartilaginous friction in these areas. We may ask why similar changes do not appear on the medial femoral condyle, which is subjected to exactly the same stress on a similar contact surface. The explanation may possibly lie in the thickness of the cartilage. While the cartilage on the femoral condyle is "only" 2.6 mm. to 3.2 mm., it is considerably thicker on the patella. On the ridge it may even be as thick as 6.4 mm. and on the facets a little thinner, but exact information on this subject

is not available. In any event, it is considerably thicker than on the femoral condyles. While not wishing to make a definite statement regarding the nutrition of the cartilage, I believe it likely that the patellar cartilage, owing to its thickness, may have smaller chances of receiving nutriment than the femoral cartilage, and that consequently it more easily falls a prey to degenerative disease. Furthermore, it should be borne in mind that as the articular surface of the medial femoral condyle is larger than on the medial patellar facet, the pressure on the condyle has more room to vary than on the patella. An obvious objection is that chondromalacia does not always occur on the medial facet (e.g. see fig. 41), although this location is undoubtedly the commonest. In defence I should reply that extreme care must be exercised in judging cases of chondromalacia. It is only possible to determine the primary location of the process as long as it is in the initial stage. If the degenerative changes have advanced it may be impossible to establish whether the disease began on the medial or lateral facet or on one of the ridges. Thus, manifest chondromalacia on both facets *may* have originated on the medial facet. I do not want to go so far as to assert that all cases of chondromalacia arise on the medial facet. *Büdinger* demonstrated that a trauma may cause cracks in the cartilage that result in chondromalacia, and such a trauma may of course affect the patella in such a way that the main damage is done to the lateral facet. In the majority of cases, however, I, for my part, should not think a trauma necessary to cause the lesions. At all events, if the knee has really received a blow on the patella, there is much more likelihood that the cartilage on the medial facet will be affected, in view of the small contact surface that is subjected to the extra stress. What I want to emphasize in particular is that even without any trauma the element of friction is likely to be greater on the medial facet than on the lateral, and as already suggested it is not improbable that we have here the explanation of spontaneous chondromalacia patellae.

It would be interesting to investigate the connection between chondromalacia patellae and some definite type of the patella.

My material was too limited for this, however, since the usable cases were confined to those displaying only slight changes, but more comprehensive material might provide an answer to this problem.

Whether it is a question of a single trauma, several smaller ones, or merely friction, we must keep in mind that these are not the only deciding factors. Other causes besides the purely mechanical ones play a part and disposing elements, such as reduced tissular vitality, are doubtless also required. At least we are inclined to fall back on such explanations when we encounter two otherwise identical cases, in one of which chondromalacia is present and in the other of which it is absent.

*Clinical observations on the femoropatellar joint in chondromalacia patellae.*

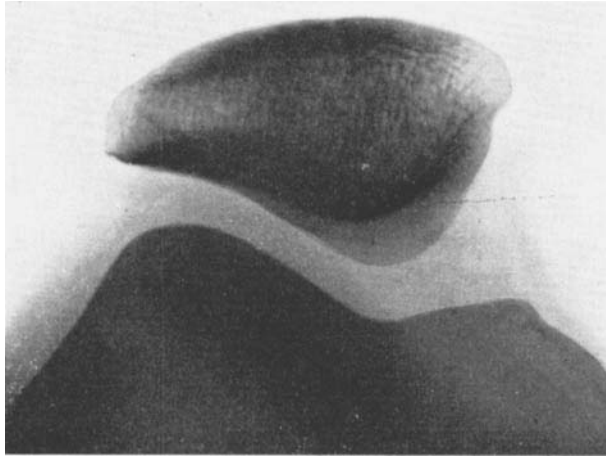
I shall now discuss the cases of chondromalacia from which I took roentgen pictures. A total of 28 patients and 53 knees were roentgenographed with the special projection, and 43 displayed manifest chondromalacic changes. The diagnosis was of course based on the clinical examination, which may be regarded as fully reliable when made by a practised medical man. The pictures were first dealt with from the viewpoint of the appearance and position of the patella. On the basis of the three type groups that I had set up as normal variants, 6 cases could be classed as examples of group I, 42 as group II, and 5 as group III, a distribution that corresponded well with that observed in the normal material. There was thus no appreciable alteration in the proportionate distribution between the groups. One feature was worthy of note, however. In the three cases in group III (two were bilateral) no trauma was mentioned in the anamnesis, and the patients in question were relatively young, namely, 24, 31, and 35 years. They nevertheless presented severe chondromalacic changes. Whether this is an indication that the third group has a predisposition to chondromalacia patellae will be left open for discussion, but the fact that the changes appeared at such an early age seems to point in that direction.

As a possible reason I shall only refer to the results of my examinations on the autopsy specimens; the extra stress on the medial facet, mentioned there, was suggested as the possible cause of the malacic changes. The medial facet on a patella classified as type III, is more convex than on the other types, and the point of contact with which the facet rests against the femoral condyle is thus even further reduced. One objection is, of course, that we ought to have encountered more examples belonging to this third group.

I was not able to observe any change in the position of the patella in relation to the femoral condyles, such as *Silfverskiöld* suggested in chondromalacia patellae. In this respect, however, one case (4089/39) might be mentioned. The patient displayed moderate bilateral chondromalacia, and on the roentgenogram of the right side (fig. 44 a) the patella showed a tendency to lateral displacement. On the left side, also, there were indications of the same condition. In my opinion, this must be interpreted as a beginning reduction in the cartilage with secondary lateral displacement of the patella, and not as a primary change in position. This assumption is based on the findings made in the complication of osteo-arthritis; where the cartilage was greatly reduced the patella in some instances was found to be much displaced laterad.

This reduction in cartilage in chondromalacia patellae is the feature most likely to be confirmed by means of an axial projection. However, it must be realized in advance that the milder forms of chondromalacia patellae, manifesting only edema of the cartilage or slight malacia, will hardly give definite roentgenologic evidence. In these cases a sufficient cartilaginous surface remains to prevent a reduction in the height of the articular cartilage as a whole. In my material also, none of the mild cases displayed any reduction on the affected side as compared with the healthy one. The condition for being able to establish a reduction in cartilage is, naturally, a healthy side to act as a comparison.

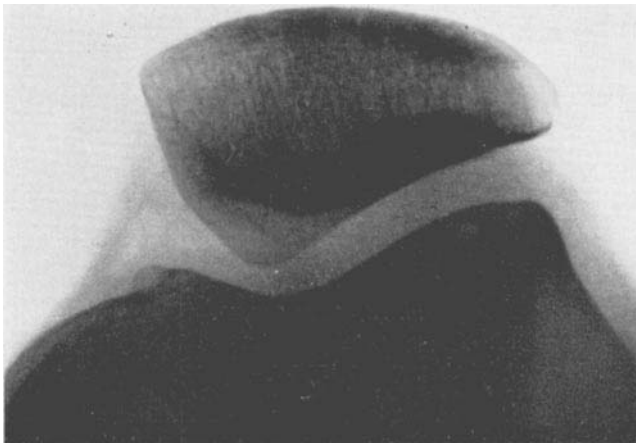
Most workers regard chondromalacia patellae as an independent disease. This is justifiable, but the process must un-



a

Lateral

Medial

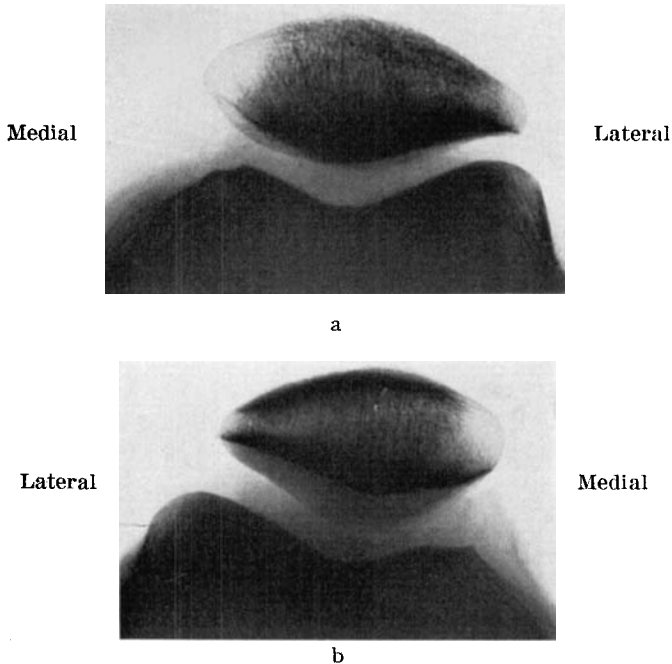


b

*Fig. 44.* Case 4089/39. A slight lateral displacement of the patella is visible on view a.

doubtedly also be regarded as a precursor of osteo-arthritis. Further, as soon as the development has begun in this direction the height of the patellar cartilage diminishes and a noticeable difference is seen between the healthy and the affected sides.

Unfortunately, since the one-sided cases are much rarer than the double-sided ones, a fact confirmed by my material, there are fewer opportunities to make use of this diagnostic aid. We may also wonder whether the cases in question should be

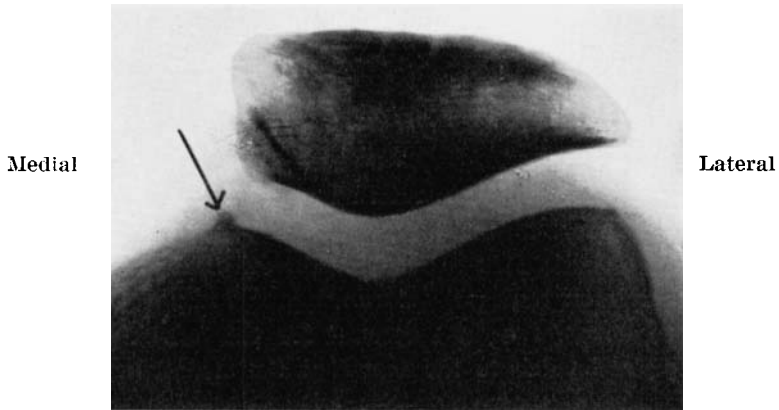


*Fig. 45.* Case 942/41.

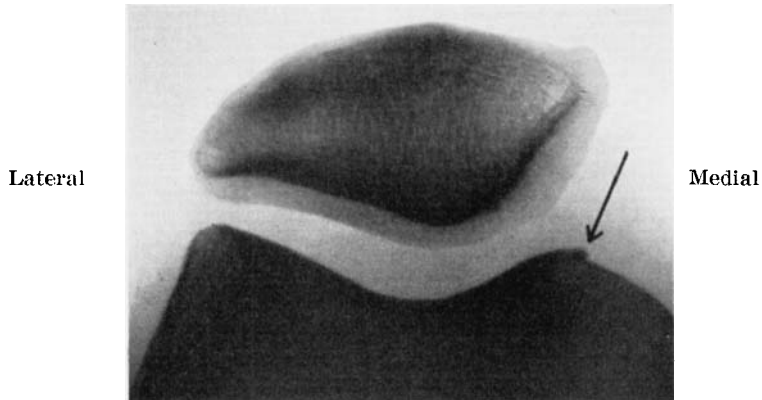
a = left side, showing a reduction in cartilage.  
 b = right side, normal.

termed chondromalacia patellae or osteo-arthritis. It is impossible to draw any hard and fast distinction; the clinical picture must act as the deciding factor. Case 942/41 (fig. 45) displays a definite reduction in cartilage in established traumatic chondromalacia.

As we know, osseous formations on the superior and inferior borders of the patella have been considered an early roentgenologic symptom of osteo-arthritis and these osteophytes may be taken as an expression of the reactive new tissue formation at



*Fig. 46.* Case 51/41. Osteophytic formation on the medial femoral condyle (indicated by the arrow).



*Fig. 47.* Case 1908/41. Osteophytic formation on the medial femoral condyle (indicated by the arrow).

the border of the patella resulting from advanced chondromalacia patellae.

According to Öwre, the malacic process reaches the border of the patella first in the lower medial area (see fig. 27), and the osteophytes might therefore be expected to appear earlier on this part of the patella than on the upper and lower borders. This does not prove to be the case, however; osteophytes do not

appear at this edge until those on the upper and lower borders of the patella are well advanced.

A small osseous formation has often been noted at a very early stage on the medial femoral condyle, sometimes even earlier than on the borders of the patella. It is not such a rare occurrence, either. Such a formation was present in 28 of my 43 cases of chondromalacia, e.g. cases 51/41 (fig. 46) and 1908/41 (fig. 47). We shall learn in the chapter on osteo-arthritis that this osteophyte on the medial femoral condyle increases as the disease progresses. I cannot account for the formation but it may of course be due to the fact that the medial part of the capsule (in chondromalacia patellae) is subjected to more traction and friction than the lateral. The subject is treated in more detail in the chapter on osteo-arthritis.

#### *Arthroscopic studies.*

During my studies on chondromalacia patellae I also tried out the relatively recent method of examination by arthroscopy. My aim was twofold. Firstly, I wanted to attempt to investigate the joint mechanism in movement, but in particular I hoped to form a clear idea of the appearance of the articular cartilage without opening the joint. The latter possibility has much practical value since we have started excising the patella in cases of severe chondromalacia patellae, particularly in cases where the cartilage is so disintegrated that therapy in the form of chondrectomy is out of the question. Since the condition of the cartilage is the deciding factor when determining whether chondrectomy or excision of the patella is to be performed, any information obtainable about it before the intervention, is of much assistance, especially as the operative methods in the two alternatives are so essentially different. Hitherto we have had to rely on the clinical examination for our knowledge of the state of the cartilage, and I therefore desired to investigate whether arthroscopy could provide better information.

We used the method described by *Vaubel*. After any exudate present had been withdrawn, the joint was filled with 120 cc.

of saline solution. As a rule the intervention was done under lumbar anesthesia, because the arthroscopic examination was usually made immediately before an operation. At first an attempt was made to inspect the joint from the lateral aspect, but as this proved troublesome we tried introducing the arthroscope from the medial aspect. It is generally easier to push the patella toward the medial aspect and the reverse side of the patella could thus be laid free, as it were.

There was no possibility of studying the mechanism of the joint. No clear enough idea could be gained of the gliding movements of the patella toward the femoral condyles to allow conclusions to be drawn.

Nine cases of chondromalacia patellae were arthroscopically examined, and of these, five were operated upon afterwards, so that the arthroscopic findings could be verified. In one case the patella was excised and various chondrectomies were done on the other four. As it proved difficult to take photographs through the narrow arthroscope I did not consider the results were worth the difficulties. In the main, the picture of chondromalacia appears in two different ways. The cartilage is either tufted, with fine, floating cartilaginous hairs resembling seaweed, or it has a frayed appearance, with coarse, cartilaginous flakes. I did not find any regularity in the occurrence of the flakes and the tufts, as, for instance, that the former were characteristic of the earlier stages and the latter of the more advanced ones. What I had chiefly wanted to investigate was whether any exposed bone could be found on any part of the patella, since this factor constitutes one of the main indications for a removal of the patella. It proved quite impossible, however, to determine whether the process involved the bone, even when a good general view of the entire surface of the patellar cartilage was obtained. To take an example, although a couple of our cases presented deep fissures penetrating to the bone, these did not by any means give the impression, on the arthroscopic pictures, of being particularly severe lesions.

Thus, we can obtain a good idea of the extent of the process but not of its depth, and this very much reduces the practical

value, from the standpoint of chondromalacic changes. The arthroscopic method may of course be extremely valuable in other diseases, but after such defects as injuries in the meniscus and the cruciate ligaments have been arthrographically revealed, its usefulness diminishes as far as the knee joint is concerned. In my opinion, its main value is more scientific than practical. For instance, it could be used to follow changes in the appearance of the synovia during treatment of a genual disease with synovial involvement.

### OSTEO-ARTHRITIS

Most workers are now in agreement that chondromalacia is often a precursor of osteo-arthritis in the knee joint, and in material consisting of cases of both chondromalacia and osteo-arthritis it is not difficult to distinguish a gradual transition from mild cases of chondromalacia to fully developed osteo-arthritis. Nevertheless, despite the fact that a differentiation is not easy to make between the two, I decided to place osteo-arthritis in a separate chapter, the clinical picture being used as the basis for distinction. The case was placed in the osteo-arthritis section as soon as, in addition to crepitation and pressure pain on the medial aspect of the patella, there was detected a manifest general thickening and tenderness of the capsule. Sixteen patients presenting such symptoms were examined, a total of 29 knees being roentgenographed.

In osteo-arthritis, as in chondromalacia, three different types of patella could be distinguished, but my material was not comprehensive enough to justify making a proportional classification between the different types. The distribution tended, however, to resemble that of the normal material, in that group II predominated. No particular type showed a greater predisposition to osteo-arthritis than the others.

I have already touched upon the question of the reduction in cartilage, in the chapter on chondromalacia patellae. One of the most striking features in the present connection was the excellent picture of the reduced height of the joint space ob-



a

Lateral



Medial

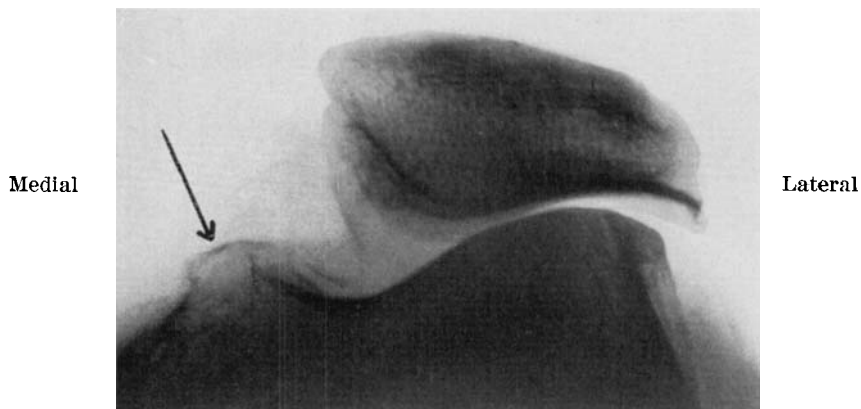
b

*Fig. 48.* Case 1800/41. a = lateral view. b = axial view.

tained from an axial view of the femoropatellar joint. A reduction in cartilage came out much better on this projection than on an ordinary lateral view. Case 1800/41 (fig. 48) is a good example. Of course it was obvious on the lateral view that a

reduction in cartilage was present, but its real extent was only revealed by the axial picture. On the latter, the cartilage on the lateral facet and the lateral femoral condyle was seen to be almost totally disintegrated.

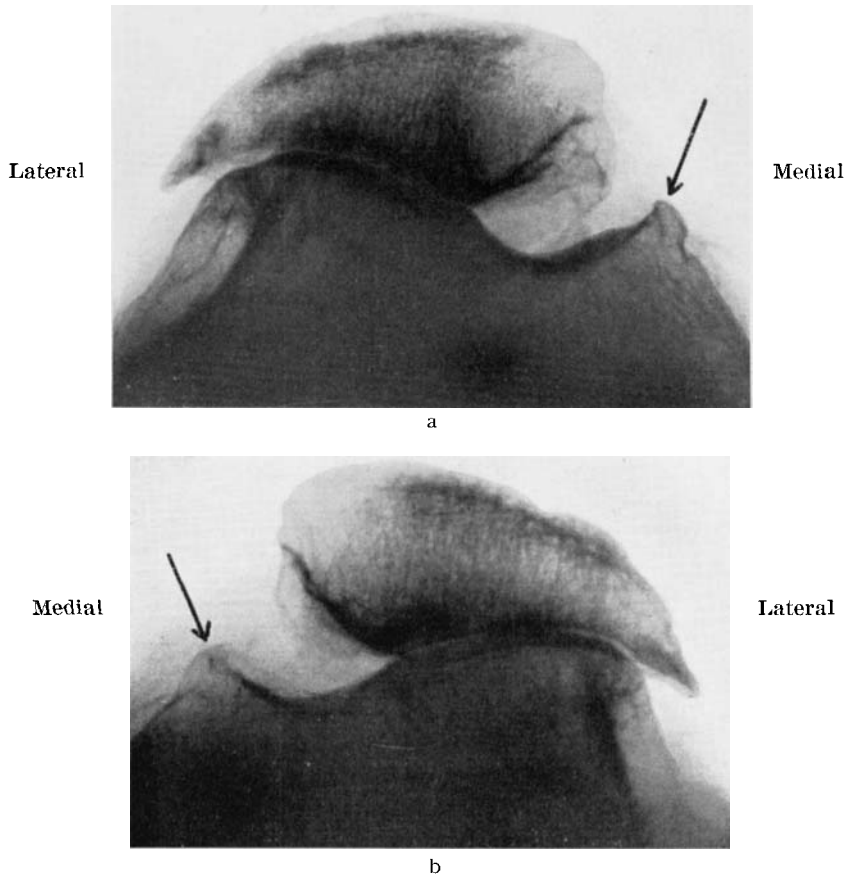
One interesting feature, in a number of cases, was that the patella, when the reduction in cartilage was pronounced, tended



*Fig. 49.* Case 671/41. Left knee. Subluxation of the patella laterally in a case of osteoarthritis. Osteophytic formation on the medial femoral condyle (see arrow).

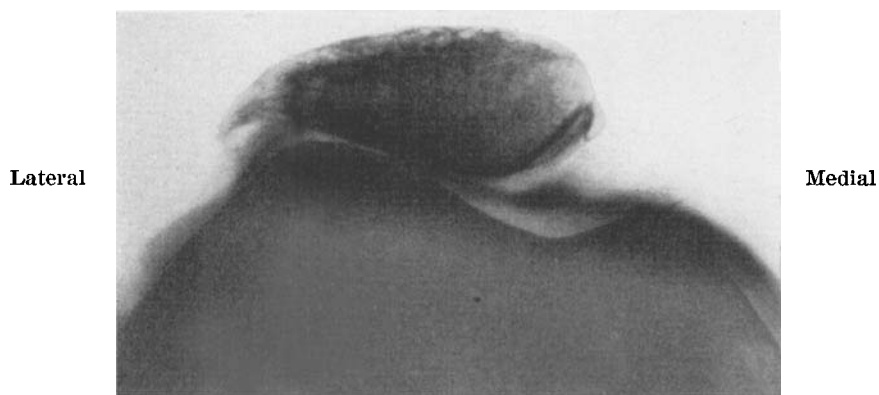
to subluxate laterally, with the consequence that the distance between the medial facet and the medial femoral condyle increased (see cases 1800/41, 671/41, and 17592, figs. 48, 49 and 50 respectively). In order to gain a better idea of this displacement I examined two cases (1800/41 and 671/41, figs. 51 and 52) arthrographically, and the picture obtained was in conformity in both instances. Thus, it was possible to establish that the contrast medium had accumulated between the medial facet and the femoral condyle in a way not found on the routine views (see figs. 9, 10 and 11). In some of the above-mentioned cases the subluxation was so pronounced that the patella overlapped the femoral condyle by as much as 1 cm.

The exceptions to the last-mentioned subluxation all belonged to group I. Even though slight subluxation was observed

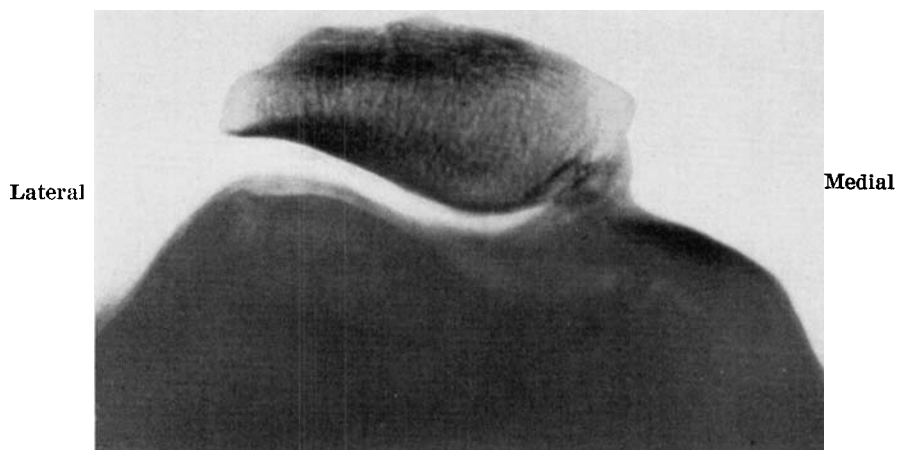


*Fig. 50.* Case 17592. a = right side. b = left side.  
 Subluxation of the patella bilaterally in a case of osteoarthritis.  
 Osteophytic formation on the medial femoral condyle (see arrow).

in this group, it differed considerably from that present in cases belonging to groups II and III, in which, as already mentioned, it may be pronounced. Case 1842/41 (fig. 53) is a typical example of group I; on the left side (view b), although the reduction in cartilage was well-advanced, there was no displacement. The more closely the type approximated to group III, the more pronounced the displacement seemed to become.

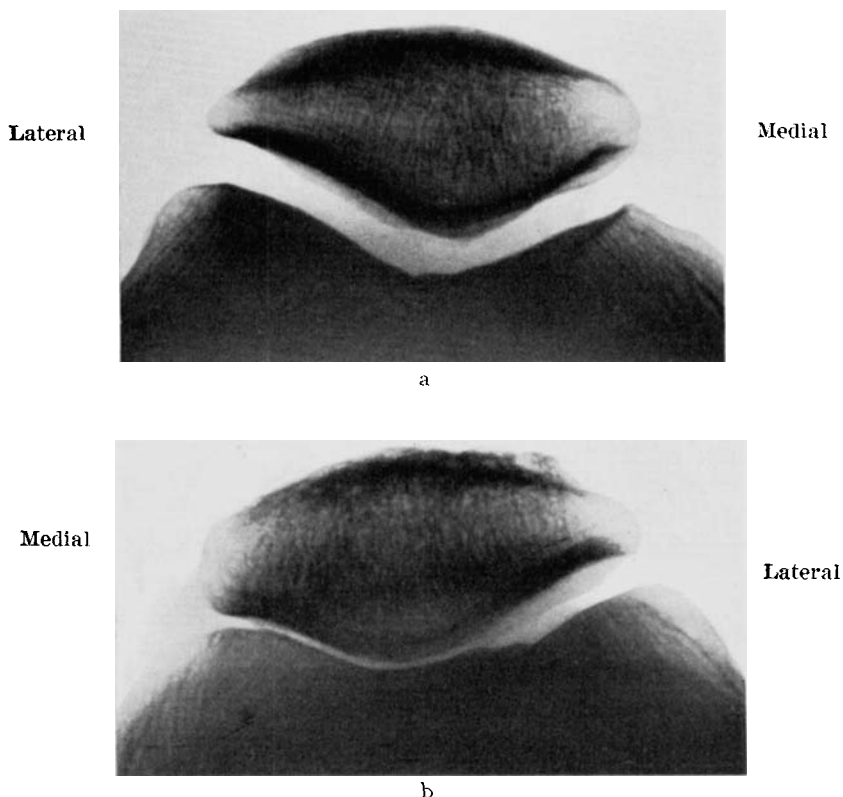


*Fig. 51.* Case 1800/41. Arthrogram of the right knee obtained by axial projection.



*Fig. 52.* Case 671/41. Arthrogram of the right knee obtained by axial projection.

Before we can hope to account for this subluxation, we must not only have access to more extensive material, but the investigations must also be combined with careful clinical observations. Possibly, the anatomic appearance of the joint (e.g. knock knees, bow legs, muscular development, etc.) may have something to do with the dislocations. As regards the possible



*Fig. 53.* Case 1842/41. a = right side.  
b = left side, showing a reduction in cartilage.

rôle played by the musculature, I have in mind more especially *Böhler's* theory as to the origin of luxation of the patella. If the vastus lateralis were to exercise a functional predominance over the vastus medialis, the natural result would be a subluxation when the reduction in the cartilage has reached an advanced stage.

This displacement of the patella should, in my opinion, be carefully distinguished from a true subluxation, such as was described in the chapter on luxations of the patella. The dislocations now under discussion must be regarded as secondary, and the reduction in cartilage not a result of a predisposing sub-

luxation. Otherwise, among all the patients with chondromalacia, one or two would have been found displaying subluxation before a reduction in cartilage had set in. Furthermore, as left and right knee joints usually resemble one another in development, we should probably have encountered at least a few cases with subluxation on the healthy side, in the one-sided cases of osteo-arthritis. To establish with certainty that it is a question of a secondary subluxation it would be necessary to follow the development from normal conditions to osteo-arthritis plus subluxation, but in the light of the anamneses, from which no information is available regarding subluxating or luxating tendencies of the patella, and of the clinical observations in general, there is no reason to believe that the circumstances were different from those I have stated, namely that the subluxation is secondary and not primary.

In conclusion, I refer back to an observation made in connection with chondromalacia patellae. The osteophytes so often seen in the axial views, on the medial border of the medial femoral condyle, were also found in the osteo-arthritis cases, but more pronounced (see cases 671/41 and 17592, figs. 48 and 49). The definite impression was that the osteophytes were in some way connected with the traction of the patella laterad, i.e. the secondary subluxation. The latter must entail a strain on the capsular attachment on the medial aspect. According to the text-books on anatomy the capsule is attached, at the lateral parts of the patellar surface of the femur, in close proximity to the margin of the articular cartilage, and this increased strain on the capsule might cause reactive irritation on the edge of the articular surface, thus giving rise to osteophytes.

#### SUMMARY

The investigations described in the foregoing communication were embarked upon in order to gain a clearer knowledge of the appearance of the femoral condyles in luxation of the patella. In practice, this implied obtaining a free projection of the femoropatellar joint. A roentgenologic and anatomic study of

normal knee joints proved that a knee with 40 degrees of flexion was the most suitable position for the purpose. On the basis of its form the patella could be classified into three normal types. In the first, the ridge separating the medial and lateral facets was situated approximately in the middle of the patella, so that the facets were about equal in size. In the second, the ridge was shifted slightly medial, so that the lateral facet occupied a larger proportion of the articular surface of the patella, while in the third, the medial patellar facet was very small. Arthrographic examinations confirmed that this classification of the skeletal parts was in conformity with the conditions prevailing in the articular surface cartilage.

In luxation of the patella, the form of both patella and femoral condyles is often much altered and the material in this section has been divided into type groups. The first group comprised cases manifesting the most pronounced changes, namely a complete levelling-down of both the patellar surfaces of the femur, and the patella. In the second group there was present mal-development of the femoral condyles with or without a planed patella. In the third was placed the cases in which no pathologic changes whatever were observed in the femoropatellar joint. The opinion is advanced that excision of the patella might be the most suitable method to deal with luxations presenting a normal joint and manifest chondromalacic changes. As regards the etiologic question in dislocations of the patella, the cases that display a disturbance in the development of the femoral condyles, and that are in the majority, are more likely to be of a congenital nature than are those possessing normally developed joints, even though the constitutional element cannot be excluded in the latter either. In the former, a trauma is hardly necessary to cause luxation, while in the latter a violent trauma is apparently required.

The investigations were not confined to luxation of the patella but also included the complications of chondromalacia patellae and osteo-arthritis.

After briefly reviewing earlier theories on the origin of chondromalacia, the author has attempted to clear up the etio-

logic aspect of chondromalacia patellae by examining the contact between the articular surfaces in the femoropatellar joint. The investigations were therefore widened to include a roentgenologic study of autopsy specimens. The articular surfaces were visualized on the roentgen picture by painting them with a thin layer of red lead, which acted as a contrasting agent. By roentgenographing these specimens in different positions of flexion an idea was formed of how the contact between the articular surfaces of the patella and the femoral condyles appeared during movements of the joint. It was observed that in the lower angles of flexion the contact between both the patellar facets and the femoral condyles was excellent, while in proportion as the angle increased and the patella approached the intercondyloid fossa, the contact with this middle part of the patella became disconnected and the load was taken over exclusively by the facets, the lateral facet continuing in good congruence with the lateral femoral condyle *while the medial facet, from an angle of about 90 degrees and upward, opposed a convex articular surface to the convex femoral condyle*. On these red lead preparations it was also possible to study the contact mechanism directly, since the red lead was scraped off during the movements of the joint. It could be seen that when the knee was flexed at angles ranging from 20 to 50 degrees a small part of the medial facet, and the whole of the lateral facet were in contact but that the ridge took the greatest stress. At the higher angles of flexion the pressure on the ridge diminished gradually, disappearing entirely at about 90 degrees when the patella approached the intercondyloid fossa.

The chief interest was concentrated on an autopsy series consisting of twenty-five knee joints, which were frozen in different positions of flexion and then cut into sections 0.5 cm. to 1 cm. thick, the cut being made at right angles to the articular surfaces between the patella and the femoral condyles. In addition to the position of extension, the following angles of flexion were included, viz.: 30, 45, 90, 115, 125, 140 degrees. It was thus possible to study how the contact functions between the patella and the femoral condyles. Two significant observations were

made. *At 90 degrees, or at further flexion, the medial patellar facet opposes a convex surface to the convex articular surface of the femoral condyle, and in proportion as the knee is flexed the contacting area on the medial facet moves further out toward the border of the patella. In some of the specimens in further flexion, incipient chondromalacia was seen, located precisely at the point of contact between the medial facet and the femoral condyles. This must be regarded as a proof that the extra stress to which the cartilage is subjected when the contact takes place on such a small cartilage surface is likely to lead to chondromalacia.* Special mention must be made of the ridge that often separates the odd medial facet from the remainder of the articular surface of the patella, and that undoubtedly constitutes a place of least resistance. On one autopsy specimen in which the contact between the articular surfaces could be examined during joint movements, incipient chondromalacia was observed just at this ridge.

A roentgenologic examination was also made of cases clinically diagnosed as chondromalacia patellae. Signs of reduction in cartilage were only detected in cases with pronounced changes. In addition, small osteophytes were found on the border of the articular surface of the medial femoral condyle.

The studies on chondromalacia were complemented by arthroscopic examinations. It was possible to form an idea of the extent of the process by this means, but not of its depth.

Since chondromalacia may sometimes be regarded as a precursor of arthritis deformans, a study was also made of material comprising cases of the latter disease. The chief feature noted was the subluxation, in the form of lateral displacement, displayed by the patella when destruction of the cartilage in the femoropatellar joint has reached an advanced stage. This must be regarded as secondary, in contradistinction to the primary subluxations exhibited in the group comprising luxations of the patella. Finally, it was established that the osseous deposits observed on the medial femoral condyle even in chondromalacia had appreciably increased in size in the patients suffering from arthritis deformans, and this was thought to have some connec-

tion with the tendency to subluxation, since the latter must involve a strain in the joint capsule in lateral direction. As the capsule on the medial aspect is attached right at the border of the articular surface of the cartilage the resultant irritation may very probably give rise to an osteophyte at this spot.

### ZUSAMMENFASSUNG

Die in der vorstehenden Mitteilung beschriebenen Untersuchungen wurden unternommen, um ein klareres Bild vom Aussehen der Condylen des Femur bei Luxationen der Patella zu bekommen. In der Praxis erfordert dies das Vorliegen einer freien Projektion des Femoropatellargelenks. Ein röntgenologisches und anatomisches Studium normaler Kniegelenke zeigte, dass eine Flexion des Knies von  $40^{\circ}$  die bestgeeignete Position für diesen Zweck war. Auf Grund ihrer Form liess sich die Patella in drei normale Typen einteilen. Bei dem ersten lag die Firste, welche die mediale und laterale Gelenkfläche voneinander trennt, annähernd in der Mitte der Patella, so dass die Flächen ungefähr gleiche Grösse hatten. Bei dem zweiten war die Firste ein wenig medial verschoben, so dass die laterale Fläche einen grösseren Teil der Gelenkfläche der Patella einnahm, während bei dem dritten die mediale Patellarfläche sehr klein war. Arthrographische Untersuchungen bestätigten, dass diese Einteilung der knöchernen Teile mit den im Gelenkflächenknorpel herrschenden Verhältnissen übereinstimmte.

Bei einer Luxation der Patella ist die Form sowohl der Patella wie der Condylen des Femur oft stark verändert, und das Material dieses Abschnitts wurde in Typengruppen eingeteilt. Die erste Gruppe umfasst die Fälle mit den ausgeprägtesten Veränderungen, nämlich eine komplette Abplattung der Facies patellaris des Femur und der Patella. Bei der zweiten Gruppe war eine Missbildung der Condylen des Femur mit oder ohne Abplattung der Patella vorhanden. In der dritten Gruppe waren die Fälle untergebracht, bei denen im Femoropatellargelenk keinerlei pathologische Veränderungen zu beobachten waren. Es ist die Ansicht geäussert worden, dass eine Exzision der Patella

die bestgeeignete Methode zur Behandlung von Luxationen sei, die beim normalen Gelenk manifeste chondromalazische Veränderungen zeigen. Was die Aetiologie der Patellarluxationen betrifft, so sind die Fälle, die eine Entwicklungsstörung der Condylen des Femur zeigen, und die in der Mehrzahl sind, wahrscheinlich eher kongenitaler Natur als die mit normal entwickelten Gelenken, wenn auch das konstitutionelle Element bei letzteren ebenfalls nicht auszuschliessen ist. In der ersten Gruppe bedarf es zur Verursachung einer Luxation kaum eines Traumas, während in der zweiten Gruppe offensichtlich ein heftiges Trauma erforderlich ist.

Die Untersuchungen waren nicht auf Luxationen der Patella beschränkt, sondern umfassten auch die Komplikationen der Chondromalacia patellae und Arthritis deformans.

Nach einem kurzen Überblick über ältere Theorien vom Ursprung der Chondromalazie hat Verf. versucht, die ätiologische Seite der Chondromalacia patellae zu klären, indem er eine Untersuchung des Kontraktes der Gelenkflächen des Femoropatellargelenks vornahm. Die Untersuchungen wurden daher auch auf ein röntgenologisches Studium von Sektionsobjekten ausgedehnt. Die Gelenkflächen wurden auf dem Röntgenbilde dadurch sichtbar gemacht, dass man sie mit einer dünnen Schicht Mennige bemalte, die als Kontrastagens wirkte. Durch Röntgenaufnahmen dieser Objekte in verschiedenen Flexionsstellungen konnte man sich ein Bild davon machen, wie der Kontakt zwischen den Gelenkflächen der Patella und den Condylen des Femur bei Bewegungen des Gelenks auf der Platte erscheint. Es wurde beobachtet, dass der Kontakt zwischen der Facies patellaris und den Condylen des Femur bei den geringeren Flexionswinkeln ausgezeichnet war, während mit zunehmendem Winkel und wachsender Annäherung der Patella an die Fossa intercondyloidea der Kontakt an dieser mittleren Partie der Patella aufhörte und die Last ausschliesslich auf den medialen und lateralen Gelenkflächen ruhte; die laterale Fläche passte immer noch gut zum lateralen Condylus des Femur, während die mediale Fläche, von einem Winkel von  $90^{\circ}$  an aufwärts, dem konvexen Condylus des Femur eine konvexe Gelenkfläche entge-

*genstellte*. An diesen Mennigepräparaten konnte man auch den Kontaktmechanismus direkt studieren, weil die Mennige durch die Bewegungen des Gelenks abgeschabt wurde. Man konnte sehen, dass bei Flexionen des Knies in Winkeln von 20 bis 50° eine kleine Partie der medialen Fläche und die ganze laterale Fläche in Kontakt waren, dass aber die Firste dem grössten Druck ausgesetzt war. Bei den grösseren Flexionswinkeln verminderte sich der Druck auf die Firste gradweise, und er wurde gänzlich aufgehoben bei etwa 90°, wenn die Patella sich der Fossa intercondyloidea näherte.

Das Hauptinteresse wandte sich einer Serie von Sektionspräparaten zu, die aus 25 Kniegelenken bestand, welche in verschiedenen Flexionsstellungen gefroren und dann in Schnitte von 0,5 — 1 cm Dicke zerlegt waren, wobei die Schnitte im rechten Winkel zu den Gelenkflächen zwischen der Patella und den Condylen des Femur geführt worden waren. Ausser der Extensionsstellung wurden folgende Flexionswinkel untersucht: 30, 45, 90, 115, 125 und 140°. Auf diese Weise war es möglich, die Kontaktfunktionen zwischen der Patella und den Condylen des Femur zu studieren. Es wurden zwei wichtige Beobachtungen gemacht. *Bei 90° oder bei stärkerer Flexion setzt die mediale Patellarfläche der konvexen Gelenkfläche des Femurcondylus eine konvexe Fläche entgegen, und mit zunehmender Flexion des Knies verschiebt sich die in Kontakt befindliche Partie der medialen Fläche immer weiter nach dem Rande der Patelle zu. An einigen der Objekte in stärkerer Flexion konnte eine beginnende Chondromalazie beobachtet werden, die genau am Kontaktpunkte zwischen der medialen Fläche und den Condylen des Femur lokalisiert war. Dies muss als ein Beweis dafür angesehen werden, dass der ungewöhnliche Druck, dem der Knorpel ausgesetzt ist, wenn der Kontakt an einer so schmalen Knorpelfläche stattfindet, leicht zu einer Chondromalazie führen kann.* Besonders zu erwähnen ist hier die Firste, die oft die unebene mediale Fläche von der übrigen Gelenkfläche der Patella abteilt, und die zweifellos eine Stelle der geringsten Widerstandsfähigkeit darstellt. An einem Sektionsobjekt, bei dem der Kontakt zwischen den Gelenkflächen während der Be-

wegung des Gelenks untersucht werden konnte, wurde eine beginnende Chondromalazie gerade an dieser Firste beobachtet.

Fälle, die klinisch als Chondromalacia patellae diagnostiziert worden waren, wurden auch röntgenologisch untersucht. Zeichen einer Reduktion des Knorpels wurden nur in Fällen mit ausgesprochenen Veränderungen gefunden. Ausserdem wurden am Rande der Gelenkfläche des medialen Femurcondylus kleine Osteophyten gefunden.

Die Studien über Chondromalazie wurden noch durch arthroskopische Untersuchungen ergänzt. Es war mit diesen Mitteln wohl möglich, sich ein Bild von der Ausdehnung des Prozesses zu machen, nicht aber von seiner Tiefe.

Da die Chondromalazie bisweilen als Vorläufer einer Arthritis deformans beobachtet wird, wurde auch Material von solchen Fällen untersucht. Das hierbei festgestellte Hauptmerkmal war die Subluxation in Form einer lateralen Verschiebung, die an der Patella auftrat, wenn die Destruktion des Knorpels im Femoropatellargelenk ein vorgeschrittenes Stadium erreicht hatte. Die Subluxation muss als sekundär angesehen werden, im Gegensatz zu den primären Subluxationen, die in der Gruppe mit Luxationen der Patella vorkommen. Schliesslich wurde festgestellt, dass die ossösen Ablagerungen, die am medialen Condylus des Femur gerade bei Chondromalazie beobachtet werden, bei den Patienten, die an Arthritis deformans litten, bedeutend an Grösse zugenommen hatten: man könnte sich denken, dass dies mit der Tendenz zur Subluxation im Zusammenhang steht, da dieses eine Ziehung der Gelenkkapsel in lateraler Richtung bedingen muss. Da die Kapsel an der medialen Seite ganz am Rande der Gelenkfläche des Knorpels befestigt ist, wird die daraus folgende Irritation höchstwahrscheinlich Anlass zur Entstehung eines Osteophyten an dieser Stelle geben.

#### RÉSUMÉ

Les recherches décrites dans l'exposé qui précède ont été entreprises en vue d'obtenir une connaissance plus approfondie

de l'aspect des condyles fémoraux dans la luxation de la rotule. En pratique, ceci implique l'obtention d'une projection libre de l'articulation fémoro-patellaire. Une étude radiographique et anatomique d'articulations du genou normales a prouvé que le genou à une flexion de 40 degrés constitue la position la plus appropriée pour arriver à ce but. Sur la base de sa forme, la patelle peut être classifiée en trois types normaux. Dans le premier, la saillie séparant les facettes médiale et latérale est située à peu près vers le milieu de la patelle, les facettes étant ainsi de dimensions presque égales. Dans le second, la saillie est située plus médialement de sorte que la facette latérale occupe une partie proportionnelle plus étendue de la surface articulaire, tandis que dans le troisième groupe, la facette patellaire médiale est très petite. Des examens arthrographiques confirment que cette classification squelettique est conforme aux conditions se faisant valoir par rapport au cartilage de la surface articulaire.

Dans la luxation de la patelle, on constate souvent que la forme de la patelle et des condyles fémoraux est très altérée et le matériel d'observation de cet ordre a été réparti en groupes d'après les types de patelle. Le premier groupe comprend les cas manifestant les altérations les plus prononcées, à savoir un nivellement complet à la fois des surfaces patellaires du fémur et de la rotule. Dans le second groupe ont été placées les malformations des condyles fémoraux avec ou sans nivellement de la patelle. Le troisième groupe comporte les cas chez lesquels aucune modification pathologique n'a été observée dans l'articulation fémoro-patellaire. On a allégué que l'excision de la patelle constitue la méthode la plus appropriée à appliquer dans les cas de luxation présentant une articulation normale et des modifications chondromalaciques évidentes. En ce qui concerne la question étiologique des dislocations de la patelle, les cas qui montrent un trouble dans le développement des condyles fémoraux, et ceux-ci sont en majorité, sont plus vraisemblablement de nature congénitale que ceux qui possèdent des articulations normalement développées, bien que l'élément constitutionnel ne saurait être exclu également dans ces derniers cas. Dans

le premier groupe, un traumatisme est à peine nécessaire pour causer la luxation, tandis que dans le dernier un traumatisme violent est apparemment requis.

Les recherches ne se sont pas bornées à la luxation de la patelle, mais ont porté également sur les complications de la patelle chondromalacique et l'arthrite déformante.

Après avoir brièvement passé en revue les anciennes théories sur les origines de la patelle chondromalacique, l'auteur a essayé d'éclaircir les aspects étiologiques de la patelle chondromalacique en examinant la contiguïté des surfaces articulaires de la jointure fémoro-patellaire. C'est pourquoi les investigations ont été étendues à comprendre une étude radiographique de spécimens d'autopsie. Les surfaces articulaires ont été montrées sur la radiographie en les colorant avec une mince couche de minium, agissant comme contrastant. En radiographiant ces spécimens dans différentes positions de flexion, on s'est formé une idée de la contiguïté des surfaces articulaires de la patelle et des condyles fémoraux telle qu'elle apparaît au cours des mouvements de l'articulation. On a constaté que dans les angles bas de flexion, le contact entre les deux facettes patellaires et les condyles fémoraux était excellent, tandis qu'au fur et à mesure de l'augmentation de l'angle de flexion et du rapprochement de la patelle et du sillon intercondyloïdien, il n'y a plus contiguïté avec la partie centrale de la patelle, et la charge est supportée exclusivement par les facettes, la facette latérale continuant en bonne congruence avec le condyle fémoral latéral *tandis que la facette médiale, à partir d'un angle de 90 degrés et plus, oppose une surface articulaire convexe au condyle fémoral convexe*. Sur ces préparations de minium il a été possible aussi d'étudier directement le mécanisme de contact, étant donné que le minium disparaît au frottement causé par les mouvements imprimés à l'articulation. On peut voir, lorsque le genou est plié à des angles allant de 20 à 50 degrés, qu'une petite partie de la facette médiale et que la facette latérale toute entière sont en contact, mais que c'est la saillie qui supporte la plus grande tension. A des angles plus élevés de flexion, la pression sur la saillie diminue graduelle-

ment, disparaissant entièrement à environ 90 degrés lorsque la patelle approche du sillon intercondyloïdien.

Le principal intérêt s'est concentré sur une série d'autopsies consistant en vingt-cinq articulations de genou, qui avaient été gelées dans différentes positions de flexion, tranchées ensuite en coupes de 0,5 cm. à 1 cm. d'épaisseur, la section étant pratiquée à angle droit avec les surfaces articulaires entre la patelle et les condyles fémoraux. A côté de la position d'extension, les angles suivants de flexion ont été compris dans les examens: 30, 45, 90, 115, 125, 140 degrés. Il a été possible en conséquence d'étudier comment se comporte l'emboîtement de la patelle et des condyles fémoraux. Deux observations importantes ont été faites. *A 90 degrés, soit à une flexion plutôt prononcée, la facette patellaire médiale oppose une surface convexe à la surface articulaire convexe du condyle fémoral, et proportionnellement à la flexion du genou, la surface de contact de la facette médiale se meut de plus en plus vers le bord de la patelle. Dans quelques-uns des spécimens en flexion active, on put observer des chondromalacies débutantes, localisées précisément au point de contact entre la facette médiale et les condyles fémoraux. Ceci doit être considéré comme la preuve que la charge supplémentaire dont les cartilages sont l'objet lorsque le contact a lieu sur une surface cartilagineuse si réduite est susceptible de conduire à la chondromalacie.* Une mention spéciale doit être faite de la saillie qui sépare souvent la facette médiale de ce qui reste de la surface articulaire de la patelle et qui constitue sans aucun doute un endroit de moindre résistance. Sur un des spécimens d'autopsie chez lequel on a pu examiner la contiguïté entre les surfaces articulaires durant les mouvements de l'articulation, une chondromalacie naissante a été constatée juste sur la saillie.

Un examen radiographique a été fait également dans les cas de chondromalacie patellaire cliniquement diagnostiqués. Des signes de réduction du cartilage n'ont été découverts que dans les cas où se manifestaient des altérations prononcées. De plus, on a trouvé de petits ostéophytes sur le bord de la surface articulaire du condyle fémoral médial.

Les études de la chondromalacie ont été complétées par des examens arthroscopiques. Il a été possible, par ce moyen, de se former une idée de l'étendue du processus, mais non de sa profondeur.

Etant donné que la chondromalacie doit parfois être considérée comme un signe précurseur de l'arthrite déformante, il a été fait également une étude d'un matériel d'observation comprenant des cas de cette dernière maladie. Le trait principal relevé a été la subluxation sous forme de déplacements latéraux que montre la patelle lorsque la destruction du cartilage de l'articulation fémoro-patellaire a atteint un degré avancé. Ceci doit être regardé comme un état secondaire, par opposition aux subluxations primaires apparaissant dans le groupe comprenant les luxations de la patelle. Finalement, il a été établi que les dépôts osseux observés sur le condyle médial fémoral, précisément dans les chondromalacies, ont augmenté appréciablement de grandeur chez les malades souffrant d'ostéo-arthrite et on a supposé que ceci avait une certaine relation avec la tendance à la subluxation, étant donné que celle-ci implique une tension latérale de la capsule de l'articulation. Sur sa face médiale, la capsule étant attachée juste sur le bord de la surface articulaire du cartilage, l'irritation en résultant doit probablement donner naissance à un ostéophyte en cet endroit.

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