CHONDROMALACIA OF THE PATELLA *

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Chondromalacia is a precursor of osteoarthritis. It can, perhaps, be regarded as an early senescence (the changes in the intervertebral discs that begin during the second decade of life are often so described) but much more must be learnt about the chemistry of proteins and polysaccharides before such an idea can be accepted. The articular cartilage of the patella is involved earlier and more constantly than almost any other joint surface. The process often begins during the second decade of life, and by the age of thirty nearly everyone is affected. It is, however, in only a few individuals that the changes cause symptoms, and in fewer still that they progress to osteoarthritis. The late stage, osteoarthritis, has been familiar for centuries. Descriptions of the early phases are comparatively recent, and even though a clinical diagnosis of chondromalacia of the patella can now be made with some precision, the condition has received but scant attention in the literature of British and American countries.

Credit for the first account is generally given to Büdinger (1906, 1908) who described fissures occurring in the articular cartilage of the knee, usually the patella, which he considered to be traumatic in origin. He operated on fifteen patients, removing the affected cartilage in thirteen with results that were, in the main, satisfactory. Ludloff in 1910 published one case in which he excised almost all the cartilage covering the patella, and Axhausen (1919) reported another in which he had removed part of the cartilage six years previously with a good result. In 1925 Låwen reported the results in thirteen operations and also that he had found similar changes in twenty-six necropsies out of forty-four. The term "chondromalacia" seems to have been introduced by Aleman (1928) who found degeneration of the articular cartilage of the patella in one-third of 220 knees on which he had operated, and in twenty this was the only lesion. There were several further reports during the next few years, and in 1936 Øwre published an extensive survey giving the results of a painstaking clinical and pathological investigation, and his findings in thirteen operations. Chaklin (1939) stated that he had removed the articular cartilage of the patella thirty-eight times, but gave no details of the results. In 1940 Karlson reported the results of operations carried out in Aleman's clinic, and also the subsequent behaviour of seventy-one knees not subjected to operation. Wiberg (1941) investigated the etiology with special reference to the congruity of the joint surfaces, and Hirsch (1944) reported certain physico-chemical investigations and forty-one operations; Soto-Hall (1945) treated six soldiers by excision of the patella, and Cave, Rowe and Yee (1945) reported eleven more in whom they had removed the cartilage. In 1948 Gray gave a summary of the morbid anatomy and clinical findings and reported eight patients treated by excision of the patella with good results. The total number of operations reported is more than 200.

INCIDENCE

The first microscopic change in the articular cartilage is absence of the normal metachromasia. The earliest macroscopic change is swelling and softening of the cartilage—often misnamed oedema—which is present in at least five out of six people by the age of thirty. The next stage is fissuring and flaking (Fig. 2), and this can be found in more than

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half the population by thirty, the incidence increasing steadily thereafter. The figures obtained by Øwre (1936) at post-mortem examination are shown in Table I.

The frequency with which fissuring of the articular surface of the patella is found at operation for removal of a semilunar cartilage is somewhat less than these figures suggest, perhaps because of the restricted view available. The severity of fissuring cannot readily be recorded statistically because estimation is a matter of personal judgment. Øwre did not find at necropsy any example under the age of thirty that he could classify as severe, but there

TABLE I
INCIDENCE OF CHONDROMALACIA OF THE PATELLA IN 124 NECROPSIES (ØWRE)

Age	Number of subjects	" Oedema "	Fissuring
14-19	18	5	—
20-29	32	27	18
30-39	26	24	19
40-59	32	30	29
60-80	16	16	15

were nine between thirty and thirty-nine, and forty over the age of forty. These findings are not in complete accord with clinical experience. The commonest age for symptoms to arise is between twenty and thirty, and we have often found advanced changes at operation on patients of this age and, indeed, in younger people. The discrepancy is probably explained by the natural selection of those attending for clinical examination of the knee.

It is difficult to estimate how often chondromalacia gives rise to symptoms but it is clear that the clinical diagnosis becomes more common as awareness of the condition increases; and it is more often seen at operation when it is deliberately sought. Some idea of the incidence is given by comparing the frequency with which chondromalacia with marked fissuring has been observed at operation with the number of meniscectomies performed during the same period. The figures for the Middlesex Hospital, including chondromalacia encountered during meniscectomy, are shown in Table II.

TABLE II
INCIDENCE OF CHONDROMALACIA OF THE PATELLA AS SEEN AT OPERATION RELATED TO THE NUMBER OF MENISCECTOMIES PERFORMED DURING THE SAME PERIOD (MIDDLESEX HOSPITAL)

	1950	1951	1952	1953	1954	1955 Jan./June	Total
Chondromalacia	4	2	8	5	22	7	48
Meniscectomy	31	24	37	29	32	13	166

NATURAL HISTORY

The natural evolution of chondromalacia cannot readily be followed because the precise condition of the cartilage cannot be estimated with accuracy by clinical examination alone; and when there are symptoms severe enough to call for operation, the affected cartilage (or the patella) is generally removed and its subsequent behaviour cannot be observed.

Nearly all adult knees show some of the pathological changes of chondromalacia, but these are generally restricted to a small part of the patella. Progress, in a large majority, is

FIG. 1

FIG. 2

Figure 1—Erosion of the lower and inner quadrant surrounded by areas of nodular swelling and fissuring, and covered with pannus. As seen at operation May 1955. Figure 2—Erosion of the lower and inner quadrant with fissuring above, and also fissuring of the lower and outer quadrant. Pannus is spreading over the lower border. Case 40.

FIG. 3

FIG. 4

Figure 3—The whole surface of the patella is disintegrating. Patella excised June 1955. Figure 4—Early osteoarthritis. The articular cartilage of the patella and the inner condyle of the femur has been shed. As seen at operation after excision of the patella October 1954.

FIG. 5

FIG. 6

Figure 5—Advanced osteoarthritis with a large marginal osteophyte and vertical scoring. Figure 6—Same patient as Figure 5 showing vertical scoring of femur. As seen at operation June 1954.

so slow that there are no symptoms throughout life. In a few the changes, almost from the start, are more widely spread, and in some of these progress is rapid. Occasionally it is very rapid; there is a type in which the entire surface of the patella disintegrates and, when the knee is opened, the synovial fluid is clouded by fragments of articular cartilage. There is at present no sure way of telling by clinical examination, or even by inspecting the articular cartilage, whether progress will be slow or quick, nor is there a constant relation to any feature of the history, such as injury. The determining factor is more likely to be found in the chemical behaviour of the ground substance of the cartilage.

Something is known about the average, or statistical, behaviour of chondromalacia after a clinical diagnosis has been made. Karlson (1940) re-examined seventy-one men who had been diagnosed in Aleman's clinic between one and twenty years previously when they were army conscripts, and whose symptoms did not then warrant operative treatment. Ten had no subjective complaints, forty-five had a little trouble such as stiffness and fatigue after severe exertion, and sixteen had had enough trouble to make them change their work or to cause frequent absence from work. Thirty-five were radiographed and seven showed slight osteoarthritic changes but none had advanced arthritis.

We are fortunate enough to have seen and recorded the presence of fissuring in nineteen knees operated upon for other conditions, the articular cartilage being left intact. Seventeen of these operations were between one and five years ago. In eleven knees only a small area of cartilage was affected; four now have no symptoms, five have a little aching or swelling after exercise and two cannot be traced. The fissuring was of moderate severity in four: one now has a "normal" knee, two have troublesome symptoms and one cannot be traced. Two patients, both operated upon three years ago, then had severe and extensive changes in the cartilage, and now both have clinical and radiological signs of osteoarthritis. These observations suggest that the more widespread the changes the more likely they are to progress.

Chondromalacic changes are quite often seen on the femur at sites corresponding to those on the opposing surface of the patella, but this is by no means invariable. There may be advanced changes in the patella without any visible alteration in the femur, or those in the femur may be more advanced than the patella, and occasionally the femur alone is affected. It seems that a rough patellar surface rubbing on the femur is not the only cause of the latter's degenerating. It may be that, as in the patella, a predisposing factor must be postulated.

Chondromalacia of the patella sometimes progresses to osteoarthritis. The course cannot be followed in a single patient but a possible sequence of events can be shown in a series (Figs. 1 to 6). The clinical evidence suggests that chondromalacia is less likely to progress when, at the time of diagnosis, it involves only a small area of the superficial and intermediate layers of the articular cartilage, but the greater the extent and severity of the changes, the greater the risk of osteoarthritis.

PATHOLOGY

Naked-eye appearances—Chondromalacia of the patella begins as a nodular swelling of part of the articular cartilage. It is situated more often on the medial than the lateral facet, commonly just below the centre. The nodular area is lustreless and grey or yellow in colour, and it is distinct from the glistening, blue, normal cartilage surrounding it. Fissures develop in the nodular zone and radiate from it, splitting the cartilage into irregular flakes (Fig. 2). The free edges of the flakes project above the surface of the surrounding articular cartilage. The fissures are usually directed obliquely into the depths of the cartilage so that the flakes, when viewed from the surface, do not stand upright but lie like the tiles of a roof, partly overlapping each other (Fig. 14). They are firmly attached to the underlying bone.

Hirsch (1944) has demonstrated by elaborate methods that, at the stage of nodular swelling, the elasticity of cartilage in the areas of chondromalacia is less than that of the surrounding, undamaged cartilage. Some elasticity remains even when the cartilage is fissured, as can

FIG. 7

FIG. 8

FIG. 9

Figure 7—Normal articular cartilage of patella stained H. and E., $\times 25$. Figure 8—Loss of normal staining in superficial and mid-zones, also fissure extending into mid-zone. H. and E., $\times 20$. Figure 9—Irregular staining of superficial and mid-zone and cysts in the latter. H. and E., $\times 50$.

FIG. 10

FIG. 11

FIG. 12

Figure 10—Hyperplasia of cartilage cells surrounded by areas of normal staining matrix. The line of calcified cartilage is broadened. H. and E., $\times 30$. Figure 11—Loose body from knee joint of a case of chondromalacia showing cell nests and areas of normal staining matrix. H. and E., $\times 25$. Figure 12—Late stage of chondromalacia showing degenerate cartilage with ossification and oedematous connective tissue in the marrow spaces. H. and E., $\times 30$.

readily be shown by inserting a fine probe into a fissure and lifting the adjoining flake to an upright position; it snaps back into its original position when the probe is withdrawn.

The damaged cartilage, at first raised above the level of the surrounding articular surface, gradually becomes thinner and the flakes acquire a shaggy appearance (Fig. 3). They are then less elastic and softer, so much so that small pieces of frayed cartilage can be detached by rubbing with a finger. On opening knees with cartilage changes such as these, it is common to find cartilaginous loose bodies with rounded edges lying free in the joint.

When the condition is progressive the size of the damaged area increases and involves most of the medial facet, the ridge and the lateral facet, usually in this order. The cartilage becomes so thin that the underlying bone is exposed, giving an appearance rather like an "ulcer" surrounded by a rim of frayed cartilage (Fig. 3). The area of exposed bone increases and eventually becomes eburnated and often scored in a vertical direction (Figs. 4 to 6).

Osteophytes develop at the margin of the patellar cartilage where it joins the synovial membrane and capsular tissues. They appear soft, as rounded masses of bone covered by a thin, grey-white layer of cartilage. They do not occur in the nodular phase, but later when the fissuring is deep or extensive and the cartilage is thin. This is the stage of osteoarthritis; it is reached by only a few people under the age of forty-five but thereafter it becomes increasingly common. There is a close correlation between the sites of the cartilage damage and osteophyte formation. The medial facet is the most frequent site of cartilage damage, and the medial border is the usual site of osteophyte formation. When the lateral facet is involved, osteophytes tend to form along the lateral border. The more severe the lesion the greater is the probability that osteophytes will develop; of ten patellae removed surgically for severe chondromalacia, nine had marginal osteophytes.

The patellar facets on the femur may show changes in the articular cartilage which are sometimes referred to as "mirror lesions." The medial part is more often affected than the lateral, the naked-eye appearances resembling those in the patella. Occasionally the patellar facets of the femur are involved although the patella is normal.

The synovial membrane shows some hyperaemia and proliferation in almost every case of chondromalacia. In a few, usually near an area of fissuring, a synovial pannus spreads over the outer rim of the articular cartilage (Figs. 1 and 2). This pannus consists of relatively vascular connective tissue covered by flattened synovial cells, and it is so firmly adherent to the cartilage as to be inseparable.

Histology—Normal articular cartilage is hyaline cartilage possessing three poorly defined layers (Fig. 7). The deepest lies on the line of calcified cartilage over the chondro-osseous plate, and it contains large cells arranged in vertical columns. The cells in the transitional layer run obliquely, and in the superficial layer they are parallel to the surface. The size of the cells decreases from the deeper zones towards the surface. Mitotic figures are not seen in any layer of normal cartilage. The matrix in the deep zone is plentiful and stains a deep blue with haematoxylin and eosin, but nearer the surface it stains less deeply and appears metachromatic (Fig. 7). No fibres are visible in normal cartilage examined by routine histological methods.

Nodular swelling, which is the earliest sign of chondromalacia, has a typical microscopical picture. There is no visible alteration in the cartilage cells, but the matrix is changed and when it is stained with haematoxylin and eosin the superficial and transitional zones appear pinker (Fig. 8). We have found, using special techniques such as the "periodic acid Schiff reaction" (P.A.S.), that there is a decrease of P.A.S. positive matrix in swollen areas; this indicates a decrease in the chondroitin sulphuric acid content. Hirsch (1944) and Matthews (1953), using biochemical methods, have made a similar deduction. It seems, therefore, that the earliest change in chondromalacia is an alteration in the chemical structure of the matrix.

Fissures—The earliest fissures run tangentially to the surface, but the deeper the fissures the

more vertical is their course (Fig. 8). The ground substance, when examined with dark ground illumination, shows a fine, web-like system of thin fibrils which encircle cartilage cells or groups of cells. The fibrils appear to be intact even when there is marked fissuring.

Benninghoff (1925) demonstrated by maceration of normal articular cartilage an orderly system of fibres arranged in arcades. Although the course of the fissures corresponds with that of "Benninghoff's fibres," we have not been able to demonstrate any such fibres in normal or degenerate cartilage of the patella either by silver impregnation or by examination with polarised light.

Thirty-one specimens of patellar cartilage removed at operation on account of chondromalacia have been examined and the depths of the fissures compared with the loss of metachromasia. The results are shown in Table III.

TABLE III
CORRELATION BETWEEN LOSS OF METACHROMASIA AND FISSURE FORMATION

Metachromasia	Fissure formation			
	None	Superficial	Half thickness	Full thickness
Slight loss	1	6	0	0
Moderate loss	0	5	12	3
Complete loss	0	0	1	3

Of four specimens with complete loss of metachromasia, deep fissures were present in three. Of the twenty specimens showing moderate loss of staining of the matrix, three had fissures reaching through the full thickness. There is, therefore, correlation between the altered staining reaction of the cartilage and the depth of the fissures.

Cysts of cartilage—Cysts are often present in degenerate cartilage when there is fissuring. They appear as irregular spaces, usually situated at the base of fissures, but sometimes nearer the surface (Fig. 9). Although a majority are empty, a few contain a homogeneous gelatinous substance which stains sometimes with haematoxylin and sometimes with eosin, but never with both. It does not, whether it is basophilic or eosinophilic, give a constant P.A.S. reaction. Cysts were present in twenty out of thirty-one surgical specimens; metachromatic staining of the cartilage around them was reduced, slightly in six, moderately in thirteen and completely in one.

Hyperplasia of cartilage—In well established chondromalacia there are focal areas in which the cartilage cells show hyperplasia both by forming cell nests and by a return of the staining properties of the ground substance in and around the nests. The ground substance appears to be streaming around the cell nests (Fig. 10). The process can be interpreted as an attempt at regeneration, but it remains circumscribed and the continuity of the cartilage is not restored. The cartilaginous loose bodies found in chondromalacia behave in a similar way (Fig. 11).

Two specimens have been examined in which the articular cartilage had first been removed at operation and then, about a year later, the patella was excised. The articular surfaces of the patella showed only a few areas of regeneration, the new cartilage being fibrous rather than hyaline in structure. A similar appearance is often seen after "mould" arthroplasty of the hip, as first recorded by Smith-Petersen (1948).

Bone and basal cartilage—The reaction of bone underlying areas of chondromalacia is proliferative. The changes begin when fissures first appear in the cartilage and then the line of calcified cartilage increases in thickness (Fig. 10). As the fissuring extends into the cartilage the increase continues until the thickness of the line is doubled or trebled. New bone is formed in the basal zone and small blood vessels from the marrow spaces penetrate the layer of

calcified cartilage. There is no evidence of ischaemic necrosis in the bone either before or after the cartilage is eroded.

A comparable reaction takes place at the edge of the patella. The surface cartilage proliferates, producing cartilage of a fibrous type, ossification occurs in the deeper layers, and marrow spaces form in the new bone. Thus are formed expanding nodules of fibrocartilage which ossify in the deeper parts to become osteophytes. This process occurs near areas of advanced cartilage degeneration and it also can be interpreted as an effort at regeneration. Occasionally proliferation occurs at the centre of a facet (Figs. 15 and 16).

FIG. 13
Section of a knee flexed 75 degrees showing the extent of the congruity of the articulations between the medial and lateral patellar facets and the femur.

Bone cysts—The bone underlying areas in which the cartilage has been destroyed becomes sclerosed, and small cystic spaces filled with oedematous connective tissue appear beneath the surface (Figs. 12 and 16). These cysts have stomata communicating with the joint, but we have not seen any detritus from the joint inside them.

ETIOLOGY

The earliest demonstrable change in chondromalacia of the patella is an alteration in the reaction of the cartilage matrix to staining. This is due not to oedema, as many authors have maintained, but to a decrease in the chondroitin-sulphuric acid content. It begins in the lower part of the medial facet of the patella, which is said by Øwre (1936) to be the thickest articular cartilage of the body. The reason for this localisation has been investigated by Wiberg (1941). He cut slices of normal knee joints frozen at different angles of flexion and showed that, in the flexed knee, congruity between the medial articular surfaces of the patella and the femur was always less than between the lateral articular surfaces.

We have confirmed Wiberg's observation using a rapid-freeze technique (Fig. 13). The lateral facet of the patella is concave in two planes and makes contact with the femur through

FIG. 14

FIG. 15

Figure 14—Fissuring of the inner and lower quadrant of the articular cartilage. Figure 15—An osteophyte is developing in the middle of the lower and inner quadrant beneath fissured and partially eroded cartilage.

FIG. 16

FIG. 17

Figure 16—There is a cyst in the bone at the outer side, and an osteophyte is forming near the median ridge. Figure 17—The entire surface of the cartilage is rough and an osteophyte is forming at the outer margin.

much of the range of movement. The medial facet is, however, slightly convex and it touches the convex surface of the femur only at a single point, except when the knee is flexed less than 60 degrees. The lower part of the medial facet makes even less contact than the upper part, and it has been suggested by several writers that chondromalacia is caused by mechanical stress applied to this surface. The supporting evidence is not strong.

Harrison, Schajowicz and Trueta (1953), when studying osteoarthritis of the hip, found that there was more damage to the articular cartilage at the non-weight-bearing than at the weight-bearing areas of the femoral head. They suggested that normal movement with its alternating pressure and rest exerted a pumping action which helped to maintain the nutrition of articular cartilage. The patella is not a weight-bearing surface, and slab radiographs do not show a trabecular pattern delineating stressed and non-stressed areas of bone (Figs. 14 to 17). Nevertheless the localisation of the lesions in the patella supports the thesis that there is an association between pressure, or its absence, and the evolution of chondromalacia. Whether this is so or not, it is our view that trauma is of importance more often as an aggravating than as a primary factor, and that it acts by disrupting already degenerate cartilage. The final stage of osteoarthritis is regarded as the result of changes in cartilage, bone and synovial membrane taking place as a reaction to degeneration of the cartilage and to the liberation of free particles of degenerate cartilage within the joint.

CLINICAL FEATURES

Symptoms—The patient is commonly a young adult or in early middle age, but symptoms may occur during adolescence and occasionally in childhood. The onset is often insidious, but it may be precipitated by a minor injury such as a blow or a twist which is regarded by the patient as the cause. Occasionally there is a history of a more violent injury several months

before the symptoms begin. Some disability may have been present for months or years, and advice is sought only after a sudden exacerbation.

When the onset is insidious there is at first discomfort rather than pain; it is noticed after exercise and is not well localised. There may also be discomfort after sitting for some time, when first moving afterwards, or when going down stairs. Later the feeling of discomfort is replaced by pain, and there is often some swelling from effusion. The symptoms are, however, intermittent and, since the knee returns to normal after a couple of days, games

such as football have not been given up. At a more advanced stage, which is reached by comparatively few, the pain and swelling become constant, with exacerbation after stress. There is considerable disability, and most games and the heavier types of work are impossible.

A history of "catching" of the knee during flexion or extension, but seldom both, is common. The patient may say that the knee lets him down. The "catch," which is produced by a partly detached flake of cartilage (Figs. 1, 3 and 18), is felt during flexion when the lower end of the flake is loose and during extension when the upper end is free. It may be more noticeable when a little pressure is applied to the patella during movement. True locking occurs when there is a loose body in the joint, as is quite common in chondromalacia.

FIG. 18

Case 16—The articular cartilage after removal showing a large flap.

The history can be summarised as one of intermittent discomfort or pain which is worse after sitting or after exercise, perhaps accompanied by a moderate effusion and sometimes by a "catch" during movement. There may be a spontaneous remission, or mild symptoms may continue indefinitely without getting worse. Sometimes there is an exacerbation associated with injury; sometimes there is gradual deterioration until finally the symptoms merge with those of osteoarthritis.

Physical signs—A positive diagnosis of chondromalacia can be made by the physical signs, but neither the history nor the signs give a reliable indication of the severity of the pathological changes. The area of cartilage involved can usually be determined, but not the stage to which degeneration has progressed. There may be considerable disability and marked tenderness beneath the patella when there is no more than a little fissuring of the cartilage, or the cartilage may be in a state of advanced disintegration when both symptoms and signs are relatively slight.

A variety of physical signs have been described but several are of little diagnostic value: patello-femoral crepitus on active movement of the knee, pain caused by rubbing the peripatellar tissues against the edge of the bone, effusion, and enlargement of the infrapatellar fat pads may be present but are open to other interpretations. Patello-femoral crepitus is particularly misleading. The important physical signs are:

1) *Pain* on grating the patella against the femur. With the knee extended, the muscles are relaxed and each quadrant in turn is gently rolled on the femur. The relation of the patella to the articular surface of the femur varies, and it may be necessary to push the patella downwards to ensure that all its articular surface comes into contact with the femur.

Pain may also be caused by pressure on the patella while the joint is moved actively or passively; as a rule it is felt only at certain points on the arc of movement.

2) *Tenderness* on pressure over the articular surface of the patella. This is accessible to palpation when the bone is displaced first to one side and then the other (Fig. 19). The amount

it can be displaced varies with the individual but often the whole under-surface except the median ridge can be felt, and even that is exposed when the capsule is very lax.

3) A "catch" on flexing or extending the knee can often be felt when there is a partly detached flake of cartilage (Figs. 1, 3 and 18). It may be easier to detect when the patella is gently pressed against the femur, and it always occurs at the same point on the arc of movement.

The presence of pain on grating the patella, together with tenderness beneath the patella, are diagnostic of chondromalacia provided other diseases such as rheumatoid arthritis have

FIG. 19

Examining for tenderness beneath the patella.

been excluded. Both signs must be present and at exactly the same part of the patella. Care must also be taken to ensure that the natural discomfort of the examination has not been misinterpreted by the patient. At operation the area of cartilage involved is often found to be greater than the physical signs suggested, but only occasionally less.

Pain and tenderness are usually severe when a vascular pannus covers part of the articular cartilage (Figs. 1 and 2). But when there is no pannus, an explanation of these signs is not easy to find because articular cartilage contains no sensory nerve endings, nor have we been able to demonstrate them in abnormal cartilage. An obvious suggestion, so far as tenderness beneath the patella is concerned, is that the synovial membrane interposed between the finger and the cartilage is inflamed. However, the same area of synovial membrane is seldom tender when pressed against the femur, and at subsequent operation it usually appears to be normal. Nor is the tenderness in the peripatellar synovial fold (although this, when inflamed, causes tenderness at the margin of the patella) because it cannot be invaginated far enough.

Radiographic examination—Radiographs are of assistance only in so far as they exclude other disease. In early and moderately advanced chondromalacia the bone is not involved and the thickness of the cartilage is not greatly reduced, so both the bone and the "joint space" appear normal. We have made many attempts to demonstrate the articular cartilage radiologically using every projection we could think of, both with and without the aid of air and other contrast media, but only on rare occasions have they been successful.

DIFFERENTIAL DIAGNOSIS

A positive diagnosis of chondromalacia is, in our experience, nearly always correct, but even when one is well aware of the condition and is constantly on the watch for it, it is surprising how often it is thought to be something else. The common mistake is to call

chondromalacia a tear of the medial semilunar cartilage, and next in frequency is the failure to recognise it as a cause of loose bodies. The association of chondromalacia with recurrent dislocation of the patella is too well known for the former to be overlooked (Macnab 1952); but it is not so well known that the patella is often affected when there is osteochondritis dissecans of the femur. Systemic diseases such as rheumatoid arthritis are unlikely to cause confusion provided reasonable care is taken.

Injuries of the medial semilunar cartilage—Most experienced surgeons will admit an appreciable error in the diagnosis of lesions of the semilunar cartilages. We have made this mistake nine times during the six years 1950 to 1955, an error of five per cent, and on each occasion there has been chondromalacia sufficiently advanced to account for the symptoms. The difficulty arises chiefly when there is a history of a twist, perhaps at football, which precipitated the onset of symptoms, and when there is complaint that "the knee lets me down," especially if there is also tenderness caused by detached fragments of cartilage that have fallen to the lowest part of the joint. In these circumstances, if the patellar pain and tenderness are but slight, it is tempting to incriminate the semilunar cartilage.

Loose bodies—Detached flakes of articular cartilage so often grow in size and calcify in the centre that chondromalacia should be suspected when there are loose bodies in the knee, whether or not there is radiological evidence of osteochondritis dissecans of the femur.

TREATMENT

The results of operation can be discovered by the ordinary methods of follow-up, but the difficulty in assessing conservative measures is that the precise condition of the articular cartilage is usually unknown. Neither the symptoms nor the signs are a reliable guide to the extent of degeneration. Moreover, in the absence of treatment, deterioration in some knees is rapid, in some it is slow, and others appear to recover. Until there is a clinical method of gauging accurately the condition of the cartilage and of following its course in individual patients the prognosis must remain uncertain and treatment can only be *secundum artem*.

The problem of treatment may be presented to the surgeon in several ways: 1) after a clinical diagnosis of chondromalacia, or of chondromalacia associated with another disorder; 2) on discovery of chondromalacia at an operation performed for another condition that has been misdiagnosed, the symptoms really being due to chondromalacia, or for another condition that proved to be present, the chondromalacia having caused no symptoms, or only trivial ones.

A clinical diagnosis may be made at any stage in the course of the disease because some patients present themselves with trivial symptoms, whereas the more robust wait until they are incapacitated. There is an infinite variation from trivial through moderate to severe. Treatment is hardly in doubt at the extremes. With minor symptoms and correspondingly slight physical signs it must be conservative. When the symptoms are incapacitating and long continued, operation gives the best chance of restoring function. The intermediate grades should first be treated conservatively and operation considered only if there is continued deterioration. There is insufficient information as to which knees will ultimately develop osteoarthritis to justify operation for this reason alone. It is our practice to advise operation only when it is indicated by the severity of the disability. Excision of the patella usually gives a good or a fair result, but seldom a perfect one, and there must be a reasonable prospect that this operation will leave the patient with a better knee than he already has.

Discovery at operation offers rather a different problem because the exposure has already been made and the condition of the cartilage can be seen.

Small areas of swollen or soft cartilage are probably best left untouched, but if there is fissuring the affected cartilage may be shaved off; it is usually unnecessary to remove the whole thickness. Lesions of this sort will be found quite often if the under-surface of the patella is inspected at every operation. Areas up to about one inch in diameter can be shaved

after slightly enlarging the incision for meniscectomy; the patella need not be everted and the time of recovery is not materially prolonged.

Advanced chondromalacia that has clearly been causing symptoms should be dealt with in the same way as if the operation were one of choice. In the absence of previous permission it may, however, be inadvisable to excise the patella.

Conservative treatment—There is no evidence that conservative measures have any effect on the course of the complaint. Many patients with mild symptoms improve without treatment, and many improve with it. However, the clinical impression is that treatment is responsible for some amelioration. During the last three years we have treated conservatively upwards of one hundred patients. Those with trivial symptoms have seldom attended for longer than a few weeks, but when the disability has been greater, they have often thought it worth while to continue for months. The effect on the subsequent course will not be known for some years.

FIG. 20

Case 28 after removal of nearly all the articular cartilage of the patella.

The methods of treatment available are rest, short-wave diathermy, and intra-articular injections. Diathermy is prescribed in every instance. Rest, when the symptoms are trivial, may consist only in avoiding games and all exercise that is not essential, but occupations involving complete and powerful extension of the knee, such as ballet dancing and walking races, should be stopped. With more severe symptoms immobilisation is desirable and a bivalved plaster-of-Paris (or polythene) cylinder is applied with the knee flexed 15 degrees. It is taken off at night, and to facilitate diathermy. Exercises without resistance may be given to reduce the amount of wasting of the quadriceps, but exercises against resistance are contra-indicated. We have no experience of intra-articular injection of hydrocortisone for this complaint.

Operation—Two procedures have been practised—removal of the affected articular cartilage and excision of the patella. Patellectomy has not been attempted because our experience with this operation performed for osteoarthritis has not been sufficiently encouraging.

The patella is first inspected through a medial parapatellar incision, and if extensive changes are seen the incision is prolonged to allow the bone to be everted. The complete incision begins at a point in the mid-line one and a half inches above the patella, and extends downwards for an inch, splitting the quadriceps. It then curves round the inner side of the bone, dividing the musculo-tendinous junction and approaches the mid-line again at the level of the tuberosity of the tibia.

Extensive fissuring, flaking and erosion of a considerable area of the articular cartilage is an indication to remove it, but whether this is best effected by shaving off the affected cartilage or by excising the patella is not yet established.

Removal of cartilage—This has been our practice when the area involved has not been greater than about one-third of the whole. With more extensive involvement we have removed the affected cartilage, if necessary, from the entire patella, when chondromalacia has been a chance finding and permission to excise the patella has not been obtained. It has also been done on other occasions after previous discussion with the patient.

TABLE IV
METHOD OF TREATMENT IN SIXTY-FIVE KNEES WITH CHONDROMALACIA OF
THE PATELLA SEEN AT OPERATION

	Males	Females	Total
Seen at operation, not treated . . .	14	5	19
Part or all articular cartilage removed	20	11	31
Patella excised	7	8	15
Total number of knees	41	24	65*

* The number of patients concerned is sixty-two.

Nodular, soft cartilage should be removed as well as fissured. This is done by shaving with a scalpel, the healthy cartilage being bevelled at the margin to leave a smooth surface. The bone is not usually exposed but remains covered with the basal layer of cartilage (Fig. 20). On a few occasions a small area of the femur has been treated in the same way, but extensive affection of the femoral part of the joint is an indication for excision of the patella. Post-operative recovery is often rather slow, and although function may be restored sufficiently to permit light work after a month, physiotherapy may be necessary for much longer.

Excision of the patella—This operation gives short-term results similar to those obtained when it is performed for fracture. Function is seldom restored completely to normal, but the risk that a second operation may later become necessary is removed. The appearance of the knee is usually quite good, but occasionally the contour of the knuckle of the femur becomes obvious and this is most unsightly.

The patella, in younger people, can usually be dissected out without injuring the quadriceps expansion to such an extent that it needs repair. In older patients more fibres are inserted into the central part of the bone and it may become so attenuated that suture is desirable. Restoration of function often takes rather longer than after removal of the articular cartilage, and manipulation may be necessary to restore full flexion.

RESULTS

We have records of the condition of the articular cartilage as seen at operation in sixty-five knees with marked chondromalacia. Those with frank osteoarthritis are deliberately excluded from this survey.

Reference has already been made under the heading of natural history to the nineteen knees in which the cartilage was left untouched. The remaining forty-six were treated by removal of all or part of the articular cartilage, or by excision of the patella. The particulars are detailed in Table V and the results are summarised in Table VI.

The result has been called good when the patient is able to follow his usual occupation and lead an ordinary life without discomfort. The knees may not be perfect but they do stand up to any ordinary strain. For example, the patient in Cases 1 and 26, who had articular

TABLE V
OPERATIVE TREATMENT OF CHONDROMALACIA (TO APRIL 1955)

Case number	Age	Sex	Occupation	Pre-operative diagnosis	Date of operation	"Time to normal" (weeks)	Date last seen	Result	Comment
ONE-THIRD OF ARTICULAR CARTILAGE REMOVED									
1	22	M	Sanitary engineer	Chondromalacia	Feb. 1952	16	May 1955	Good	Operation on both knees. This one causes no trouble. See Case 26
2	16	M	Bank clerk	Osteochondritis dissecans: Chondromalacia	Oct. 1953	22	Aug. 1955	Good	Loose fragment removed from femoral condyle. Now has no disability
3	16	F	Clerk	Chondromalacia	Dec. 1953	8	Oct. 1954	Good	Obese. Now pupil nurse and knee causes no trouble
4	37	M	Sales manager	Chondromalacia	May 1954	13	June 1955	Good	Superficial scar tender. No other symptoms
5	41	M	Heavy lorry driver	Chondromalacia. Torn medial semilunar cartilage	June 1954	—	—	Bad	Torn semilunar cartilage removed. Patella excised four months later for continuing pain and disability. (See Case 44)
6	21	M	Metal machinist	Chondromalacia	Aug. 1954	14	Aug. 1955	Good	Now has no symptoms
TWO-THIRDS OF ARTICULAR CARTILAGE REMOVED									
7	15	M	School	Chondromalacia	Mar. 1952	—	—	Bad	Patella excised eight months later. Other knee also affected. See Case 35
8	19	F	—	Torn medial semilunar cartilage	Sept. 1953	8	Oct. 1954	Good	Semilunar cartilage normal. Now no symptoms
9	16	F	School	Torn medial semilunar cartilage	Oct. 1953	50	Aug. 1955	Good	Slow to recover but now free of symptoms
10	27	M	Doctor	Multiple loose bodies	Nov. 1953	10	Oct. 1954	Good	More than 100 cartilaginous loose bodies removed. Now has occasional ache
11	24	M	Industrial chemist	Torn medial semilunar cartilage	Nov. 1953	28	May 1954	—	Semilunar cartilage normal. Now in South Africa
12	21	F	P.T. instructor	Torn medial semilunar cartilage	Apr. 1954	8	Sept. 1955	Good	Now practically normal
13	45	M	Flat manager	Chondromalacia	May 1954	50	June 1955	Good	Slow to regain good function but now has only slight swelling after much exercise
14	23	M	R.A.F.	Torn semilunar cartilage	June 1954	8	May 1955	Good	Semilunar cartilage normal. Now has occasional "stiffness"
15	18	M	Student	Torn medial semilunar cartilage	June 1954	6	Aug. 1955	Good	Torn semilunar cartilage removed. Now free of symptoms but other knee beginning to cause trouble

TABLE V—*continued*

Case number	Age	Sex	Occupation	Pre-operative diagnosis	Date of operation	"Time to normal" (weeks)	Date last seen	Result	Comment
TWO-THIRDS OF ARTICULAR CARTILAGE REMOVED—<i>continued</i>									
16	28	M	School and games master	Torn medial semilunar cartilage	Aug. 1954	12	June 1955	Good	Sometimes swells after much exercise
17	43	M	Inspector of taxes	Torn cruciate and medial ligament	Aug. 1954	—	June 1955	Bad	Repair of medial ligament; meniscectomy. Knee deteriorating and swells after moderate activity
18	20	M	Student	Torn medial semilunar cartilage	Jan. 1955	8	Mar. 1955	—	Free of all symptoms two months after operation
19	37	M	Garage hand	Loose bodies	Mar. 1955	—	June 1955	—	At work but still lacks 25 degrees flexion
20	28	M	Clerk	Loose body and osteochondritis dissecans	May 1955	—	—	—	Articular cartilage removed from femur also
21	22	M	Librarian	Chondromalacia	May 1954	6	May 1955	Good	Knee sometimes feels stiff
22	33	M	Telephone engineer	Torn medial semilunar cartilage	June 1955	—	—	—	Torn semilunar cartilage
ALL ARTICULAR CARTILAGE REMOVED									
23	—	F	Housewife	Torn medial semilunar cartilage	Dec. 1951	16	Aug. 1954	Good	Only symptom is aching in wet weather
24	27	F	Secretary	Chondromalacia	Aug. 1952	—	Feb. 1954	Fair	Gross villous synovitis. Very slow recovery but now is usually free of symptoms and can walk miles; occasional episodes of stiffness and swelling
25	15	F	Telephonist	Torn medial semilunar cartilage	June 1953	—	—	Bad	Subsequently had patella excised elsewhere
26	25	M	Sanitary engineer	Chondromalacia	Mar. 1954	12	June 1955	Good	Operation on both knees. No trouble except some pain after running about twelve miles. See Case 1
27	22	F	Nurse	Torn medial semilunar cartilage	May 1954	12	July 1955	Good	Semilunar cartilage normal. Only symptom is some aching after kneeling for long
28	36	F	Technical staff B.B.C.	Chondromalacia	Sept. 1954	27	Aug. 1955	Good	Now has no symptoms
29	43	F	Canteen manageress	Chondromalacia	Oct. 1954	—	July 1955	Bad	Still much disability; requires excision of patella
30	28	M	Transport executive	Chondromalacia	Feb. 1955	6	July 1955	Good	Only symptom is swelling after several sets of tennis
31	24	F	Secretary	Chondromalacia	Apr. 1955	—	July 1955	—	No pain but has not yet regained full flexion

TABLE V—*continued*

Case number	Age	Sex	Occupation	Pre-operative diagnosis	Date of operation	"Time to normal" (weeks)	Date last seen	Result	Comment
PATELLA EXCISED									
32	34	F	Clerk	Chondromalacia	June 1948	16	May 1955	Good	Aches if "overdoes it"
33	32	M	Air steward	Chondromalacia	Feb. 1950	—	June 1950	—	Cannot be traced
34	25	M	Salesman	Chondromalacia	Aug. 1950	?	Sept. 1954	Good	Now has no symptoms
35	15	M	School	Chondromalacia right patella.	Nov. 1952	20	Sept. 1954	Fair	Previous removal two-thirds cartilage right patella (Case 7). Now signwriter. Both knees ache if he stands long, and does not like climbing ladders
36	16			Chondromalacia left patella	Mar. 1953	?	Sept. 1954	Fair	
37	17	F	Shop assistant	Recurrent dislocation with chondromalacia	Jan. 1953	60	May 1955	Fair	Transplantation patella tendon. Slow regaining function. Now finds kneeling difficult and sometimes swells
38	34	F	Housewife	Chondromalacia	Sept. 1953	24	Sept. 1954	Good	Aches after sitting for long
39	24	F	Housewife	Chondromalacia	May 1954	No	July 1955	Bad	Several previous operations on same knee elsewhere. Unlikely ever to get good function
40	33	F	Saleswoman	Chondromalacia	June 1954	—	Aug. 1955	Good	Lacks 10 degrees flexion. Aches in cold weather
41	27	M	Engineer	Chondromalacia	Aug. 1954	24	June 1955	Fair	Lacks 50 degrees flexion and has difficulty in kneeling
42	28	F	Invoice clerk	Chondromalacia; old recurrent dislocation	Aug. 1954	12	Apr. 1955	Good	Transplantation patellar tendon 1945. Now has no symptoms
43	40	F	Hotel manageress	Chondromalacia; loose bodies	Oct. 1954	—	May 1955	Fair	Still swells after exercise
44	42	M	Heavy lorry driver	Chondromalacia	Oct. 1954	12	Aug. 1955	Fair	Still aches and occasionally gives way. Driving a light van. See Case 5
45	19	F	Teaching student	Chondromalacia	Apr. 1955	—	July 1955	—	Much muscle wasting before operation and has not yet gained full control
46	49	M	Clerk	Chondromalacia	Apr. 1955	—	July 1955	—	Back at work but has not yet full flexion

cartilage removed from both patellae, has had to give up his hobby of long-distance running because the knee that had all the cartilage removed hurts after about twelve miles.

Removal of cartilage—Thirty-one knees have been treated in this way, nineteen being classified as good, one as fair, five as bad, and six are recent or unknown. Only one has been called fair because a moderate early result usually deteriorates quickly and becomes bad. The exception is the patient in Case 24 who had a gross villous synovitis and has been very slow to recover. Three years after the operation she is unconscious of her knee most of the time, and usually

can walk miles without any trouble, but occasionally there are episodes of stiffness and swelling lasting a few days. The patients with bad results have either had the patella excised later or are likely to require further operation.

The results become less satisfactory as the amount of cartilage removed increases. However, the bad results include two patients aged forty-three, and two with very extensive degeneration at the age of fifteen. The older patients, who are approaching the age of osteoarthritis, are probably better treated by excision of the patella. Very young patients with extensive degeneration are likely to have early involvement of the femoral articular cartilage and a lasting result is improbable whatever is done. Better selection of cases for removal of cartilage should improve the results.

TABLE VI
RESULTS OF OPERATION (FORTY-SIX CASES)

Nature of operation	Result				Total
	Good	Fair	Bad	Recent or unknown	
Articular cartilage removed:					
one-third . . .	5	—	1	—	6
two-thirds . . .	9	—	2	5	16
completely . . .	5	1	2	1	9
Patella excised . . .	5	6	1	3	15
Total	24	7	6	9	46

The only comparable figures are those given by Karlson (1940) who re-examined the patients operated upon in Aleman's clinic one to twenty years before, but he did not give details of the amount of cartilage removed. Of forty-eight knees with chondromalacia (but without frank osteoarthritis), thirty-two had made a functional recovery, thirteen had improved and three had not improved; seven patients (it is not stated in which group) had radiological evidence of osteoarthritis.

Excision of the patella—The patella has been removed for chondromalacia on fifteen occasions. The results are not strikingly good but they compare with those of the corresponding operation for recent fracture, which are not as brilliant as is commonly supposed. Scott (1949) followed up a number of men who had been operated upon in the Royal Air Force during the war. He found that only 5 per cent regarded themselves as having normal knees; the remainder had a variety of troubles, for example, 79 per cent complained of pain and 55 per cent said that they were unable to walk downstairs normally.

The long-term results of the more conservative operation will not be known for some years. If complete removal of all degenerate cartilage prevents the reactive changes that lead to osteoarthritis, it may well become the procedure of choice in properly selected cases.

SUMMARY

1. Chondromalacia, sometimes a precursor of osteoarthritis, is present in the articular cartilage of the patella of most people by the age of thirty; it causes symptoms in only a few, and it gives rise to osteoarthritis in fewer still. It may progress slowly or quickly but there is no clinical method of assessing the prognosis at an early stage.

2. The earliest change is swelling of the cartilage associated with a decrease in the chondroitin sulphuric acid content of the matrix. Later the cartilage fissures and flakes off to expose the bone, and there are reactive changes in the cartilage, bone and synovial membrane. The process is described and the etiology discussed.

3. The symptoms, signs and treatment are discussed. Operation, which has been performed only when there are disabling symptoms, may consist in removing part or the whole of the articular cartilage, or in excision of the patella. The results in forty-six knees are given.

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