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CHONDROMALACIA OF THE PATELLA

Incidence, Macroscopical and Radiographical Findings at Autopsy

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Cartilaginous changes on the patella, generally known as chondromalacia of the patella, were first described as a clinical entity by Büdinger (1906). Numerous authors (Heine 1926, Silfverskiöld 1938, Øwre 1936, Darrach 1939 and Wiles et al. 1956) have reported on its early and common occurrence on the basis of post-mortem as well as operative findings. The aetiology is uncertain, and it has not yet been definitely elucidated whether or not the condition is closely related to osteoarthritis. Wiberg (1941) related the cartilaginous changes to the shape of the patella and to the articulation with the femur, thus suggesting a mechanical factor. In Darracott & Vernon-Roberts' (1971) opinion the primary cause is to be found in the underlying trabecular bone, possibly as a result of derangement of the blood supply.

The purpose of the present study was to ascertain the incidence of chondromalacia of the patella, and to determine the site and extent of the cartilaginous changes and their relation to the radiological changes.

MATERIAL AND METHOD

The material comprises 59 autopsies on 38 male and 21 female persons, all of whom died before the age of 50. This upper age limit was fixed in order to avoid the osteoarthritic changes of senescence in the knee joint as a whole and their possible secondary influence on the patella. Knee joints with changes following fractures, inflammation, etc. were also excluded. Death was due to violence in 29 cases, heart disease in 14, and in 16 cases it was due to various surgical and medical diseases, none of which could be classified as joint diseases.

All post-mortem examinations of the knee joints were performed by the author through a wide medial incision. After inspection of the joints, the thickness of the cartilage on the patella, femur, and tibia was measured with a slide gauge. Both patellae, with a surrounding rim of synovial membrane and joint capsule, were

excised and described macroscopically, and tissue from normal and altered synovial membrane, cartilage, and bone was removed for microscopic study.

The last 60 patellae removed were x-rayed (before the specimens were taken) in the a-p view and the tangential view—the projection used clinically with the lower pole of the patella against the film and the beam parallel to the patella joint surface (the so-called conventional tangential view). Finally, slices 2 mm thick, containing both cartilage and bone from areas with macroscopically normal cartilage and also from areas with abnormal cartilage, were sawn in a horizontal plane using an electric saw. These slices were x-rayed at right angles to the sawn surface (using 40 kV and 10 mA at a focal distance of 90 cm, and film type Gevaert Curix Rapid).

RESULTS

The main emphasis will be placed on the macroscopic appearance of the patella and its relationship to the radiological findings. The microscopic specimens were studied, but as the changes found were in accordance with previous work (Øwre 1936 and Wiles et al. 1956) they will not be mentioned further here.

Macroscopic findings

The cartilage-lined posterior surface of the patella may be described roughly as oval with the inferior arch drawn downwards at the lower

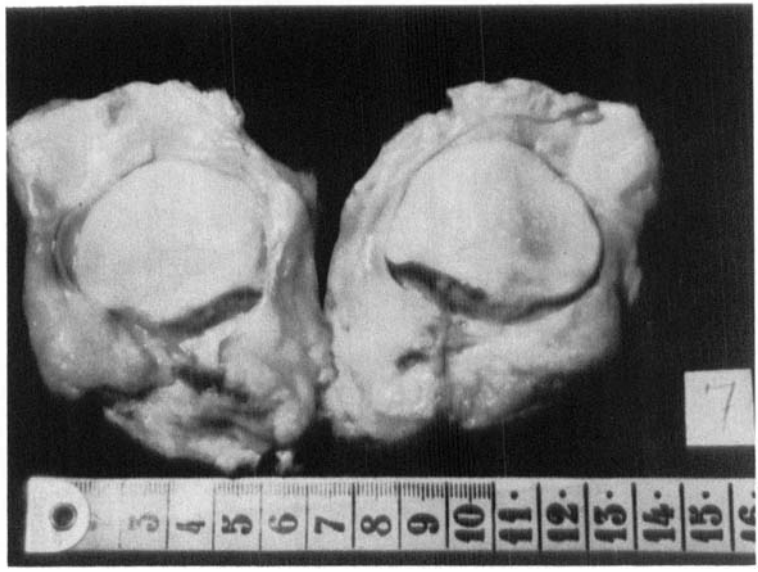


Figure 1. R. and L. patellae from a 43-year-old man. Cartilage macroscopically normal. Medially the synovial fold covers part of the cartilage. Distally the bone is without cartilage.

Table 1. Distribution by sex and age of 118 knees with and without cartilaginous changes on the patella. The area involved on the medial (M) and lateral (L) facet in mm².

Sex	Age (years)	Number of knees	Normal cartilage		Area with cartilaginous changes					
					<100 mm²		100-200 mm²		>200 mm²	
			M	L	M	L	M	L	M	L
Male	10–19	8	6	6	0	1	2	1	0	0
	20–29	14	4	8	5	6	2	0	3	0
	30–39	18	5	11	6	6	3	1	4	0
	40–49	36	5	9	8	20	16	6	7	1
Female	10–19	4	2	4	2	0	0	0	0	0
	20–29	10	4	6	3	4	1	0	2	0
	30–39	10	4	6	3	2	3	2	0	0
	40–49	18	0	6	7	4	8	5	3	3
Total		118	30	56	34	43	35	15	19	4

pole of the patella. Distally and medially the cartilage does not reach the margin; at this site the bone is covered with synovial membrane from which a flap may extend over the joint surface, even in cases with macroscopically normal cartilage (Figure 1).

The joint surface is divided by a sagittal ridge into a smaller medial and a larger lateral facet. The medial joint surface may be divided by yet another sagittal ridge. This was so in five male and nine female patellae (bilaterally in five). In seven patellae (one male and six female) there was a transverse ridge, slightly inferior to the middle and most distinct on the medial half.

Cartilage thickness was measured proximally and distally on both facets and on the sagittal ridge in areas with macroscopically normal cartilage. The maximum value, 4.0 mm, was measured medially in a 17-year-old female, and the minimum value, 1.1 mm, also medially in a 44-year-old female. The mean values for the medial facet, the ridge, and the lateral facet were 2.7 mm, 2.6 mm, and 2.8 mm, respectively, in the male group and 2.5 mm, 2.4 mm, and 2.4 mm in the female group. The equivalent mean values for both sexes were 2.7 mm, 2.7 mm, and 2.9 mm in the youngest age group and 2.5 mm, 2.4 mm, and 2.5 mm in the oldest.

Corresponding measurements on the patellar joint surface of the femur, and on the weight-bearing surfaces of the femur and tibia

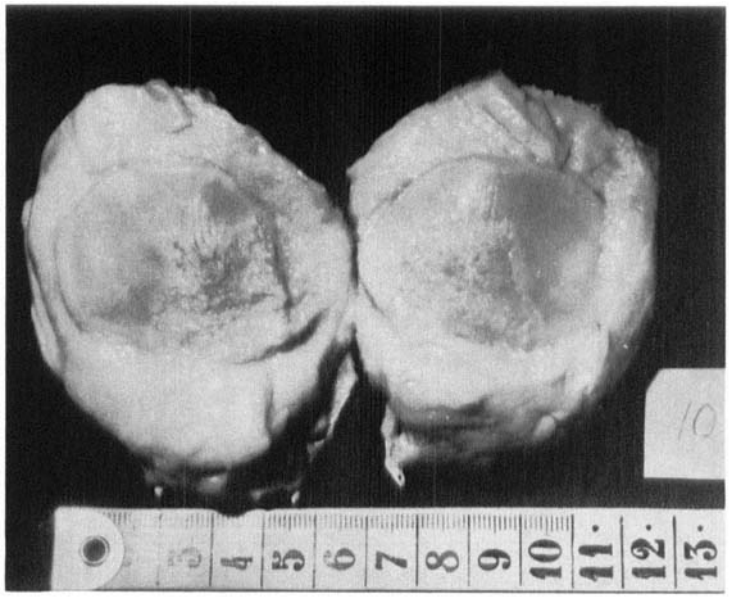


Figure 2. R. and L. patellae from a 40-year-old man. Considerable cartilaginous changes with deep fissures and flaking on both articular facets.

Table 2. Distribution of the macroscopic cartilaginous changes by sex and age.

Sex	Age (years)	Number with degeneration	Oedema	Fissuring	Fraying	Fissuring to the bone	Naked bone
Male	10–19	2	2	1	0	0	0
	20–29	10	9	1	2	2	2
	30–39	13	13	7	5	0	0
	40–49	31	29	19	13	3	3
Female	10–19	2	2	0	0	0	0
	20–29	6	6	2	1	0	0
	30–39	6	6	2	2	0	0
	40–49	18	17	11	13	4	3
Total		88	84	43	36	9	8

ranged from 1.9 to 4.1 mm, with mean values 2.5 mm, 3.1 mm, and 2.6 mm, respectively.

The thickness of the altered cartilage on the patella ranged from 0.0 mm to 6.0 mm, the high values being found in areas with considerable oedema of the cartilage.

Pathological changes in the cartilage. The changes in the patellar cartilage on the medial and lateral facets were determined, and the size of the involved area, as distributed by sex and age group, is given in Table 1. The changes were equally common in females and males and showed a greatly increasing frequency with advancing age. In most cases the alterations were bilateral, involving the medial more often than the lateral facet. In all cases with changes on the lateral facet the medial facet was also involved.

The site on the joint surface was usually distal or distal as well as proximal, and changes were more rarely seen on the proximal half only.

The area of altered cartilage was largest on the medial facet. Thus, 19 patellae with medially situated changes were in the group with the largest area (exceeding 200 mm^2), whereas this applied to only four with laterally localized changes.

The severity of the cartilaginous changes ranged from oedema by way of fissuring, with or without flaking (Figure 2), to denuded bone (Table 2). The most severe changes were found medially. Oedema was present in practically all cases. With advancing age the changes became more pronounced, and this applied particularly to females. Loose flakes of cartilage were not observed in any case.

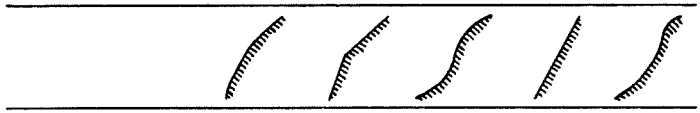
In addition to the more centrally located cartilaginous changes, 33 patellae also had changes in the most medial location, covered with a fold of the synovial membrane. This was also found on three patellae with no other cartilaginous changes.

Radiological findings

The last 60 patellae removed were also examined by radiography. A large number of them were from the older age groups and had a higher incidence of cartilaginous changes than the total series (only eight patellae being entirely devoid of cartilaginous changes and another eight having changes only on the medial articular facet).

The distribution according to sex was 44 patellae from males and 16 from females.

The curve of the joint surface was easier to assess directly from a conventional tangential view than from macroscopic examination, to the result of which it corresponded in all essentials. Figure 3 gives the distribution according to a number of depicted profiles. In the above-mentioned eight patellae with macroscopically normal cartilage the medial facet was straight or slightly concave and the lateral one con-



MEDIAL	18	10	21	6	5
LATERAL	0	0	0	5	55

Figure 3. Grouping of patellae by the curve of the joint surfaces, assessed radiologically.

cave. In 10 patellae the medial facet was divided into two smaller facets. On macroscopic study five of these cases showed a longitudinal ridge and the other five a centrally localized prominence on the medial facet.

Patellar slices from the central and widest part of the patella exhibited largely the same curve of the articular facets as did the con-

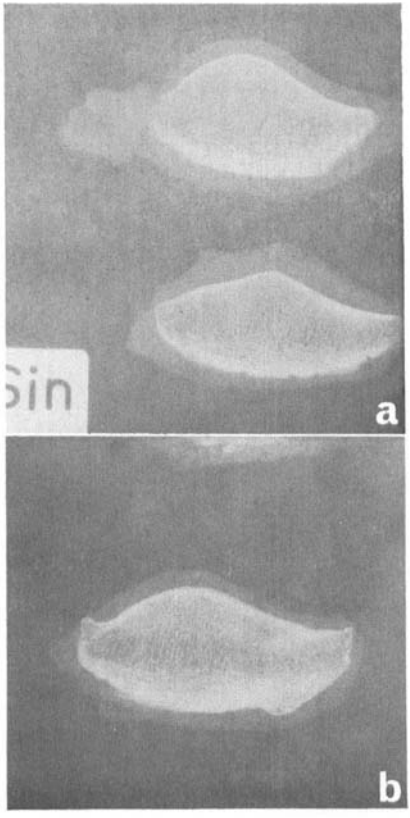


Figure 4. a. X-ray film of slices sawn proximally and distally from the same patella originating from a 49-year-old woman. The curve and the termination medially of the medial joint surface differ on the two slices. The distal one shows cartilaginous changes.
b. X-ray film of a patellar slice from a 47-year-old woman. Cartilaginous changes on both articular facets, most pronounced laterally. Osteophyte formation medially as well as laterally.

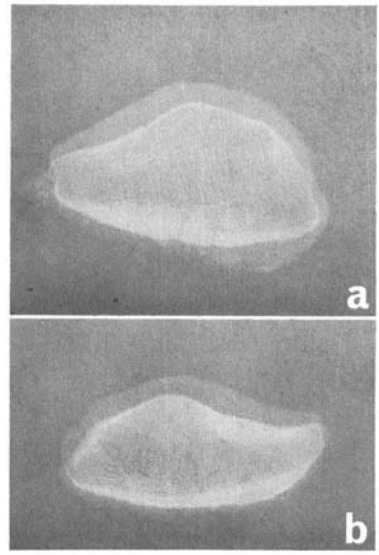


Figure 5. a. X-ray film of a patellar slice from a 29-year-old man. Cartilaginous changes medially on the osseous prominences.
b. X-ray film of a patellar slice from a 44-year-old woman. Cartilaginous changes only medially on the osseous prominences. On the lateral articular facet the cartilage is macroscopically normal. Distinct densification of the bony structure at this site.

ventional tangential view of the whole patella. Slices from the proximal, and especially from the distal, narrower part of the patella sometimes showed a different surface curve, with increased convexity and a more abrupt ending medially (Figure 4 a). In the conventional tangential view of the "entire patella" this may create an illusion of a prominence on the joint surface, especially if the lower pole is slightly tilted. On the other hand, small prominences visible on the patellar slices may disappear in the conventional tangential views.

The patellar slices showed an uneven joint surface curve only medially, but it was not possible on a radiograph of a single slice to ascertain whether there was a longitudinal ridge or a more localized prominence. In 28 patellae out of the 60 such osseous changes were present, and 18 of them had macroscopic cartilaginous changes at the same level (visible also on the X-ray films of the patellar slice (Figure 5 a & b)). In the other 10 the cartilage proceeded across the osseous prominence, with the same thickness, forming a cartilaginous prominence.

To gain an impression of the relationship between the joint facets on the patella, the lengths of the medial facet m and of the lateral facet l were measured on the conventional tangential films, and the ratio m/l between the two was determined. The ratio differed between the extremes 0.51 and 0.89, with a mean value of 0.72. Thus, the medial facet

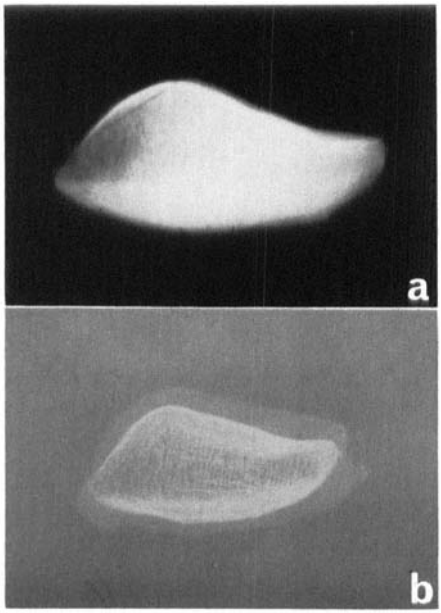


Figure 6. a. X-ray film of the R. patella from a 47-year-old woman. Cartilage macroscopically normal. Skeletal structure less dense medially than laterally.
b. X-ray film of a patellar slice from a 43-year-old man. Cartilage macroscopically normal. It manifests itself as an approx. 2 mm thick layer on top of the bony surface. The bony structure shows distinct densification laterally.

was never larger than the lateral one, and never smaller than half the lateral one. There was no difference between sides. The angle P, with vertex at the top of the sagittal ridge and the sides passing through the medial and lateral corners of the articular surface, was measured. The mean value was 133.5°, with minimum value 116.4° and maximum value 145.2°. Here too there was no difference in the mean values between the sides. A comparison of these values, including localization, extent, and severity of the cartilaginous changes, failed to reveal any definite relationship.

Bone density. When estimating the density of bone in the patella, the shape of the joint surfaces may be of some importance. The lateral facet makes up a more even, smoother surface, parallel to the X-ray beam in the conventional tangential view, than the convex, perhaps somewhat humpy medial facet. The beam will, therefore, pass laterally for a greater distance through the more compact bone at the base of the cartilage, giving the impression of greater skeletal density (Figure 6 a). Even in cases with extensive cartilaginous changes medially, the conventional tangential views never showed a bony density medially, or sclerosing, as pronounced as on the corresponding lateral facet (where the cartilaginous changes were not present or were usually less marked). The lateral facet, on the other hand, exhibited among the

oldest subjects increased bony density or sclerosing under cartilaginous changes, sometimes with denuded bone.

Radiography of the patellar slices may afford a better picture of the density because of the straighter and more equal distance the X-ray beam has to pass in the medial and lateral halves of the patella. However, such slices with macroscopically normal cartilage still showed an increased bony density on the lateral half, most marked centrally and decreasing laterally as well as towards the sagittal ridge. In a few patellae this increased density may extend deeper down (Figure 6 b). The slices with macroscopic medial cartilaginous changes showed in 11 patellae a less dense bony structure, in eight patellae admixed with small sclerotic fields, but only in three patellae a distinctly sclerotic area underneath the cartilaginous changes. The remaining 30 patellae with cartilaginous changes and the eight with normal cartilage had no definite skeletal changes medially. On the lateral joint surface only one patella with lateral cartilaginous changes showed a less dense bony structure alternating with sclerotic fields. Twenty-one patellae had sclerosis of the bone centrally underneath the cartilaginous changes (but this was present also in four patellae with normal cartilage on both facets and in two with normal cartilage on the lateral facet). In the remaining 22 patellae with cartilaginous changes laterally the bony structure did not differ from that in the 10 with normal cartilage.

Bony proliferation. At this point only osteophyte formations will be mentioned, not the above-mentioned osseous prominences on the joint surface which may also possibly be signs of new bone formation.

Osteophyte formation was observed on 12 patellae in the older age groups in the conventional tangential views (on the corresponding patellar slices they could be demonstrated at the same location). The osteophytes measured from 1 to 5 mm, and were in all 12 cases located laterally and in two cases also medially. Macroscopic cartilaginous changes were present medially in all 12 cases and in 11 cases also laterally.

In the case of the patellar slices the osteophytes were present on 22 patellae, with location medially on three, medially and laterally on 11 (Figure 4 b) and laterally only on eight patellae. In both sex groups the osteophytes occurred most often in the oldest age group, but among the males they were also seen in the age group 20–29 years (three cases) and in the age group 30–39 years (four cases). In all cases macroscopic cartilaginous changes were found medially and in 17 cases also laterally.

Bony attrition or defects in the bone surface could not be detected with certainty in the conventional views. On the patellar slices it was found in eight patellae medially and in one laterally, most often in the oldest group of males. In five of these cases it was situated on top of a bony prominence.

DISCUSSION

The present investigation confirmed the common occurrence of cartilaginous changes on the patella, even in the younger age groups, and a marked increase in this frequency with advancing age. There does not seem to be any major difference between the sexes or between sides.

Several aetiological theories have been advanced. Many authors believe in a traumatic origin (Büdinger 1906, Aleman 1928, Hilzensauer 1936, Franke 1971), others in a certain degree of patellar dysplasia (Soto-Hall 1945, Bengert 1964, Deburge & Benoist 1972), possibly combined with a tendency towards lateral dislocation of the patella (Macnab 1952, Fürmaier 1953, Viernstein & Weigert 1968). Bengert (1964) and Crooks (1967) feel that a prominence at the upper boundary of the patellar joint surface of the femur may be of importance. Others have mentioned certain changes in the synovial membrane influencing the nutrition of the cartilage (Sundt 1938, Hirsch 1947). With respect to cartilage thickness the present investigation showed no major difference between the two facets on the patella or other joint surfaces in the knee joint. The high values for cartilage thickness which Øwre (1936) measured, in particular medially, were possibly due to appreciable oedema in association with the chondromalacia. In an important paper by Wiberg (1941) the shape of the patella was advanced as representing an essential factor. He suggested that the articulation of the medial joint surface with the patellar surface of the femur took place on a limited area of the joint surface which was thereby exposed to an exceptionally high weight-bearing stress.

The present studies have shown that the medial articular facet is more frequently and more severely involved in the case of cartilaginous changes which are also more pronounced than on the lateral articular facet. Macroscopic assessment as well as radiography of the entire patella and of patellar slices showed medially a varying surface curve, most often convex, as opposed to the concave lateral facet. Both are to articulate with convex joint surfaces on the patellar surface of the femur.

On the basis of the varying shape and in particular size of the medial articular facet, various types of patella may be distinguished (Wiberg 1941, Baumgartl 1966). In the present paper this is expressed by the ratio m/l between the lengths of the medial and lateral facets and was found to range from 0.5 to 0.9. No definite relationship was found between the size of this ratio and the cartilaginous changes. Moreover, the medial facet may also show the most marked longitudinal and transverse ridges. Together with the osseous prominences observed on the patellar slices, these ridges could compromise satisfactory articulation and thereby cause abnormal stress on the cartilage.

Harrison et al.'s (1953) theory of lack of weight-bearing as a possible cause of cartilaginous degeneration can perhaps explain the common occurrence of cartilaginous changes in the extreme peripheral part of areas which do not take part in normal articulation.

Changes in the bony structure are important criteria for making a diagnosis of osteoarthritis from the X-ray film (Ahlbäck 1968). The conventional tangential view shows, in cases with normal cartilage, a less dense bony structure medially than laterally (where there may be densification of the bone just underneath the joint surface). Even in the presence of fairly marked cartilaginous changes medially, these films (which are standard exposures according to clinical practice) cannot show definite sclerosis medially. Sclerosis occurred only laterally, where the cartilaginous changes were far less marked. These findings were confirmed using the films of the patellar slices and were most distinct in the presence of cartilaginous changes but observed also in cases with macroscopically normal cartilage. Thus, the patella may be the seat of fairly severe cartilaginous changes which do not give rise to demonstrable bony changes on the X-ray film in the form of sclerosis. If the changes progress, however, clinical experience has shown that the marked femoro-patellar osteoarthritis will manifest itself on the X-ray film as sclerosis of the adjacent bony surfaces. Presumably, most of these cases indicate a condition which has persisted for years and which has caused to a greater or lesser extent a disappearance of the cartilage.

Osteophyte formation has previously been regarded as an important criterion for the radiological diagnosis of osteoarthritis, and Billing (1942) considered it to be a definite sign of patellar chondromalacia. However, Danielsson & Hernborg (1970) pointed out that the diagnosis of osteoarthritis could not be based entirely upon the presence of osteophytes. In the present study osteophytes were scanty on the conven-

tional tangential films, often localized laterally, and increasingly common with advancing age. On the patellar slices they were seen more often, but the majority were only 1 mm to 2 mm in length. This is no doubt the explanation of why they did not manifest themselves on the conventional films. Cartilaginous changes were present in all these cases. This, however, cannot form the basis for establishing whether they are conditioned by advancing age or by cartilaginous changes which were present, as stated already, on practically all patellae from the older age groups. Even so, it should be mentioned that the few patellae with normal cartilage did not exhibit osteophytes in any of the radiographic exposures.

From what has been stated above it may be concluded that cartilaginous changes on the patella are common. Aetiological factors are presumably numerous. The cartilaginous changes are most pronounced on the medial facet, and a mechanical factor caused by the convex shape of the medial facet, with simultaneous osseous prominences located centrally on this joint surface, may be contributory. The skeletal structure under the cartilaginous changes does not always show the expected sclerosing, particularly not on the medial joint surface. Thus, the absence of bony changes on the X-ray films does not necessarily indicate absence of cartilaginous changes on the patella. The occurrence of osteophytes is scanty even in the presence of the cartilaginous changes. They are most often localized laterally, where cartilaginous changes are least marked. Accordingly, only very cautious conclusions can be drawn from the absence or presence of osteophytes. Nevertheless, it should be mentioned that cartilaginous changes were present in all cases showing osteophytes.

SUMMARY

In a post-mortem series of 59 persons aged 10–50 years, 91 of the 118 patellae exhibited cartilaginous changes. These changes were most common in the older age groups and usually affected the medial articular facet where they were also most extensive and most profound. Clinical and radiological assessment showed this facet to be less suited to articulation with the femur because of its convex joint surface, central ridges, and prominences.

Radiography using tangential views of the entire patella and of 2 mm thick slices of the patella showed in cases with macroscopically normal cartilage a less dense bony structure medially and a denser structure

laterally. Even in the presence of distinct cartilaginous changes this difference in bone density did not alter essentially. In particular, there was no definite sclerosing medially, where the changes in the cartilage were most marked. Osteophyte formation was sparse, but most common in the older age groups, and laterally. Osteophytes were seen only on patellae with cartilaginous changes.

REFERENCES

Ahlbäck, S. (1968) Osteoarthrosis of the knee. *Acta radiol. (Stockh.)*, Suppl. 277.

Aleman, O. (1928) Chondromalacia posttraumatica patellae. *Acta chir. scand.* **63**, 149–186.

Baumgartl, F. (1966) Anatomische und klinische Bedeutung des Femoropatellargelenkes. *Zbl. Chir.* **91**, 506–516.

Bengert, O. (1964) Beitrag zur Chondropathia Patellae. *Arch. orthop. Unfall-Chir.* **56**, 458–474.

Billing, L. (1942) Der Wert der Röntgenuntersuchung für die Diagnose der Chondromalacia Patellae. *Acta radiol. (Stockh.)* **23**, 317–325.

Büdinger, K. (1906) Über Ablösung von Gelenkteilen und verwandte Prozesse. *Dtsch. Z. Chir.* **84**, 311–365.

Crooks, L. M. (1967) Chondromalacia patellae. *J. Bone Jt Surg.* **49**-B, 495–501.

Danielsson, L. & Hernborg, J. (1970) Clinical and roentgenologic study of knee joints with osteophytes. *Chir. orthop.* **69**, 302–312.

Darrach, W. (1939) Chondritis of knee. *Ann. Surg.* **110**, 948–950.

Darracott, J. & Vernon-Roberts, B. (1971) The bony changes in "Chondromalacia patellae". *Rheum. phys. Med.* **11**, 175–179.

Deburge, A. & Benoist, M. (1972) Chondropathies traumatiques de la rotule. *Rev. Prat. (Paris)* **22**, 537–543.

Franke, K. (1971) Patella-Chondropathie nach Trauma und Überlastung. *Zbl. Chir.* **96**, 1570–1574.

Fürmaier, A. (1953) Beitrag zur Ätiologie der Chondropathia Patellae. *Arch. orthop. Unfall-Chir.* **46**, 178–196.

Harrison, M. H. M., Schajowicz, F. & Trueta, J. (1953) Osteoarthritis of the hip: A study of the nature and evolution of the disease. *J. Bone Jt Surg.* **35**-B, 598–626.

Heine, J. (1926) Über die Arthritis deformans. *Virchows Arch. path. Anat.* **260**, 521–663.

Hilzensauer, K. (1936) Zur Chondropathie der Patella. *Arch. orthop. Unfall-Chir.* **36**, 614–618.

Hirsch, C. (1947) Synovectomy in cases of chondromalacia of the patella. *Acta chir. scand.* **95**, 513–518.

Macnab, I. (1952) Recurrent dislocation of the patella. *J. Bone Jt Surg.* **34**-A, 957–967.

Øwre, A. (1936) Chondromalacia patellae. *Acta chir. scand.*, Suppl. 41.

Silfverskiöld, N. (1938) Chondromalacia of the patella. *Acta orthop. scand.* **9**, 214–229.

Soto-Hall, R. (1945) Traumatic degeneration of the articular cartilage of the patella. *J. Bone Jt Surg.* **27**, 426–431.

Sundt, H. (1938) Chondromalacia of the patella. (Discussion of Silfverskiöld's paper). *Acta orthop. scand.* **9**, 223–226.

Viernstein, K. & Weigert, M. (1968) Chondromalacia Patellae beim Leistungssportler. *Z. Orthop.* **104**, 432–435.

Wiberg, G. (1941) Studies of the femoropatellar joint. *Acta orthop. scand.* **12**, 319–410.

Wiles, P., Andrews, P. S. & Devas, M. B. (1956) Chondromalacia of the patella. *J. Bone Jt Surg.* **38**-B, 95–113.

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