THE BONE CYSTS OF OSTEOARTHRITIS


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Rounded areas of translucency in the bones forming an osteoarthritic joint are well known to radiologists and to orthopaedic surgeons. They are not given much prominence in pathological accounts: their formation is vaguely ascribed to degeneration in the bone in keeping with the degeneration in the neighbouring cartilage. Their frequency was given by Plewes (1940), from clinical and radiological studies, as thirty-two in 242 cases; he also drew attention to their situation in areas of greatest bone sclerosis and greatest loss of "joint space," and to their frequently paired or "kissing" position on either side of the joint line. Collins (1949) described them as incidents in the remodelling of the trabeculae—"a concentric arrangement of healthy trabeculae around an enlarged marrow space filled with ordinary adipose tissue."

The presence of these cysts is often indicated clinically by severe pain in the joint, and in the cases selected for surgical treatment of osteoarthritis the cysts are neither so rare nor so incidental as has been suggested. They have been present in eleven of the last nineteen heads of femur and in one of the last three patellae excised for osteoarthritis and examined in this department. I have found other examples in an osteoarthritic pisiform bone, and in a fractured carpal scaphoid excised ten years after the injury; and in the course of routine post-mortem examinations of patellae they were found in three of ten consecutive bones, and in one of the only two severely arthritic heads of femur in a series of a hundred; another was an incidental finding on microscopy of the acromio-clavicular joint of a patient with ankylosing spondylitis.

The cysts appear to the naked eye as grey gelatinous rounded spaces from a millimetre up to 2.5 centimetres in diameter; the large cysts, over 1 centimetre across, are found only in the femoral head. The cysts are usually multiple—ten were found in one patella—and surrounded by a zone of dense bone up to half a centimetre thick; some are multilocular. A good example of a large cyst is shown in Figure 1, where the greater part of the femoral head is seen to be involved. The smaller cysts (Figs. 3 and 5 to 7) always lie in the bone immediately adjacent to the joint space, and are often pyriform, the pointed end towards the joint. There is always one place where the cyst comes close to the joint cavity, and in a number of specimens it is possible to demonstrate an opening between the two, usually in the form of a linear fissure. It is the purpose of this paper to suggest that these cysts always take origin in such communications and are not due to primary degenerative changes in the bone.

PATHOLOGICAL OBSERVATIONS

Direct evidence in favour of the hypothesis mentioned above includes the demonstration of an opening into the joint cavity, the finding inside the cyst of fragments of cartilage clearly derived from the articular cartilage, and the similarity between the fluid in the cyst and the synovial fluid.

Openings between cyst and joint cavity—Patent openings can be found in a number of cysts, though they may be very oblique and tortuous; a simple example is shown in Figure 2, which is a higher power photomicrograph of the mouth of the cyst shown in Figure 1. Here a direct channel leads past the broken articular lamella of an osteoarthritic femoral head into one loculus of a multilocular cyst. The opening is partly filled with fibrocartilaginous material from other parts of the articular surface, which has closed the entry to a second loculus.
Such secondary closure of the articular surface is much more frequently found than the patent opening; more careful assessment of the detailed structure of the articular lamella is then necessary to prove that an opening has been present earlier.

*Cartilage fragments within the cysts*—Occasionally it is possible to recognise in the cyst pieces of cartilage that are clearly derived from the hyaline articular cartilage. Some cartilage found in this situation cannot be certainly assigned to this origin and may be metaplastic, but the two examples shown in Figures 3 to 5 are unequivocal. The specimen was taken from the acromio-clavicular joint, which showed fairly well marked fibrillation of its cartilage, though none of the changes of the ankylosing spondylitis which had brought the patient to hospital. In Figure 3 the bilocular cyst is seen with the gap in the (nearly black) cartilage.

**Fig. 1**
Case 1—Coronal section of head of femur. A large system of cysts replaces much of the femoral head. (Van Gieson's stain. X 2.)

**Fig. 2**
The same. Higher magnification showing the opening of a cyst through the articular lamella. Dense bone on one side of the cyst; fibrous tissue, fibrocartilage and woven bone on the other (X 12).
now plugged by new fibrocartilage and bone. The higher magnification of Figure 4 shows clearly recognisable cartilage cells in the debris floating loose in the corner of the upper cyst; this is even clearer in the original slide with the metachromatic staining by toluidine blue. It is particularly to be noted that in this cyst, in the fluid contents, the cells of the cartilage

Fig. 3
Acromio-clavicular joint, showing a bilocular cyst; the gap in the articular lamella is closed by bone and fibrocartilage. (Toluidine blue. : 21.)

Fig. 4
The same. Detail of the detritus in the corner of the cyst. Note the cartilage cells ( : 670).

are fresh and alive. In the second example (Fig. 5), the cyst was found in a pisiform bone which was denuded of articular cartilage. The cyst has become completely filled now with fibrous tissue and its original content of fluid can only be guessed at; but in this fibrous tissue there is a flake of cartilage whose form proves its origin from the surface of the joint.
Pisiform bone. Eburnation of the joint surface, with a fibrous plug at its edge leading into a fibrous cyst. In the middle of this a strip of articular cartilage, with the cells dead. (Van Gieson. · 21.)

Figure 6—Patella. Fracture in articular lamella plugged by displaced tongues of fibrillated cartilage with new bone deep to them; bone fragments being removed in depths by osteoclasts. (Van Gieson. · 52.)

Figure 7—Scaphoid. Cyst pointing to its original opening through the fracture line into the joint; opening now closed by reaction, and new bone also shown in the cyst wall. (Van Gieson. · 60.)
The cells in it are dead, but their spaces can be faintly made out. The finding of living cartilage in fluid cysts and dead cartilage in fibrous cysts is strong evidence that the fluid forms before the fibrous tissue, and is not, as has been suggested, a secondary development in a fibrous area in the bone.

Occlusion of the opening is brought about by the formation of fibrocartilage and new woven bone near the throat of the opening, which interrupts the pattern of the articular lamella so clearly that it can usually be recognised as new. Immediate occlusion is found also after the impaction into the opening of plugs formed from the degenerate cartilage when this has not been completely eroded. Such a picture is found in Figure 6, in which there is a clean fracture through the articular lamella plugged by fibrillated cartilage with its characteristic hypertrophic groups of cells, under which new woven bone has formed and re-established the articular surface. Deeper in, replacement by fibrous tissue is complete, except for the fragments of broken bone at the bottom undergoing resorption. The importance of this occlusion of the surface opening is very great, for it enables granulation tissue to develop in its appropriate environment, and in time fibrous tissue may fill the cyst, though densely encapsulated loculi of fluid may persist even when the surrounding bony shell is complete. Nevertheless on detailed examination openings or traces of openings (if the features described are accepted as such) can be made out in all cases.

Nature of the contained fluid—The glairy yellowish-green fluid found in the cysts is entirely in keeping with a derivation from the synovial fluid. The mononuclear cells in it resemble detached synovial cells, and staining reactions show mucopolysaccharide in both cells and fluid. These cysts, unlike others found in bone, do not commonly contain blood pigments, cholesteride crystals or fibrin.

DISCUSSION

Considerable indirect evidence supports the hypothesis that cysts arise from intrusion of synovial fluid into the bone at the joint surface.

Firstly, it has been noted that small cysts are found in the subchondral bone and large cysts extend more deeply. If the cysts were due to bone degeneration, it might be expected that small early foci would be found on routine examination of the deep bone, but such foci have not been found nor are they described in the literature. Again, the bone surrounding the cysts is always more or less sclerotic, and often shows active bone formation, a sequence of changes difficult to account for as a degeneration. Moreover it is unusual to find areas of osteoclastic resorption in the walls of the cysts, and when they do occur they affect only a small part of the circumference.

The cartilage over the cysts is never normal, though the stage of its degeneration varies from quite early vertical splitting to complete erosion. The cysts are not found in eburnated bone, probably because of its rigidity, and because the marrow spaces in such bone are sealed off from the joint cavity by new bone formation; but cysts with a vent in the cartilage at the side may burrow extensively under eburnated bone.

There is therefore good reason to believe that the penetration of synovial fluid is likely to occur in the regions where the cysts are found, and sometimes there is visual proof that it has occurred.

On the hypothesis that intrusion of synovial fluid into the interstices of the bone occurs, the further developments that would be anticipated are in fact much the same as those that have been observed, when allowance is made for the varying size and duration of the opening. Thus, with a persistent opening the uniform fluid pressure would tend to convert the irregular outlines of the marrow spaces into the smoothly rounded or pyriform outlines characteristic of the cysts, with the narrow end of the cyst towards the joint space where expansion is limited by the strong articular lamella. Around this pressure zone would be expected dense bone formed partly by bodily displacement of the trabeculae, partly by new bone formation in response to the strain. Such sclerosis around the cysts is one of their most conspicuous
features, and one most hard to explain on a hypothesis of degeneration. The larger cysts are almost confined to the head of the femur; elsewhere it is unusual for them to reach a diameter of a centimetre. The rounded outlines suggesting fluid pressure, the increase of synovial fluid in osteoarthritis, the pressure built up in the hip by the weight of the body, the extremely tough capsule of that joint compared with that of the knee, and the clinical relationship between painful hips and cystic bone changes, form a chain of evidence of some strength in favour of the hypothesis that these large cysts are virtually internal incomplete fractures of the bone brought about by the slow persistent transfer of pressure from the synovial fluid to the weak internal cancellous trabeculae unaccustomed to such lateral thrusts. Some evidence in support of this hypothesis is available from clinical cases.

**CASE REPORT**

Case 1—A woman aged fifty-nine, who had had pain in both hips for eighteen years, was seen with a view to cup arthroplasty. The hips showed radiographic evidence of severe degenerative arthritis, and there were small areas of translucency in the upper part of the head of the right femur and the opposite surface of the acetabulum. The left hip, at that time the more painful, showed no cysts. She was unwilling to have an operation. Two years later she fell downstairs, twisting her right foot and wrenching the hip. This hip then became very painful, keeping her awake at night and she requested surgical relief. A Judet arthroplasty was performed. The excised head showed no ordinary callus or fracture but the unusually large system of cysts with the patent opening illustrated in Figures 1 and 2. It is true that the original cysts might have advanced in the two years, and that in any case they formed a zone of weakness through which any subsequent fracture might be expected to run, but the correlation between injury, severe pain and unusually extensive cyst formation is quite often observed.

Cysts will not necessarily be formed in every case in which breaches occur in the articular lamella, but only when such breaches remain open to the synovial fluid and in particular when the fluid is under pressure. The cyst (already mentioned) in the acromio-clavicular joint developed in a patient whose lower limbs were ankylosed and who got about on crutches. He had unusual muscular development of the arms and probably there were unusual strains on the acromio-clavicular joints. The joint examined showed cyst formation on both sides at one point in the articulation; this feature, already referred to, is related partly to the usual congruence of osteoarthritic changes on the opposing faces, and partly to strains developing at right angles to the plane of the joint, which will be as likely to fracture both articular lamellae as one. But it is not easy on a hypothesis of degeneration to account for such paired foci in the deeper bone.

Once the opening becomes occluded—and this may occur at any stage in the development of the cyst—fresh synovial fluid cannot enter and granulation tissue can develop without the competing pressure and unsuitable environment of the joint fluid. As long as fluid is present, the marrow spaces are filled with fibro-myxomatous tissue, which in some circumstances may become cartilaginous; but once the fluid is encapsulated ordinary fibrous tissue forms and has a tendency to ossify, in part as woven bone, but also with lamellar apposition to pre-existing trabeculae. This process does not usually go on to complete obliteration of the cyst, but ends by forming a rounded thick-walled bone space with the mucinous marrow and occasional encysted fluid collections described by other authors.

Further support for the fluid hypothesis comes from a case in which the fluid gained access to the interior of the bone through a fracture line.

**CASE REPORT**

Case 2—A healthy man of twenty-two fractured his carpal scaphoid. It remained ununited and was excised because of persistent non-union ten years after the original injury. The proximal fragment was found to have undergone avascular necrosis, with survival of the cartilage. In the other half a typical closed mature cyst was present; there was much new bone around the throat of the cyst, but it was possible to identify a clear line of old communication now filled with bone and fibrocartilage through the fracture into the joint (Fig. 7). There was no evidence of degeneration in the cartilage or in the rest of the bone.
It is possible that these traumatic cysts are less rare than they are thought to be, for it is clearly only occasionally that a fissure will neither completely detach a piece of bone nor remain unoccluded by callus long enough to allow the formation of a cyst visible on radiography; and such bones are seldom excised for close morbid anatomical study. The coarser fractures do not provide the necessary blind cavity for the fluid to be forced into, and in nine heads of radius and four patellae excised for fracture I have found no cyst.

Objections to the alternative hypothesis—The alternative view, namely that these fibrous and myxomatous changes are primary, leading to accumulation of fluid and so to cyst formation, involves several difficulties. The absence of osteoclastic activity in any quantity is probably the least, for the osteoclast is believed to be short-lived. The formation of rounded spaces out of the irregular marrow spaces suggests the agency of fluid, but these spaces are often round when they are fibrous. Concentric zones of fibro-myxomatous changes in the marrow and bone-forming reaction would be improbable. The openings into the joint would imply either trauma consequent on cyst formation or the rupture of the cyst through the overlying dense articular lamella, a process for which the necessary forces do not seem to be available. Fractures undoubtedly occur through the articular lamella in relation to cysts, but for reasons given I believe the fracture antedates the cyst. The presence of living cartilage derived from the articular surface in open fluid-filled cysts, and of dead cartilage in the fibrous cysts, appears to be conclusive.

Osteoarthritic changes may legitimately at present be called degenerative so far as they affect the superficial part of the cartilage; but the removal of the fragmented cartilage and many if not all of the bony changes which are responible for the greatest deformity are clearly traumatic or reparative. It is desirable whenever possible to replace the vague conception of degeneration by precise chemical or mechanical changes; and it is the purpose of this paper to do so by pointing out that the cyst formation responsible for a great deal of the deformity and pain of an osteoarthritic joint is in fact traumatic and not degenerative in the accepted sense of the word.

SUMMARY

1. The bone cysts of osteoarthritis are found in relation to defects in the watertight layer between the joint space and the cancellous bone; these defects are sometimes obvious openings, but more often they are openings closed by fibrous tissue, fibrocartilage or new bone. The small cysts lie close to the surface. Their rounded outlines suggest the agency of fluid pressure in their formation, and the fluid and cells found in the cysts are compatible with origin in the joint space and articular cartilage.

2. The hypothesis is advanced that the cysts are formed by the intrusion of synovial fluid under pressure into the substance of the bone, and the sclerosis around by displacement of the trabeculae and their reinforcement by new bone.

3. The objections to the hypothesis that the cysts represent a primary degeneration in the bone are discussed.

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REFERENCES
