THE EARLY STAGES OF REPLACEMENT OF THE SEMILUNAR CARTILAGES OF THE KNEE JOINT IN RABBITS AFTER OPERATIVE EXCISION[1]

By ROBERT WALMSLEY and JOHN BRUCE

Departments of Anatomy and Clinical Surgery, the University of Edinburgh

THE changes which occur in the knee-joints of adult dogs after operative excision of the lateral semilunar cartilage have been recorded by the authors (1937), and at the same time certain clinical observations were made.

In a series of six adult dogs the lateral semilunar cartilage was replaced after its excision by a meniscus of fibrous tissue which had the general form of the excised cartilage. Some 5 months after the removal of the cartilage the regenerating mass (Pl. I, fig. 1) is a definite structure easily seen with the naked eye, but is not so thick nor so wide as the excised cartilage. One year after removal of the cartilage, however, the new meniscus has a transverse measurement greater than the normal cartilage, although, even at this time, it is not as thick as the normal. The new mass thus relatively soon attains, or even exceeds the normal cartilage in its surface area, a fact which is related, we believe, to the function of the cartilages.

The peripheral border of the regenerated meniscus is continuous in its entire extent with the articular capsule, but as a satisfactory examination of the replacing mass could only be made after the separation of the femur and the tibia, the exact origin of the new mass was difficult to determine. We have now performed a further series of experiments on the knee-joints of young rabbits to discover the exact origin of the new meniscus and the reaction of the related articular surfaces. These parts, it will be understood, can be observed only by the use of microscopic sections through entire joints. Young rabbits have been found to serve this purpose very well, as in addition to providing joints that are easily sectioned their medial semilunar cartilages are mobile—much more so than in man—and can be excised with the minimum of operative trauma.

OPERATIVE PROCEDURE AND HISTOLOGICAL METHODS

In view of the important clinical considerations the operative technique was substantially the same as that employed in the removal of the semilunar cartilages in the human subject.

[1] The expenses of this work were defrayed by a grant from the Earl of Moray Endowment Fund, Edinburgh University.

Under open ether anaesthesia an incision was made along the medial side of the patella and patellar ligament. The joint capsule was thereafter incised in the line of the skin incision, the edges of the capsular wound being retracted with fine forceps and the meniscus identified. A scalpel was inserted between the anterior end of the cartilage and the upper surface of the tibia, and carried laterally to divide the anterior horn. The anterior end of the cartilage was then grasped in forceps, the peripheral attachment of the cartilage divided, and the whole mass thereafter displaced by traction into the interior of the joint. The only remaining attachment—the posterior horn—was then cut across with a tenotomy knife.

The edges of the capsular incision were approximated by a running catgut suture and the skin closed with a continuous linen stitch.

After the operation the animals were allowed complete freedom of movement, and each of them, on the evening of the operation, was freely using the limb.

The first rabbit was killed 2 days after the operation and the others at intervals of 2 days after that. The knee-joint was isolated by dividing the bones about 2 cm. from the joint and it was then fixed in 10% formalin. Thereafter the blocks were decalcified in 3% nitric acid, embedded in paraffin, and sections 10μ thick were cut in the coronal plane and stained with haematoxylin and eosin.

The sections which have been found of most value in interpreting the process of formation of the replacing cartilages have been those passing through the region of the intercondylar eminence and it is photographs of these sections that have been reproduced.

EARLY CHANGES AFTER EXCISION OF CARTILAGES

In the normal knee-joint of the rabbit (Pl. I, fig. 2) the semilunar cartilages have the form and position which are typical of most mammals, and as is usual, the lateral cartilage is thicker than the medial. The articular cartilage of the femur and tibia is thickest over the parts of the bones which are not directly related to the semilunar cartilages.

A change in the articular capsule is seen 4 days after the operation. It consists of a proliferation of the fibrous tissue beneath the surface layer of the synovial membrane at the level of the plane of the knee-joint (Pl. I, figs. 3 and 4); the new cells are typical young fibroblasts. There is, at this time, also an increase in the thickness of the articular cartilage of the tibia where it is normally covered by meniscus, but the proliferation of cartilage cells is not uniform and there is an irregularity of the surface (Pl. I, fig. 3). During the next few days the proliferation of fibroblasts extends over all the synovial membrane, including the part of the membrane that is related to the non-articular parts of the bones. At the plane of the joint the proliferation now forms extensions inwards between the bones; these extensions are the begin-

nings of the new meniscus, which in the early stages is formed in two parts, an upper part which is related to the femur and a lower part related to the tibia (Pl. II, figs. 5, 6). In the following days the ingrowths grow rapidly and this early extension of the new meniscus over the articular surfaces suggests that the menisci are primarily related to the distribution of the synovial fluid on the articular surfaces rather than that they are weight-transmitting structures. The condition is analogous to that which was observed in dogs where the new meniscus first attains a surface area equivalent to or exceeding the normal and only secondarily attains the normal thickness.

About 20 days after the excision, the two parts of the meniscus fuse with each other to form a single mass, but as the fusion is secondary to the increase in thickness of the peripheral part of the meniscus the time at which it takes place varies within fairly wide limits, as the rate of growth is by no means constant in different rabbits.

During the period of active growth the new meniscus is much more cellular than the normal semilunar cartilage (Pl. II, figs. 8 *a*, *b*) and throughout this period there are no cartilaginous cells in any part of it; it is formed only of actively proliferating fibrous tissue cells, and these have been derived from the synovial stratum of the articular capsule of which the menisci are morphological parts.

The attachments of the new meniscus differ from the typical lateral semilunar cartilage not only in that there is no bony attachment by anterior and posterior horns, but also in the wide and continuous attachment of its peripheral margin to the articular capsule and the non-articular parts of the femur and tibia immediately adjacent to the articular cartilage.

SUMMARY

1. Replacement of the semilunar cartilages invariably takes place after their complete removal.

2. The replacing mass is derived from the synovial layer of the articular capsule.

3. The replacing mass is composed, in the early stages at least, of fibrous tissue and fibrous tissue alone.

4. Replacement begins within a very few days and the replacing mass very soon has the form and surface area of the removed disk.

We should like to express our thanks to Prof. J. C. Brash for his help and guidance and to Prof. Sir D. P. D. Wilkie for facilities afforded by his Department.

REFERENCE

BRUCE, J. & WALMSLEY, R. (1937). *Brit. J. Surg.* vol. xxv, p. 17.

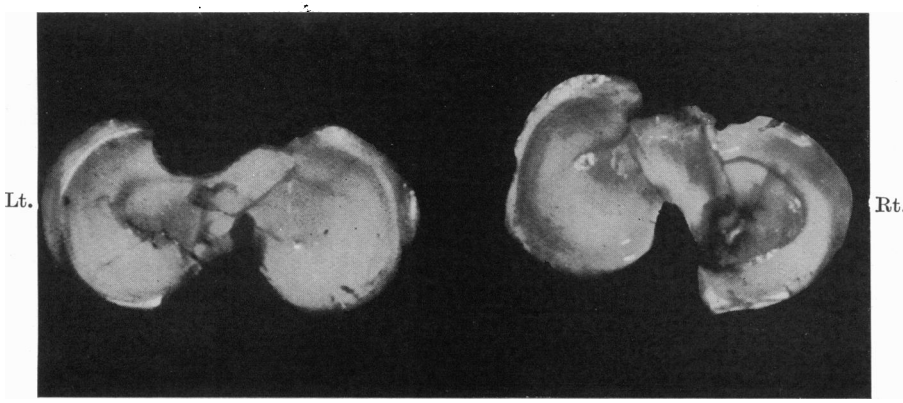

Fig. 1.

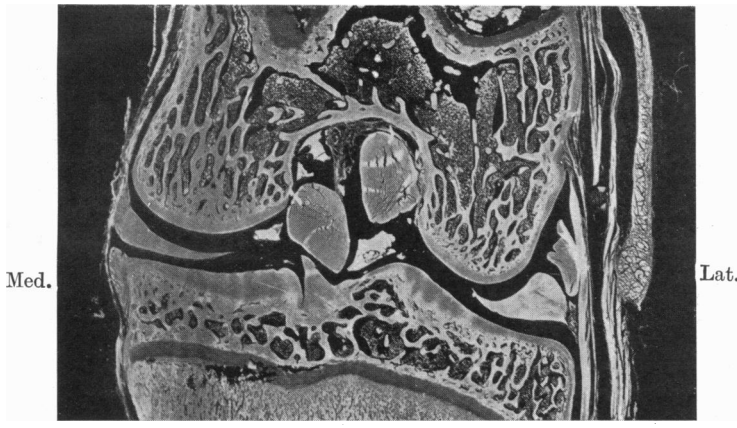

Fig. 2.

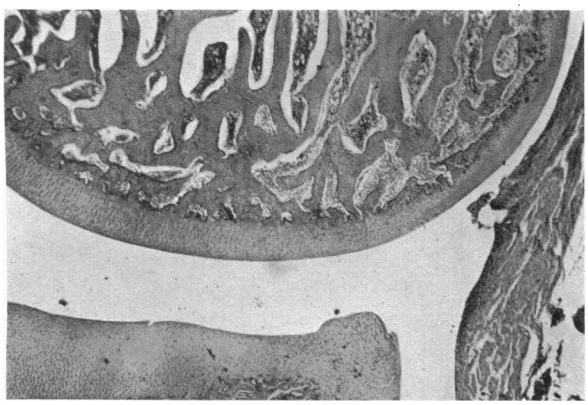

Fig. 3.

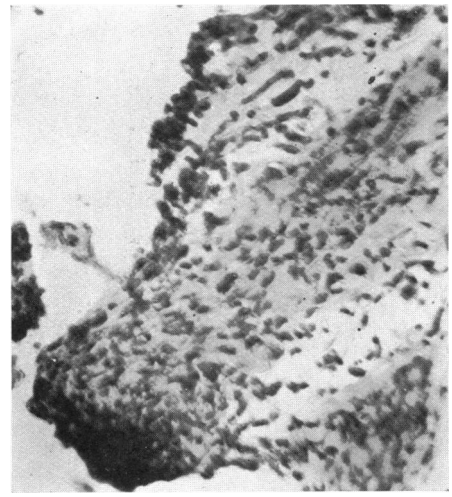

Fig. 4.

WALMSLEY AND BRUCE—SEMILUNAR CARTILAGES OF THE KNEE JOINT IN RABBITS.

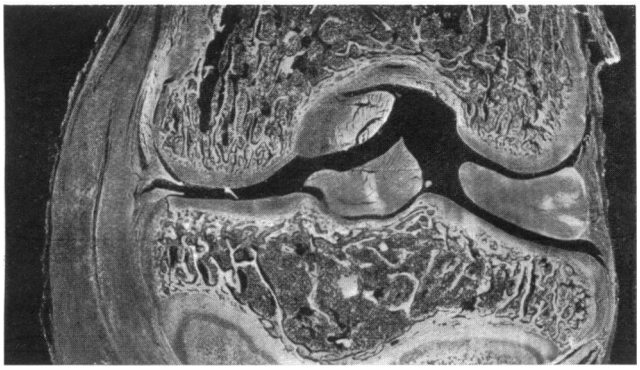

Fig. 5.

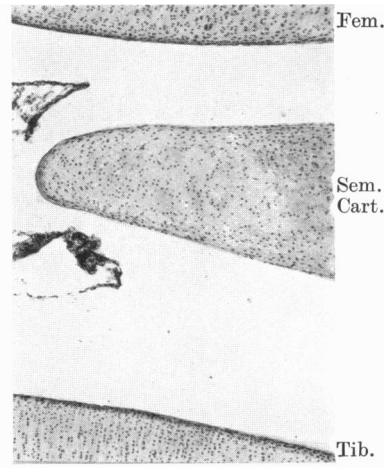

Fig. 8*a*.

Fig. 6.

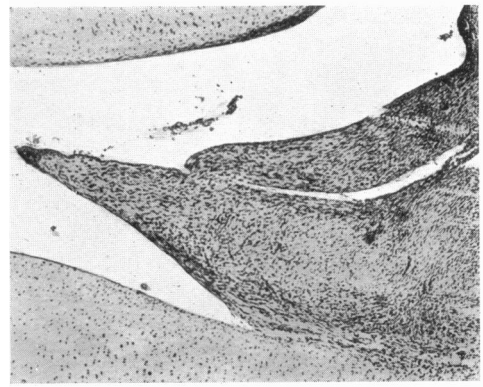

Fig. 8*b*.

Fig. 7.

EXPLANATION OF PLATES I AND II

PLATE I

Fig. 1. Upper surfaces of right and left tibiae of dog 5 months after the removal of the right lateral semilunar cartilage. The new meniscus is neither so thick nor so wide as the normal left lateral cartilage.

Fig. 2. Coronal section of normal knee-joint of young rabbit.

Fig. 3. Coronal section of knee-joint of young rabbit 4 days after the removal of the medial semilunar cartilage. The dark area in the articular capsule at the level of the plane of the joint is the region of the cellular proliferation in the synovial membrane.

Fig. 4. Synovial membrane of same specimen as fig. 3 to show the proliferation of fibroblasts at the level of the plane of the joint.

PLATE II

Fig. 5. Coronal section of knee-joint of rabbit 10 days after removal of the medial semilunar cartilage. The new meniscus has distinct upper and lower parts both of which are continuous with the articular capsule.

Fig. 6. Same specimen as shown in fig. 5 to show the continuity of the new meniscus and the articular capsule. In this figure the tibia is uppermost.

Fig. 7. Coronal section of knee-joint of rabbit 22 days after the removal of the medial semilunar cartilage. The new meniscus in this specimen is a single structure, the upper and lower parts having fused.

Fig. 8 *a*, *b*. (*a*) Illustrates the central part of a normal medial semilunar cartilage, and its relative non-cellularity is to be contrasted with (*b*) which shows the replacing mass 20 days after the excision of the medial cartilage.