AN ANALYSIS OF KNEE-JOINT OPERATIONS.

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The increase of sport and athletics in the Army has brought in its train so many injuries to the knee-joint that the subject is one of considerable importance. The object of this article is to analyse the results of knee-joint operations for the excision of fractured semilunar cartilages and allied conditions which I have performed in the last few years, and to discuss any causes of failure.

The total number of operations upon the knee-joint throughout the Army at home and abroad for a given period I have been unable to obtain, but Morris reports 203 cases operated upon in the Army at home for the year 1934. If one adds to this number the operations performed abroad one might give 300 cases as a conservative estimate. From information available it appears that the number of cases invalided from the Army as a result of knee-joint injuries has lately averaged 55 cases a year. It is, I think, reasonable to assume that practically all these cases had undergone operation. This would mean that roughly one in every six cases operated upon comes to invaliding later. In this connexion it must be remembered that the knee injuries the soldier receives are usually incurred "on duty," i.e. either on strictly military duties or during organized games which are included in the category "on duty." In such instances he is entitled to receive compensation.

It will be seen, therefore, that the activities of sport exact a not inconsiderable toll upon the Army—a toll assessed at the rate of one soldier per week from knee disabilities alone.
The cost to the State has also to be borne in mind; not only the cost of training and feeding the soldier, but the cost of a disability pension afterwards. If this means that 55 men yearly receive disability pensions for long periods or for life, then the subject reaches great importance. I am not, however, prepared to make this statement. The exact significance can only be discovered by the study of statistics to which I have no access.

This paper is based upon the after-results of over 80 operations upon the knee-joint; a small number, but sufficient to lead one to certain conclusions. The after-results have been judged on the condition existing at least six months after operation.

Before describing the results of operations, certain aspects of cartilage trouble require consideration:

THE MECHANISM OF KNEE-JOINT INJURIES.

Bristow describes three varieties of knee strain:

(a) Lateral Strain.—Causing a tear of the ligaments of the inner or outer side of the knee.

(b) Rotation Strain.—Causing injury to the semilunar cartilages; and usually combined with some degree of lateral strain.

(c) Hyperextension Strain.—Causing a tear of the crucial ligaments.

Let us translate these strains into injuries of the semilunar cartilages and neighbouring structures.

(1) The Internal Semilunar Cartilage.

This cartilage is injured by the combination of a lateral strain and a rotation strain. The lateral strain in this case is an abduction strain which forces the lower leg outwards at the knee-joint, thus tearing the internal lateral and coronary ligaments, and opening up the inner side of the knee-joint. The rotation strain in this case is an internal rotation of the condyles of the femur on the head of the tibia which is fixed through the foot to the ground. This rotation strain is not always essential before a semilunar cartilage is injured; certain fractures of the cartilage can be caused by the effects of abduction strain alone. The tearing of the ligaments on the inner side of the joint to which the internal semilunar cartilage is anchored allows the joint space to open and the cartilage to pass inwards towards the centre of the joint between the internal condyle of the femur and the head of the tibia. When the force of the injury is expended, the bones resume their normal positions, and the semilunar cartilage is trapped between the internal condyle of the femur and the head of the tibia and is injured. The fracture affects the anterior, middle, or posterior portion of the semilunar cartilage according to the position of the knee at the time of the accident, and the force and direction of the damaging factors.
(2) The External Semilunar Cartilage.

Injury to this cartilage is caused by the combination of a lateral strain and a rotation strain. The lateral strain is an adduction strain which drives the lower leg inwards at the knee-joint, damaging the external lateral and coronary ligaments, while the rotation strain is an external rotation of the condyles of the femur on the head of the tibia, the foot being fixed. The semilunar cartilage becomes trapped between the outer femoral condyle and the head of the tibia and is fractured.

In both internal and external cartilage injuries there are degrees of damage depending, as stated before, on the force and direction of the causative factors. It is possible, therefore, to imagine a state of affairs where the force is insufficient to cause a fracture of the cartilage after the tearing of the lateral ligaments. The semilunar cartilage will, however, have been wrenched from its lateral attachments, and though in correct position, it will be loose as it lies on the head of the tibia. This, in fact, is the condition occasionally found on opening the knee-joint. It is in such cases that rest and immobilization after a primary injury may lead to recovery. The lateral attachments of the cartilage undergo repair, thus anchoring it once more in place.

(3) Crucial Ligaments.

The anterior and posterior crucial ligaments are tight in full extension of the knee-joint. A hyperextension strain will, therefore, if forceful enough, rupture one or both crucial ligaments, thus allowing hyperextension to occur with an accompanying lack of stability.

(4) Osteochondritis.

The question of the mechanism of knee-joint injuries cannot be dismissed without discussing osteochondritis of the joint. By this is implied damage to the articular cartilage which covers the femoral condyles or the head of the tibia. This damage is generally the result of direct injury. A kick at football received full on the femoral condyle when the knee is bent is sufficient to damage or split the articular cartilage of the condyle. A case due to indirect injury which came under my care was caused by jumping. The patient, while fishing, jumped down several feet from one rock to another. The knee gave way with great pain, and an operation later showed an extensive split in the articular cartilage of a femoral condyle with many small pieces of cartilage loose in the joint.

In my series of 83 cases there were five cases of osteochondritis, and this condition should always be looked for on opening a knee-joint, especially when no obvious fracture of the semilunar cartilage is visible.

(5) Loose Bodies.

To complete this short survey of knee injuries, “loose bodies” must be mentioned. Loose bodies may consist of: (a) Synovial membrane: Portions
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of synovial membrane, chiefly fringes, torn off by injury. (b) Semilunar cartilage: When a fracture occurs a piece of cartilage may be completely detached. (c) Articular cartilage: This loose body is a detached portion of articular cartilage; usually from a femoral condyle. (d) Bone: When a piece of articular cartilage is detached by injury it may take with it some bone cells. All cartilaginous and bony loose bodies gradually increase in size by proliferation.

(6) Fractures Involving the Semilunar Cartilage.

Bristow gives the following figures for fractures involving the semilunar cartilages:

(a) Complete longitudinal fractures, 48 per cent. This is the so-called bucket-handle fracture where the fractured portion often lies between the condyles of the femur. In many instances this is really a fracture dislocation of the cartilage.

(b) Fracture of the anterior portion of the cartilage, 21 per cent.

(c) Fracture of posterior portion of the cartilage, 31 per cent.

Diagnosis.

The common symptoms of fracture of a semilunar cartilage are pain, locking and synovitis, following a sudden injury to the knee. When a typical case occurs the diagnosis presents no difficulty, but at other times one has to consider carefully every sign and symptom before making a decision. These are a few remarks on special points in the diagnosis:

(1) A careful and accurate history is of the greatest importance. We have to base our diagnosis on what the patient tells us of the injury, and special care must be taken to put leading questions as to pain, locking, synovitis, etc.

(2) Locking. The knee becomes locked when a portion of a fractured and displaced semilunar cartilage becomes wedged between the bones, and in this position prevents full extension of the knee. Flexion is often free. The knee may also become locked by a cartilaginous loose body being caught between the bones. In this case the disability is usually a long-standing one; and the patient is often aware of the fact and can sometimes manipulate the body into a palpable position.

(3) Synovitis. In recent cases of injury synovitis is always present, but the more chronic the case the less the degree of synovitis likely to occur. This is because the joint fails to react to a condition to which it has grown accustomed.

(4) It may be necessary in certain cases to make a diagnosis without locking or synovitis. The following points often help:

(a) Tenderness. Careful palpation along the joint line will often detect a painful spot. A fracture of the posterior portion of the cartilage may often be located by this sign. Palpation of the posterior joint line
should never be omitted, as it is the fracture of this portion of the cartilage which is the most difficult to detect, and constitutes the greatest problem in knee-joint surgery.

(b) Lateral mobility of the joint. Lateral mobility is the result of chronic and recurrent synovitis which stretches the capsule of the knee-joint and with it the ligaments which maintain its stability. This lateral mobility is highly significant of a semilunar cartilage injury.

(c) Wasting of the quadriceps. A tape measure should be used in every case of knee-joint injury. Wasting is rarely absent following a semilunar cartilage injury, especially with recurrent attacks.

(d) Manipulation of the knee-joints. This is done as follows: Grasp the foot with one hand and the knee with the other. Rotate the foot outwards and bend the knee. Abduct the leg as strongly as possible at the knee-joint and slowly extend the leg until the knee-joint is straight. The opposite movement should then be done. Grasp the knee and foot as before; rotate the foot inwards and bend the knee. Adduct the lower leg and slowly extend. These manipulations will sometimes reveal grating or crunching in the joint, thus demonstrating a fracture not discoverable by other means.

(e) Pain at the back of the joint is sometimes complained of on straightening the knee at the time of injury. This is due to the stretching of tendons behind the knee, caused by a displaced semilunar cartilage jamming between the bones.

(f) Finally, X-ray should never be omitted.

Some of these points in diagnosis can best be illustrated by examples: —

(1) Serjeant S., while bayonet fighting, suddenly twisted to the left, with the right foot fixed on the ground. He experienced severe pain on the inner side of the right knee, heard a crack, and found that his knee was locked and he could not extend it. He could not put his heel to the ground but hopped off on his toe. On examination twenty-four hours later in hospital there was no synovitis, but the knee was locked and there was a point of tenderness over the anterior end of the internal semilunar cartilage. The usual hollow to the inner side of the patella ligament was absent. Operation a few days later revealed a bucket-handle fracture (or fracture dislocation) of the internal semilunar cartilage, the whole of which was lying between the femoral condyles.

This illustrates the acute case, where diagnosis was obvious and immediate operation was undertaken, resulting in complete cure.

(2) Gunner G., while doing the long jump fell awkwardly and rolled over on his left side. He states he remembers no pain in the left knee at the time, and noticed nothing until his knee swelled up two days later, when pain and tenderness were present over the inner side of the joint. Operation revealed a bucket-handle fracture of the left internal semilunar cartilage.

This case illustrates the mildness of the symptoms which accompanied a severe injury. Both cases show that immediate operation is justified in recent primary injuries, a procedure which is not always advocated.
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(3) Pte. C. Football injury in 1932. Diagnosed then as a sprain of the external lateral ligament of the knee. He was invalided out of the Army in 1934 as he was unable to do duty. His symptoms since then have been slight. He has an aching pain over the outer side of the leg, which sometimes causes him to walk with a limp. No synovitis or locking ever occurs. He came to have the joint explored owing to the length of the symptoms. At operation a fracture of the inner border of the external semilunar cartilage was found.

This case is an example of the chronic knee condition where severe symptoms may never be complained of, and one might hesitate to operate in the absence of more conclusive evidence.

Operative Procedure.

No originality is claimed for any of the following operative procedures. After a certain amount of experience, however, I have been impressed with the necessity of carrying out knee-joint operations according to a plan. Unless a plan is adopted it is possible to overlook the cause of the disability and fail in the operation. It is to indicate the steps and to help those who may have more limited experience that the following notes are given.

Preparation.—As for all bone operations, three preparations of the leg with iodine, commencing two days before the operation.

Technique.—A tourniquet is used and both legs hang at right angles over the end of the operating table.

The surgeon sits on a stool covered with a sterile sheet and facing the knee. The theatre should be capable of being quickly darkened.

For the internal semilunar cartilage, an oblique incision is used, crossing the joint line but avoiding, as far as possible, the patella branch of the internal saphenous nerve. A fresh knife is employed to open the aponeurosis and the synovial membrane, after tetra towels have been clipped to the skin edges. On opening the joint, a fractured cartilage may be visible, and the operation completed by its removal.

If a fracture of the semilunar is not visible the following steps are taken in succession:

(i) The lower leg is grasped below the knee, and the leg twisted and pulled downwards to open up the joint space and see as much of the semilunar as possible.

(ii) If this reveals nothing, the knee-joint is bent up and the femoral condyle in the operation field examined for any sign of osteochondritis.

(iii) If nothing is found, a spot-light is directed into the joint and, if necessary, the theatre darkened. This will reveal the intercondyloid notch and the anterior crucial ligament. In addition, if there is a bucket-handle fracture of the opposite semilunar cartilage, it will be at once visible. I have been able in this way to reveal a fracture which, without a spotlight, would never have been seen.
(iv) If the light reveals nothing, the next step adopted is to place a hand over the popliteal area behind the knee. By pressing on the joint behind and by manipulating the knee with the other hand, I try to extrude any loose body.

(v) If this manoeuvre fails, the joint is syringed out with sterile water to displace any loose body.

Assuming that these steps have shown nothing wrong, we know that we have eliminated: 
(1) Any visible fracture of the internal semilunar cartilage; 
(2) osteochondritis of the internal condyle of the femur; 
(3) injury to the anterior crucial ligament; 
(4) a bucket-handle fracture of the external semilunar cartilage; and 
(5) a loose body. The conditions left are: 
(1) A fracture of the posterior portion of the internal semilunar cartilage; 
(2) a fracture other than bucket-handle of the semilunar; or 
(3) osteochondritis of the external condyle.

A decision must now be taken on what is to be done. There are three alternatives:

(i) Close the knee-joint and complete the operation.
(ii) Remove the internal semilunar cartilage in toto with the expectation that there is a fracture of the posterior third.
(iii) Expose the external semilunar cartilage to see if it is fractured, or if osteochondritis of the external condyle is present.

It is now that the importance of a careful and detailed written history comes in. This is our surest guide to the next step.

If we are sure from the history that a fracture of the internal semilunar cartilage exists then we adopt alternative (ii). Bristow’s statistics show there is a fracture of the posterior portion in 31 per cent of cases.

If the diagnosis is not certain we may adopt alternative (iii) first, and if nothing abnormal is found, then we carry out (ii).

The temptation to remove the visible half of an internal semilunar cartilage on the chance of success must be firmly resisted. It is easy to imagine that the semilunar is slightly loose when a hook is put under it. There is of course a genuine disability due to a loosened internal semilunar cartilage (where the force causing the injury has stopped short of causing a fracture), but there must be no doubt of the fact that the cartilage is loose.

Removal of the Semilunar Cartilage.—I now remove the cartilage in toto and not only the fractured portion. I have adopted this procedure after failing at times to cure the condition by partial removal.

Pte. H., while playing football, twisted round while running and experienced severe pain in the left knee, fell to the ground, and the knee became locked. In August, 1931, he had an operation, when the anterior portion of the cartilage was removed. This did not cure him and he had recurrence of symptoms. In April, 1932, I removed the posterior part of the semilunar cartilage and he has been able to play all games since.

To remove the whole cartilage, anterior and posterior incisions are necessary, except in the case of bucket-handle fractures, when one can remove almost the whole cartilage by the anterior incision alone.
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The technique adopted for removal of the internal semilunar cartilage is as follows:

The anterior extremity of the semilunar cartilage is grasped by a pair of Kocher's forceps, and is separated with a knife as far back as possible, making sure that the internal lateral ligament is retracted and not damaged.

The knee, which has been bent at right angles over the end of the operating table, is then raised on the leg rest to a horizontal position, the knee flexed slightly and turned outwards. This exposes the inner and back portion of the knee-joint. An incision is now made over the postero-internal aspect of the internal condyle of the femur and the head of the tibia, 3 inches in length and crossing the joint line. This incision is made from above downwards and slightly forwards, approximating to the line of the internal saphenous vein, and if possible just in front of it. If the vein is divided the ends should be ligatured. Tetra towels are clipped to the skin edges, and the muscular aponeurosis and synovial membrane divided by a fresh knife. The object should be to obtain a view into the pouch at the back of the knee-joint. This will give an excellent view of the back of the semilunar cartilage. The Kocher's forceps from the anterior incision with the anterior portion of the cartilage still in its grasp is now pushed gently backwards, avoiding injury to the internal lateral ligament, until the anterior extremity of the semilunar cartilage appears at the posterior incision. It is then grasped by another pair of Kocher's forceps introduced through the posterior incision, and the first pair of Kocher's forceps are removed. By traction and cutting the semilunar cartilage can now be removed complete, under direct incision.

The joint is now syringed out with sterile water from both the anterior and posterior incisions to remove any debris which may have been left behind. The incisions are closed in two layers by suturing the synovial membrane and aponeurosis separately. Occasionally the posterior incision must be closed with one layer of sutures taking up both synovial membrane and aponeurosis together. All knots are tied with forceps and the catgut untouched by hand. The knee, it is to be noted, is still in a horizontal position and not hanging at right angles as at the commencement. This makes suturing much simpler. I use small half-circle fistula needles, and No. 1 plain catgut.

After painting with iodine a gauze roll is bound tightly round the joint; then a large roll of cotton-wool; and a flannel bandage applied firmly from mid-calf to mid-thigh. The tourniquet is then released. No splint is applied. The gauze roll is usually cut in bed under sterile precautions twenty-four hours later, after releasing the bandage.

I have tried the method of exposing the inner side of the knee-joint by a horse-shoe flap of skin as described by Timbrell-Fisher, and Pannett. I have abandoned it, however, for the procedure described above. The horse-shoe flap cuts across nerves and vessels. It is a large skin wound to stitch up, and I have found there is a tendency to slough at the edges.

The operation for excision of the external semilunar cartilage follows
similar lines. To make the posterior incision in this case, it is better to keep well back to avoid the tendon of the popliteus muscle. This muscle arises from the external condyle of the femur and runs downwards and slightly backwards to be inserted into the posterior aspect of the tibia. I have divided it when making the posterior incision too far forward, and its position should always be kept in mind. One can appreciate when it has been cut by feeling that a material support of the joint has been divided, and the tibia at once falls slightly away from the femur. It should be sutured at once.

When a bucket-handle fracture exists, division of the anterior and posterior attachments is usually all that is required. The posterior attachment is best divided by a special knee-joint knife which is introduced into the intercondyloid notch under a good light. It is important to carry out all divisions of the cartilage under direct vision as far as possible, as one can easily cut off slivers of articular cartilage from the surface of the tibia and femur unless care is exercised, and these slivers, if left behind, will in time grow and form loose bodies. The use of the special knee-joint knife will help to avoid such accidents. To remove any minute particles of cartilage which may be left in the knee-joint, I always syringe out with sterile water.

Post-operation Care.—From the third day the patient is encouraged to exercise the quadriceps by lifting the leg off the bed, or contracting the muscle. The stitches are removed on the eighth day, and two days later the patient is allowed up, with a short back splint behind the knee to give support, and with a crooked heel. The back splint is only retained for a day or two. Subsequent exercises to the quadriceps are given by sandbags over the instep, by faradism, and later by bicycle exercises.

(To be continued.)