ARTROPLASTY OF THE KNEE

Preliminary Report of a New Method

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This is the first of two reports to describe a new method of knee arthroplasty. It represents the end of the first stage, a period of five years of design and experiment to produce a satisfactory prosthesis. The following account describes the prosthesis, its method of insertion, and details of the first two patients operated upon, now over a year ago. It is hoped to publish a second report at the end of a further five years describing a series of cases.

The problem of arthroplasty of the human knee has intrigued surgeons the world over for many years. Since Verneuil in 1860 first suggested the interposition of soft tissue between bone ends to prevent ankylosis a great variety of materials has been used in the elusive search for a substance which, while permitting the bared bone ends to round and develop new cartilage, will not itself abort the operation by initiating suppuration or fibrosis.

It is a far cry from the chromicised pigs' bladders of Baer (1918) to the modern sheets of nylon (Kuhns and Potter 1950), but as in the 'tween years—the years of fascia lata (Putti 1920), the prepatellar bursa (Campbell 1921), fascia lata and fat (Albee 1928), cellophane (Samson 1949) and Vitallium crowns (Campbell 1940)—the only major difference lay in the chemistry of the interposed material; the broad basis of the operation remained the same.

Briefly this consisted in a wide exposure of the joint, removal of the diseased cartilage and bone and the reshaping of a femoral condyle or condyles together with a tibial surface chiselled to receive them.

In 1949 Speed and Trout published a follow-up study of sixty-five such arthroplasties of the knee from the Campbell Clinic, Memphis, analysed as follows:

<table>
<thead>
<tr>
<th>Results</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>29 (44·6 per cent)</td>
</tr>
<tr>
<td>Fair</td>
<td>17 (26·2 per cent)</td>
</tr>
<tr>
<td>Poor</td>
<td>6 (9·2 per cent)</td>
</tr>
<tr>
<td>Failures</td>
<td>13 (20·0 per cent)</td>
</tr>
</tbody>
</table>

In 1952 Miller and Friedman analysed the results of thirty-seven cases of knee arthroplasty extracted from the Orthopaedic Service of the State University of Iowa Hospitals, covering the period from 1917 to 1947, with the following results:

<table>
<thead>
<tr>
<th>Results</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>11 (30 per cent)</td>
</tr>
<tr>
<td>Fair</td>
<td>8 (22 per cent)</td>
</tr>
<tr>
<td>Failures</td>
<td>18 (48 per cent)</td>
</tr>
</tbody>
</table>

These results are not good—they are bad.

The knee depends for its stability partly upon the massive muscles that invest it and partly upon a beautiful and complex system of ligaments that arise or are inserted within it.
The attachment of these ligaments is to the cartilage and subjacent bone. It is this very cartilage and bone which is removed as one of the initial steps in arthroplasty; thus the ligaments are removed too and the knee loses stability.

The problem is therefore threefold: 1) to permit flexion; 2) to limit extension at 180 degrees; and 3) to preserve lateral stability.

It is submitted that these criteria can never be really fulfilled by any operation which, while removing the ligaments that performed this duty, omits to replace them with an efficient substitute.

THE PROSTHESIS

This is a hinge. It permits flexion because that is the purpose for which hinges originated. It limits extension at 180 degrees because it has been so designed. It preserves lateral stability because of its large bearing surfaces.

The hinge, shown in Figures 1 and 2, is made of 18 8 stainless steel, non-electrolytic and reverse plated. Such material causes no resorption of the encircling bone (Collins 1953). It is made in two parts because it is assembled in the knee joint. Each part has a stem, one for insertion in the marrow cavity of the femur, and the other in the marrow cavity of the tibia. The stems are of varying length determined from radiographs before operation; they are screwed into the hinge and then locked. The smallest sizes are designed for the elbow. The smaller screw has a left hand thread, so that, once tightened into the main bearing which has a right hand thread, no amount of flexion or extension can ever loosen it.

INDICATIONS FOR OPERATION

No arthroplasty may be considered successful until it has stood up to at least ten years of normal use; therefore to lay down indications for operation at this stage would be presumptuous. It is merely suggested that if an arthrodesis of the knee be contemplated for instability due to injury, or for pain from osteoarthritis, this method be given a trial. Should it fail arthrodesis can easily be performed—the bone ends are already prepared.
OPERATIVE TECHNIQUE

The patient is admitted ten days before operation and put under the charge of a competent physiotherapist whose task it is to teach and go on teaching the voluntary contraction of the quadriceps mass. The same physiotherapist remains with the patient for the post-operative rehabilitation.

With a tourniquet high up on the thigh, so as to avoid any possible distortion of the quadriceps group, a long, slightly curved incision is made on the lateral side of the knee. It commences at the top of the suprapatellar pouch and, curving to embrace the patella, terminates just below the tibial tubercle. The skin flaps are reflected to their respective sides and the tendinous expansion is divided in the same line as the skin incision. The joint is now open. By inserting two straight fids in front of the femur and beneath the patellar tendon the latter is easily displaced to the medial side and the patella shelled out from below. The continuity of the tendon is not interrupted, a thin pouch being left between the medial and lateral expansions to mark the place where the patella had rested. The expansions may be brought together with two mattress sutures to obliterate this cavity and, by inserting them in the long axis of the limb, to reef the tendon. Further gentle leverage on the fids now causes the patellar tendon to slip over the medial femoral condyle. The tibia is flexed and the joint made to yawn widely open. The femoral condyles are removed with a saw. It is useless to nibble; the cut must be firm and bold, removing three-quarters of an inch of femoral bone. The flexed tibia is now pushed backwards, carrying to safety the popliteal vessels (Fig. 3) and permitting the posterior parts of the femoral condyles to be brought into view. These are removed with an osteotome. The uppermost quarter of an inch of the tibial plateau is now sliced off, carrying with it both menisci and the remains of the cruciate ligaments. The lateral ligaments fall back and are spared. Their preservation is of the utmost importance. The flat, raw bone surfaces are thoroughly charred with a ball-pointed diathermy and the field is prepared.

Fig. 3
Prosthesis in the knee of a cadaver with a ureteric catheter threaded down the popliteal artery. The vessel is well clear of the prosthesis and moves farther away in flexion.
The stem of the female component is hammered gently up the marrow cavity of the femur, it being always remembered that this lies much further posteriorly than one would think. A slow tide of bone marrow, flowing smoothly down the flanges of the stem, is the reassuring guide to the accuracy of the insertion. The male stem is now similarly hammered down the marrow cavity of the tibia; this is much farther forward than one would think.

The tibia is extended, and with a little care the two parts of the hinge are fitted together and the bearing is screwed home. The reverse-threaded locking screw is engaged in the bearing and tightened. As the limb is snapped into full extension the curious finger may feel the lateral ligaments bar taut. The wound is closed and the leg ensheathed in a plaster cylinder for seven days.

The steps of the operation are shown in Figures 4–7.
POST-OPERATIVE MANAGEMENT

The plaster is removed after a week and mobilising exercises are begun in bed. After removal of the skin stitches—usually three to five days later, depending on the patient’s rate of healing—the limb is gently flexed to the right angle under Pentothal anaesthesia. Weight bearing with crutches is permitted at the end of a fortnight and progress from then on varies with the patient. The acid test of a knee arthroplasty is coming down stairs. The patient in the second case to be described was able to climb stairs with sticks by the sixth week and to descend with one stick by the seventh.

Physiotherapy is of the utmost importance and the static bicycle plays a large part in rehabilitation, but there is more than this. The patient has a completely new joint, a joint of steel with no terminal sensory nerve fibres. Time must be allowed for an actual cerebral cortical adjustment to take place, as with an amputee. The quadriceps must slowly relax as the hamstrings tighten. At first the patient will look down watching the knee, and then suddenly the cortex seems to become readjusted and the rate of progress increases.

CASE REPORTS

Case 1.—A woman of sixty-four sought advice for painful osteoarthritis of both knees, the left worse than the right (Fig. 8). Prolonged short-wave diathermy and quadriceps exercises over two years had failed to relieve the pain. Active flexion was through 20 degrees, but pain was the real complaint. It was so bad that the patient requested amputation. Arthroplasty was offered her, it being pointed out that there was no guarantee of its success, but that if it failed she could have an arthrodesis with an inch of shortening. She desired the operation, which was performed in May 1953. In this, the first case, the patella was trimmed and not removed completely—this proved a mistake.

The patient walked well and was soon flexing and extending actively through a range of 70 degrees, but already the radiographs showed increasing new bone formation about the joint.

Fig. 8
Case 1. Figure 8—Before operation. Figure 9—Ten weeks after operation. Movement was prevented by excessive new bone formation.
Fig. 10
Case 2—Before operation.

Fig. 11
Case 2—Nine months after operation.
Within two months an inch of bone had grown, the patella was adherent and the hinge was incarcerated in a solid bony coffin (Fig. 9). Flexion was impossible. Arthrodesis was performed and it was observed, once the solid bone had been chiselled away, that a new capsule filled with normal-looking synovial fluid was present and a thin synovial layer was surrounding the prosthesis. There was no trace of any fibrous bands or adhesions.

**Case 2**—Before this next operation was undertaken enquiries were made as to how bone could be discouraged from growing. It was learned that certain ear surgeons had met a similar problem in the fenestration operation, when new bone grew over their tiny, newly made bony canal. In America this problem had apparently been solved by burring the bony edges with a soft lead burr.

The second case was that of a woman aged sixty-four, with severe osteoarthritis of both knees (Fig. 10). Relief was sought because of constant pain in spite of prolonged physiotherapy extending over twelve months. Operation was performed in September 1953. The range of movement steadily increased. At eight weeks the knee was painless and the patient was walking well with one stick and could walk without a stick. She was able to climb and, more important, descend stairs. In radiographs taken nine months after operation the hinge was seen to have bedded down a little (Fig. 11) but there was no evidence of new bone formation and the patient has requested a similar operation on her other knee. Figure 12 shows the range of active movement at nine months.

A further two patients have been operated upon since this paper was commenced. So far they promise well and at three months there is no evidence of new bone formation. It is hoped to include them in the second report referred to at the beginning of this article.

**CONCLUSIONS**

If conclusions are to be of any value they must be definite and one cannot draw definite conclusions from less than, say, fifty cases followed up for at least five years. However, few surgeons will ever see fifty patients requiring arthroplasty of the knee, let alone operate on them, even in five years. Accordingly, this account of a new approach to the problem of knee arthroplasty is submitted in the hope that other surgeons may care to try it and thereby learn, and thus be able to teach, the modifications and improvements that all new techniques seem so surely to need.
I wish to express my thanks to Mr Raymond King and my brother, Dr Duncan Shiers, who sent me cases, to Mr W. A. Law and Mr H. A. Pearce, who allowed me the use of their hospital beds, to Mr M. A. Gunn and Mr R. Ruddick, who took the photographs, and last, but by no means least, to Mr Guy Drew, of Messrs Down Bros. and Meyer & Phelps, who placed his vast knowledge of metals and prostheses so unreservedly at my disposal.

REFERENCES