The Classic

Total Replacement of the Knee Joint by a Prosthesis

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MOBILIZATION OF THE ANKYLOSED KNEE JOINT by fascial-flap arthroplasty, which is the generally accepted method of treatment, has not proved to be a consistently satisfactory procedure. Results have been particularly disappointing in patients with ankylosis of the knees due to generalized arthritis, even though the same criteria were not used in judging the outcome as in patients with conditions more favorable to arthroplasty.

A new approach to the problem of mobilization of joints developed with the advent of articular replacement by a prosthesis. As yet, this procedure has been undertaken at the knee in only a small number of cases. Most attempts have been at partial replacement; few surgeons have ventured to replace the entire knee joint.

The same measure of success is not expected from a mobilizing operation of the knee in a patient severely disabled from polyarthritis as in one with monoarticular involvement. From the standpoint of locomotion, the result will naturally depend upon whether other joints are impaired. If a patient with generalized arthritis involving both knees recovers a painless, stable joint with sufficient flexion to permit him to sit comfortably and to stand and

take a few steps, rather than to remain a total invalid, a mobilizing operation will have been worth while.

Case Report

E. Y., a 45 year old woman, had a history of polyarthritis of many years' duration. The symptoms had progressed, despite various methods of treatment, until she was completely disabled. In the upper extremities, the shoulders, elbows, wrists, and finger joints were stiff and painful; in the lower extremities, the hips, knees, and ankles were affected, and there was a drop-foot on the right side. The hip joints still had a fair range of motion. For 2 years, the patient had been a helpless invalid, unable to feed herself or touch her face, dependent upon a nurse to lift her in and out of bed, and prevented from sitting in a chair with any comfort at all. The general condition of the patient, despite the prolonged invalidism, was surprisingly-good. The musculature was poor.

The immediate problem in the rehabilitation of this patient was the mobilization of one elbow joint. Both

Fig. 1A–B Destructive ankylosing arthritis of the knees. (A) Right knee. (B) Left knee.

Fig. 2 Photograph showing knees ankylosed in the position of 50 degrees of flexion. There is a drop-foot on the right side.

elbows were stiff at a right angle, permitting no motion upward and only approximately 15 degrees of motion downward. A replacement operation was performed upon the right elbow on December 4, 1953. Nearly 1 year later, at the patient's request, the left elbow was mobilized by the same procedure [3].

Mobilization of the right knee joint was next considered. Both knees were stiff in flexion deformity of approximately 50 degrees (Figs. 1 and 2). Since a fair range of motion existed at the hips, particularly on the right side, the patient would be able to sit with more comfort and stand on the right leg if the knee joint could be mobilized.

On January 6, 1956, the entire right knee joint was replaced by a prosthesis. The patient made an excellent recovery, experiencing remarkably little pain. Within 10 days, she had voluntary motion in the joint, and 3 weeks after the operation the knee flexed easily to a right angle over the edge of the bed. When the patient was reclining the leg was in perfect extension.

The results of the replacement operations were assessed from a recent examination. The time-lapse from the operative restitution of the right elbow is nearly 3 years; of the left elbow, exactly 2 years; and of the right knee,

Fig. 3 Lateral roentgenogram taken 10 months after total replacement of the knee joint, showing the prosthesis in place.

approximately 11 months. No pain is experienced in any of the restored joints. There is a sufficient range of motion at the elbows to permit the patient to feed herself.

A roentgenogram of the right knee taken 10 months after operative replacement is seen in Fig. 3. The patient can easily flex the joint to 80 degrees from the extended position and voluntarily extend the leg again to 180 degrees (Fig. 4). She is more comfortable in the sitting position, and can stand on the extremity with complete stability of the joint, but the drop-foot prevents the heel from touching the floor. Walking is impossible because of the Achilles tendon contracture and the stiff knee on the opposite side.

The patient is extremely pleased with the result of the mobilizing operations. Dependent upon others, as she was for years, it gives her the greatest satisfaction to be able to help herself, even to this limited degree. It is her feeling that she would be able to walk, if the left knee had motion and the Achilles tendon contracture were corrected.

Description of Prosthesis

The dimensions for the prosthesis (Fig. 5) were based upon those of an adult knee joint of average size, the model

Fig. 4A–B Photographs taken 10 months after total replacement of the knee joint. (A) Voluntary flexion to 80 degrees. (B) Voluntary extension to 180 degrees.

Fig. 5A–B Total knee prosthesis. (A) Anteroposterior view. (B) Lateral view.

being made slightly smaller. The prosthesis was made entirely of vitallium. Two parts, a femoral and a tibial component, lock together by means of a rod and bolt to form a hinge-joint. This joint, which is mechanically stable anteroposteriorly and laterally, limits extension to 180 degrees and permits flexion to 10 degrees beyond the right angle. Each part is equipped with a stem for insertion into the medullary cavity. In addition, provision is made to ensure stability by means of flanges, which are perforated to allow for new bone growth, and by means of teeth, which lie on the posterior sides of the components and bite firmly into the cortical shell.

Operative Technique and After-care

Prior to the operation, the patient should be instructed in contraction exercise of the extensor muscle.

The extremity from the ankle to the groin is prepared. An Esmarch bandage is used as a tourniquet.

A longitudinal incision is made slightly to the medial side of the midline of the extremity, starting approximately 5 inches above the patella, passing just slightly to the inner margin of the patella, and terminating well below the tibial tubercle. The skin flaps are reflected to their respective sides. In the case described, the patella, which was ankylosed to the femur, was shelled out with care to preserve the continuity of the patellar tendon. In the absence of patellofemoral ankylosis, the patella could be retained, as the prosthesis is provided with a surface to receive it.

A 2 inch incision is made in the quadriceps tendon, following the line of the skin incision, in order to obtain better exposure of the lower end of the femur. The patellar tendon is retracted to the outer side without disturbing its continuity. The capsule is incised, and both flaps are reflected to expose the upper tibial surface and the lower femoral extremity for a distance of approximately 5 inches. Blunt dissection is used as much as possible in this process to preserve the periosteal structure intact.

After blunt dissectors have been introduced to protect the popliteal region, a transection of the femur is made with a saw approximately 3 inches above the joint line. One-half inch of bone is removed from the tibial surface. All spicules of bone are excised. The joint is now flexed.

The femoral section of the prosthesis is inserted by driving its stem and flanges into the medullary cavity and its teeth into the cortical bone. The tibial component is then introduced. The two parts of the prosthesis are fitted together, and the rod is inserted and fixed tightly with the bolts. The wound is closed in layers. A voluminous dressing is applied with slight compression.

Gentle contraction exercises of the quadriceps are begun on the third day after the operation. Within a few days,

when the stitches have been removed, the joint is carefully flexed. Gradual progress is made, under the supervision of a physiotherapist, in developing the power of the extensor muscle by exercises and in active movement of the new joint.

Discussion

Mobilization of an ankylosed knee joint is a far more exacting problem than the restoration of motion in other joints. To be successful the mobilizing operation must fulfill two requirements: (1) the newly created joint must be stable; and (2) a functional degree of painless motion must be regained. Stability is indispensable for the utilization of the joint, for only a stable knee has satisfactory weight-bearing capacity.

From studies made in recent years of the results of fascial-flap arthroplasties of the knee, it is clear that the operation often fails to meet the requirements of mobilization of this joint. The procedure has been least successful when the ankylosed knee was incident to a generalized arthritis, in which complicating disease militates against this method of arthroplasty.

There are several factors that may account for the unfavorable prognosis after fascial-flap arthroplasty of the knee. In the first place, the joint is a complex structure, depending to a great extent upon ligamentous support for stability. All investigators are in accord that the collateral ligaments must be respected in the execution of an arthroplasty. Actually, however, these ligaments may not even be recognizable because of their involvement in scar tissue and, hence, they are often of no value. The support furnished by the cruciate ligaments is always lost, since these ligaments must be sacrificed in the excision of bone in the arthroplasty.

Other difficulties of fascial arthroplasty of the knee joint are its precise technique and the inadequacy of fascia lata as an interposing substance. A particularly exacting-technical detail is the reshaping of the articular surfaces to the conformation of the normal knee joint, which is recommended by many surgeons. Studies of the evolution of newly created joints have shown that an interposed fascial transplant tends to break down under weight-bearing and is no guarantee against recurrence of ankylosis.

Arthroplasties of the knee in which various other substances, both organic and inorganic, were used to hold the articular surfaces apart have produced even more disappointing results than the fascial-flap method.

In recent years, the development of new plastic products and metals, which are durable and, in principle, inert in the body, gave impetus to further experimentation with a foreign substance for interposition. Vitallium molds,

metal plates, and non-metallic substances have been tried. The only measure of success in the utilization of one of the newer substances was reported by Kuhns, Potter, Hormell, and Elliston, who interposed nylon membrane in the joint. A follow-up examination of 70 arthroplasties of the knee, which had been performed in patients with chronic arthritis, showed that 58 joints were stable and had satisfactory function. This membrane seems to have been used in only a few isolated cases subsequent to the report of Kuhns and associates, quite possibly because of the danger of hypersensitiveness to nylon. In my early experience in surgical replacements at the hip joint, prostheses made of nylon were used. It did not prove to be a satisfactory material. Not only were there manifestations of hypersensitiveness to the nylon in some instances, but also the plastic prosthesis in some cases failed to withstand wear and tear when the patient became active.

It was inevitable that prosthetic replacement, which has been so extensively used, and with considerable success, at the hip joint, would be extended to the ankylosed knee joint. The first attempt at total replacement of this joint was reported by Judet and associates in 1947. An acrylic prosthesis, which consisted of femoral and tibial sections, was utilized. Early complications forced the removal of the artificial part in this case. Majnoni d'Intignano, in 1950, also attempted replacement of the knee joint by an acrylic prosthesis. It consisted of two sections which were attached by pin-fixation. Later, d'Intignano followed the same principle of replacement in 6 other knee joints—in 4 cases for tuberculosis, in 1 case for posttraumatic arthritis, and in the sixth case for sarcoma. The result is given in only the first case in which there had been a post-operative time lapse of 1 year. The patient, a young girl, had limited mobility of the joint, although she was able to dance. It was pointed out by d'Intignano that tolerance of the prosthesis had been perfect in all his cases. However, in a communication to Lacheretz a few years later, he reported that fibrous reactions with secondary stiffness and intolerance had been observed. Since d'Intignano's initial attempt at knee replacement, cases have been reported by Walldius and by Shiers. Experimental work on dogs has also been reported by Moeys.

Walldius used an acrylic prosthesis composed of 2 sections, which combine to form a hinge-joint, in 4 cases of pronounced polyarthritis. The results were encouraging when the patients were examined from 6 months to 15 months postoperatively. No patient complained of pain, and all had stable knees and were able to move about. Three patients had a range of flexion from 180 degrees to a right angle.

Shiers has replaced 4 knee joints by prostheses of the hinged type and made of stainless steel. The results are

given in 2 cases in which bilateral osteoarthritis of the knee was the indication for the replacement operation. One reconstruction resulted in failure because of the formation of new bone. The second patient, when examined 1 year after the operation, was walking well with a cane and had no complaint of pain.

According to Lacheretz, Merle d'Aubigné has also replaced knee joints by prostheses consisting of a tibial and a femoral component. It was too early to evaluate the results in these cases.

Summary and Conclusions

Total replacement of an ankylosed knee joint by a prosthesis in a patient with multiple arthritis is described. This new approach to the problem of mobilization of the knee has thus far been attempted by only a few surgeons. Some of the results have been encouraging, and the outcome in the present case is promising.

The uncertainty of the end results of fascial-flap arthroplasty of the knee joint, which is the generally accepted method, as well as the even more disappointing attempts to use other substances for interposition has been discussed.

Replacement surgery at the knee joint is still at a pioneering stage, and it would be presumptuous to evaluate the method at this early date. It is possible by prosthetic reconstruction to meet the requirements of mobilization of the knee joint. Moreover, recovery is relatively painless. Whether the body will tolerate such a large metallic prosthesis is not known. There is little doubt, however, that in this new era of the utilization of foreign substances in the body, investigation into this method of mobilizing the knee joint will be continued.

References

1. JUDET, J., JUDET, R., CREPIN, G., and RIGALT, A. *Essais de prosthèse ostéoarticulaire*. Presse méd. 1947, 55: 302.
2. KUHN, J. G., POTTER, T. A., HORMELL, R. S., and ELLISTON, W. A. Nylon membrane arthroplasty of the knee in chronic arthritis. *J. Bone Surg.*, 1953, 35-A: 929.
3. LACHERETZ, M. *Traitement des ankyloses*. Rev. chir. orthop., Par., 1953, 39: 495.
4. MACAUSLAND, D., W. RUSSELL. Nylon prosthesis in lesions of the shoulder, elbow and finger. *Am. J. Surg.*, 1953, 85: 164–173.
5. MAJNONI D'INTIGNANO, J. M. *Articulations totales en résine acrylique*. Rev. chir. orthop., Par., 1950, 36: 535.
6. SHIERS, L. G. P. Arthroplasty of the knee; preliminary report of a new method. *J. Bone Surg.*, 1954, 36-B: 553.
7. WALLDIUS, B. Arthroplasty of knee joint using an acrylic prosthesis. *Acta orthop. scand.*, 1953, 23: 121.