ARTICULATED TWO-PART PROSTHESIS REPLACING THE KNEE JOINT

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ABSTRACT

The invention provides a two-part knee prosthesis comprising components which, respectively, are implanted in the distal end surface of the femur and the proximal end surface of the tibia and which cooperate to provide a substituted articulated knee joint. The femoral component has an upwardly directed anterior fin for upward driven implantation into the distal part of the femur shaft and two transversely spaced femoral condyle replacement support members each of which has a downwardly directed bearing surface which is curved in cross section and in side elevation, the curvature in side elevation being on successively decreasing radii from the anterior portion to the posterior portion of the prosthesis. The tibial component is generally circular and flat in configuration whereby it will lie on the prepared proximal surface of the tibia and its upper surface has a circular upwardly facing groove therein which receives the two transversely spaced femoral condyle replacement support member surfaces of the femoral prosthesis.

3 Claims, 8 Drawing Figures
ARTICULATED TWO-PART PROSTHESIS REPLACING THE KNEE JOINT

BACKGROUND OF THE INVENTION

The normal human knee is a joint which is constructed to permit movement in flexion and rotation. Flexion is the normal bending of the knee and may be performed through an angular movement from approximately \(-6^\circ\) to \(150^\circ\). Rotation is the relative movement of the tibia and femur about their vertical intramedullary axes and is permitted by a range of motion in the knee joint from approximately \(-15^\circ\) to \(+15^\circ\), an arc of \(30^\circ\). The condylar curves of the distal femur are not simple curves but move relatively to the tibial plateau in flexion of the knee in such a way that the areas of contact on the condyles constantly change in location because of rolling and sliding movements, and also each distal femoral condyle surface presents a curve of constantly decreasing radius as the amount or degree of flexion increases. Exact reproduction of the structure and operation of a normal, healthy knee would be ideal in knee arthroplasty but has never been achieved.

Many forms of knee arthroplasty have been described in the literature and used in practice, all of which are based on one of two principles. The first requires the interposition of materials between the bony surfaces after removal of synovial membranes and articular cartilage, while in the second the knee joint is resected and replaced by a metal hinge (Wallatius 1957, Shiers 1960). Material interposed between the bony surfaces has included chromicised pig's bladder (Baer 1918), facia lata (Putti 1920), skin (Brown, McGraw and Shaw 1958), nylon (Kuhns and Potter 1950) and Vitallium (Campbell 1940). Such materials often had serious disadvantages. Chromicised pig's bladder was not tolerated by the tissues, and facia lata, skin and nylon wore away after a short time. Hinge arthroplasty can work well but the hinge prosthesis does not permit the complex movements of the knee in flexion and rotation, and resection of the knee joint results in undesirable shortening of the limb if for any reason the prosthesis must be removed for subsequent arthrodesis.

SUMMARY OF THE INVENTION

The present invention overcomes these disadvantages of known knee arthroplasty and provides a two-part knee prosthesis including a distal femoral component having two transversely spaced bearing surfaces facing the tibia and corresponding closely in position and shape to the normal human femoral condyles and, in cooperation with this femoral component, a tibial component consisting of a generally circular flat bearing plate constructed and adapted to rest on, and be attached to, the prepared proximal plateau surface of the tibia and in its upper surface having a circular upwardly facing concenetric groove which receives the bearing surfaces of the support members of the femoral component. The lower central axis or bottom of this groove is level, by which it is meant that it lies in one plane. This two-part prosthesis permits reproduction of the flexional, rotational, rolling and sliding movements of the normal human knee.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing the two-part prosthesis provided by the invention in place in association with the flexed human knee; FIGS. 2 and 3 are, respectively, a lateral or side elevational view of the knee joint and the implanted prostheses shown in FIG. 1 with the knee joint simulating \(0^\circ\) flexion. FIGS. 3 and 4 are, respectively, top and posterior elevational views of the femoral prosthesis provided by the invention; FIGS. 5, 6 and 7 are, respectively, top, posterior and bottom views of the tibial prosthesis provided by the invention, and FIG. 8 is an anterior perspective view showing the preferred method of preparing the proximal tibial plateau for implanting the tibial prosthesis.

DESCRIPTION OF THE INVENTION

The invention is a two-part prosthesis which may be substituted for the malfunctioning or diseased human knee, leaving the cruciate and collateral ligaments in place and functioning normally. The parts of the prosthesis are implanted, respectively in the distal femur and proximal tibia plateau after suitable preparation thereof, and when implanted permit flexion, rotation, rolling and sliding movements substantially reproducing those movements of the normal human knee.

The femoral component of the two-part prosthesis provided by the invention is preferably of integral construction and may be made by die casting, molding or otherwise suitably forming stainless steel, cobalt-chrome alloy, titanium or other suitable metallic implant material. This component is disclosed in FIGS. 1 to 4 of the drawings and comprises a lower part which is designated generally by the letter A and which provides two downwardly facing bearing surfaces which substitute for the condyles of the femur and which rest on and co-operate with the tibial component provided by the invention. The femoral component also comprises an upper part B which extends upwardly from the lower part A and is constructed and adapted to be driven upwardly into the femur shaft in order to implant the component into the femur.

The lower part A of the femoral prosthesis component comprises two substantially parallel transversely spaced support members 2, 4, each of which has on its bottom a downwardly facing bearing surface which are shown at 6, 8 and each of which is convex and curved in both cross section and in side elevational views. These bearing surfaces are spaced apart by a distance substantially equal to the spacing of the natural femoral condyles and they therefore substitute for these condyles in cooperating with the tibial component of the prosthesis to provide knee action in the operation of the two-part prosthesis provided by the invention. The transverse or cross sectional curvature of each of these bearing surfaces is a regular curve forming part of a circle and is of relatively shallow depth. However, the lateral or side elevational shape of the bearing surface of each support member is not a simple curve forming part of a circle, but is formed of a continuous series of curves of constantly diminishing radii from the anterior portion of the curve at C to the posterior portion at D. This curvature is particularly shown in FIG. 2 of the drawings, in which the anterior portion is designated by the letter C and the posterior portion by the letter D, the anterior portion being at the front of the knee and the posterior portion being at the rear of the knee when the prosthesis is in place. It will be seen that the curvature near the anterior portion has a relatively long ra-
dium and that the radius of curvature of each increment of length of the bearing surface decreases as the surface approaches the posterior end, being a minimum at D. The curvature of each of these bearing surface reproduces that of the natural femoral condyle in the same location in the human knee. Each of the contact or bearing surfaces 6, 8 is polished to a mirror finish, while the other parts of the component may have a dull finish.

The upper part B of the femoral component provides means for connecting the support members and bearing surfaces of the lower part A to the femoral shaft, and this part provides a V-shaped assembly of three elongated thin fins which are constructed and adapted to be implanted in the osteotomized areas of the femur and which serve the purpose of stabilizing and maintaining the placement of the component. These fins are provided by a central upwardly extending fin 10 which has inverted V-shaped and two fins 12, 14 each of which extends forwardly and upwardly from the lower end of one of the arms of the inverted V-shaped central fin 10 and which are connected to the upper surfaces of the two support members 2, 4. Each of the three fins 10, 12, 14 of this upper part B is inverted V-shaped in cross section to provide an upwardly facing edge 16, permitting the upper part B of the component to be driven into the distal surface of the femur and upwardly into the femur shaft after removal of the condyles in the operative procedure of implanting the prosthesis. Fins 12 and 14 form an angle slightly more than 90° with respect to fin 10 to provide stability of the femoral unit in full flexion with the tibial prosthesis.

The tibial component of the prosthesis is disclosed in FIGS. 1, 2 and 5 to 8 and, as particularly shown in FIG. 8, is adapted to be connected to and rest on the proximal plateau surface of the tibia after preparation thereof in the suggested manner described hereinafter. The tibial component is shaped as a disc being of generally flat circular configuration having an upper surface 20, a lower surface 22 and an outer peripheral wall 24.

The component is C-shaped in plan, having the two arms 26, 28 separated by space 29, and its upper surface 20 is provided with a circular concave groove 30 which is concentric with the side wall 24 and which in cross section is part circular and has the same cross-sectional shape and dimension as that of each of the downwardly facing surfaces 6, 8 of the support members 2, 4 of the femoral component, by reason of which such surfaces are received in and exactly fit the spaced parts of the circular upwardly facing groove in the tibial component when the parts are in place.

The lower surface 22 of the tibial component is generally flat but is formed with two groups of curved ridges or ridges 32, 34. One group 32 is formed on the bottom surface of one arm of the C-shaped component, while the other group is formed on the bottom surface of the other arm. The ridges of each group are part circular and concentric in plan and those of one group are curved oppositely to those of the other. Each ring or ridge is shaped as a triangle in cross section and has a sharp edge 36 so that it will bite firmly into the bone of the prepared tibial plateau.

The tibial component of the prosthesis is fabricated from ultra high molecular weight polyethylene or other suitable implant material, and has a wire 40 positioned in a groove formed in its side wall 24. The wire serves as an X-ray locator and as a reference line to permit observation of wear characteristics of the material of the prosthesis while in use. X-rays taken at one year or some such interval will indicate any variations in distance between the bottom edge of the femoral component and the wire.

The two prosthetic components are designed to work together in a unit in such a fashion as to emulate the normal motion characteristics of a healthy human knee. Due to the configuration of the condyles there are both flexion and rotational motions involved in the flexion of the human knee, and the configuration of the prostheses permits both motions. The position of the bearing surfaces 6, 8 in the laterally spaced parts of groove 30 in the tibial prosthesis and the shape of the bearing surfaces themselves permit flexion of the tibia with respect to the femur from approximately −6° to approximately +150° thus substantially reproducing the range of flexional movement of the human knee. The lateral or side elevation shape of each of the bearing surfaces 6, 8 closely approximates the average configuration of the surface of the correspondingly positioned femoral condyle and thus permits a combined rolling and sliding motion of the bearing surfaces of the femoral component on the tibial component which corresponds to the motions of the normal human condyles. The circular shape of the groove 30 of the tibial component permits relative rotational movement of the femoral and tibial components corresponding to the same movement of parts of the human knee, the bearing surfaces 6, 8 riding levelly in the groove 30 during rotational movement of the knee and without riding up on the sides of the groove. The two components of the prosthesis are designed so that in use the theoretical limits of motion are from −6° to +150° of flexion and ±15° of rotation.

If the nature of the case requires or permits it, the femoral component of the complete prosthesis may consist of only one of the support members 2, 4 and the tibial component may consist of only one-half of the circular tibial component described above.

A SUGGESTED SURGICAL PROCEDURE

UTILIZING THE PROSTHESIS PROVIDED BY THE INVENTION

The patient lies supine on the operating room table, with a padded pressure tourniquet in place on the thigh. The knee is draped free and the distal portion of the table may be dropped so that the knee hangs at 90° of flexion if desired. A long medial parapatellar incision is made and the patella is subsequently everted and displaced laterally. This provides excellent exposure of the anterior aspect of the entire knee joint. Care should be taken not to detach a significant part of the patella tendon insertion on the tibia, for if this is inadvertently done the prolonged immobilization required for healing jeopardizes the attainment of flexion.

With the knee in extension and using an air saw and special blades a transverse plane cut is made in the distal femur perpendicular to both the AP and lateral anatomical axes of the tibia, removing the prominent portion of each of the frontal condyles and leaving a plane surface or plateau. Care should be taken not to sever the cruciate ligaments, if present. This cut may be completed with the knee flexed or extended. The thickness of this cut will preferably be approximately 1/4 inch and additional bone may be easily removed later.
The knee must now be flexed to 90° and the posterior condyles removed in the frontal plane. A template is available for determining the maximum amount of the posterior condyles that should be removed. The template is placed on the cut surface with its top edge aligned with the anterior edge of the osteotomy and the posterior osteotomy is made along the bottom edges of the template. It is important that an adequate amount of posterior condyle bone be removed as failure to do so will prevent flexion beyond 90°. However, removing too much bone will bring the prosthesis forward and cause it to interfere with the excursion of the patella during extreme flexion. The femoral template is designed so that it may be implanted against freshly cut bone of the femur in order to accurately show the proper position for osteotomy of the posterior condyles. The posterior corners are now removed ("rounded off") by a 45° cut which represents a minor trim of the sharp corners made by the first two osteotomies.

A femoral saw guide is now placed in position on the condyles, the reference line on the top edge of the saw guide indicating the location of the anterior edge of the prosthesis, if implanted without methyl methacrylate. The air saw is then used to cut slots for the reception of the fins 10, 12, 14 of the femoral prosthesis. The femoral trial prosthesis is then inserted to verify the femoral osteotomies, and is then removed with an extractor. If utilization of methyl-methacrylate is desired, the fin slots are enlarged and undermined with the air saw to accommodate fins and cement. The trial prosthesis is identical in size and configuration to the prosthesis which is actually used and which has been described, except that the contact or weight-bearing surfaces are not polished to a mirror finish. This device is utilized in surgery some what like an instrument used to determine the proper fit between prosthesis and bone without risking a regular prosthesis to the exposure of being scratched or damaged by such handling.

Attention is then directed to the tibial surface. The menisci, if present, should be excised. Four sagittal cuts are made for the tibial prosthesis and two transverse cuts are made 3/8 inch beneath the articular surface of the tibia, and the sections of the tibial plateau are removed. It is important that these cuts be complete, as irregular fractures may occur posteriorly otherwise. A similar midline transverse cut is made to an AP depth of 3/8 inch only, and this is joined by a frontal cut at right angles in order to accommodate the anterior bridging portion of the tibial prosthesis. The final prepared tibial plateau surface is shown in FIG. 8 with the tibial component in place on the plateau. The prosthesis rests on freshly cut surfaces of the tibial plateau and surrounds the cruciate ligaments except in the direct posterior. If methyl methacrylate is not to be utilized with the tibial prosthesis, the extreme medial and lateral parts of tibial plateau should be retained for stabilization of the prosthesis. If cement is to be utilized, the extreme medial and lateral parts of the plateau may be removed without seriously jeopardizing the stability. Minor adjustments should be made with air saw so that a satisfactory fit of the trial tibial prosthesis is accomplished. Minor variations between medial and lateral cuts in the tibia may be made in order to compensate for varus or valgus deformity. Considerable care should be taken to retain the middle portion of the tibial plateau so that most of the insertion of the anterior cruciate ligament is preserved. The trial tibial prosthesis is used to verify the tibial osteotomies. If methyl methacrylate is to be utilized, two drill holes should be placed in the tibial surface to anchor the cement. The trial tibial component is very similar to the regular tibial prosthesis, which has been described, except that it is fabricated of steel, does not have an X-ray locator wire, and the bottom surface is smooth. It also is to be used as though it were an instrument in order to determine the proper fit of the regular prosthesis.

When correct bone preparation has been determined by use of both trial prostheses, the femoral prosthesis may be implanted. If methyl methacrylate is not used, the femoral prosthesis is pushed into place using a prosthesis seater. When emplaced, the prosthesis may be seated or set by light mallet taps on the handle of the seater. If cement is used the cement should be mixed and handled in accordance with the manufacturer's instructions. When in a dough-like state, small portions of cement should be inserted in the fin slots and a thin (approximately 1/8 inch) layer of cement placed on the freshly cut surfaces which will receive the prosthesis. The femoral prosthesis is then pushed slowly into place using the femoral prosthesis pusher. The prosthesis may be coined into the cement by taps with a mallet against the prosthesis pusher. Any excess cement should be removed with curettes. If cement is not used, the tibial prosthesis is placed in position while the knee is still in 90° flexion. After the prosthesis is inserted, the knee is slowly brought to full extension. If cement is utilized, with the knee still in 90° flexion, a thin (1/16 inch to 1/8 inch) layer of cement is spread on the prepared tibial surface. The tibial prosthesis is emplaced, taking care not to push or exude cement to the posterior. If cement is pushed beyond the prosthesis posterior, it may impinge during flexion, thereby limiting the amount of flexion to be obtained. While it is not recommended that methyl methacrylate be used to build up the prosthesis or correct major deformities, minor abnormalities may be offset by this technique in order to provide an axis of weight-bearing that is perpendicular to the tibia and parallel with the floor. After implantation of the prosthesis, the knee is slowly returned to full extension. (0° flexion). During the elevation from flexion to extension, the surgeon must feel the pressure required to compensate for varus or valgus, remembering that excessive pressure in either direction will result in migration of the uncured cement.

The patella is then reduced and the absence of the impingement on the anterior portion of the prosthesis confirmed. The cut is closed in layers with interrupted sutures over suction drains in the usual fashion. The recommended postoperative routine includes immobilization in a splint or dressing with the knee in extension for 5 to 7 days, at which time the initial bulky dressing is replaced. Mobilization is continued as tolerated in balanced suspension with protective weight-bearing started at seven days. Quadriceps exercises are encouraged, but flexion beyond 60° is discouraged for 2 weeks until quadriceps healing is advanced and postoperative reaction in the joint is diminished. At three weeks, inadequate flexion can be encouraged by a gentle manipulation under anesthesia.

It will be understood that the described surgical procedure included in this specification imposes no limitation on the invention and that departures may be made
from this described procedure within the scope of the invention.

We claim:

1. A two-part prosthetic device for arthroplasty of the knee joint, comprising a component for replacing at least a part of the distal end of the femur and a component for replacing at least a part of the proximal end of the tibia, the femoral component comprising a unitary integrally formed device constructed and adapted to be connected to the distal end of the femur and serve in lieu of the condyle surfaces thereof, said femoral component having an upper part having an upwardly directed bone fixation element for upward implantation in the femur shaft and a lower part providing two substantially parallel transversely spaced support members which serve in lieu of the natural condyles, each of said support members having a downwardly facing bearing surface the anterior to posterior shape of which is a continuously changing curve of constantly decreasing radii and the transverse cross sectional shape of which is a curve forming part of a circle and of shallow depth, the tibial component being disc shaped and having upper and lower surfaces and a side wall and being constructed and adapted to lie with its lower surface on and connected to the prepared plateau surface of the proximal tibia, the tibial component having an opening extending from the posterior part of its side wall to its center whereby the component is C-shaped, the tibial component having a groove in its upper surface which is C-shaped in plan, following the C-shape of the component, to receive the support members of the femoral component, the groove being of uniform cross sectional shape and shallow depth throughout its length and its bottom shaped in each transverse cross section as a curve forming part of a circle.

2. As a new article of manufacture, a femoral prosthesis forming part of a two part knee prosthesis, comprising a unitary, one-piece device constructed and adapted to be connected to the distal end of the femur and replace the condyle surfaces thereof, said prosthesis having a lower part having two transversely spaced substantially parallel condyle replacing members each of which has a downwardly facing bearing surface which is shaped in anterior to posterior direction as a continuously changing curve of constantly decreasing radii and is shaped in transverse cross section as a curve forming part of a circle and a shallow depth, and means for connecting the prosthesis to the femur by upward driving implantation, comprising two fins extending upwardly from the upper surfaces of the condyle replacing members, respectively, and having upwardly facing upper edges, and a third fin of triangular shape extending upwardly from the upper surfaces of the condyle replacing members at the anterior parts thereof and having upwardly converging upper edges extending from the anterior parts of the upper edges of the first two fins.

3. As a new article of manufacture, a tibial prosthesis forming part of a two-part knee prosthesis, comprising a circular disc shaped device having upper and lower surfaces and a side wall and having an opening extending from one part of the side wall to the center of the device whereby the device is C-shaped, a shallow groove in the upper surface of the device extending throughout substantially the entire length thereof and therefore also being C-shaped, the groove being of uniform cross sectional shape and depth and in each of its cross-sections its bottom being formed as a curve forming part of a circle.