A knee-joint prosthesis comprises a femoral condyle component and a tibial condyle component secured, respectively, to the femoral and tibial condyles by a cement in resected areas of the bones. The femoral component is an elongated, doubly-curved member that extends from the anterior to the posterior of the femoral condyle and has an external surface shaped to match closely the anatomical shape of the femoral condyle. The tibial component is an elongated member extending from adjacent the anterior extremity to adjacent the posterior extremity of the tibial condylar plateau and positioned for engagement by and support of the femoral component. The external surface of the tibial component closely matches in transverse cross-sections along its length the transverse shape of the external surface of the femoral component and is generated by a generally straight, anterior-posterior line moved along said transverse curvature. The prosthesis may be duo-condylar, or it may be made uni-condylar by provision of the components on only one pair of condyles.

10 Claims, 6 Drawing Figures
KNEE-JOINT PROSTHESIS

BACKGROUND OF THE INVENTION

This invention relates to a knee-joint prosthesis and, in particular, to a prosthesis that provides for replacement of the inter-engaging surfaces of the femoral and tibial condyles by which the weight of the body above the knee is transmitted from the femur to the tibia.

The knee joint is the largest joint of the body and is also subject to the greatest stresses of any joint in the body. It supports the entire weight of the body above the knee and does so in various relative angular positions of the femur (thighbone) and the tibia (legbone) upon articulation of the joint. In addition to sustaining high stresses, the knee joint must also provide freedom of articular movement. Injury or disease of the knee joint can, of course, be extremely painful and prevent functioning of the joint.

At present, as far as is known to the inventor, two forms of knee-joint prosthesis of a form generally similar to the invention are being used. In one form, large metal and plastic components occupying most of the surface areas of the extremities of the femur and tibia, respectively, and shaped to match the surfaces of the extremities are implanted. This form requires considerable resection of the extremities of the bones and removal of the cruciate ligaments. The removal of the cruciate ligaments can seriously impair joint durability and function.

The other type of knee-joint prosthesis consists of femoral and tibial components in the form of metal and plastic bands received on the femoral and tibial condyles. The components are arcuate in both the lengthwise and transverse directions. Substantial bone resection is required for placement of both components, and the matching curvatures in both the anterior-posterior and lateral directions significantly restrict flexibility of joint movement and only partially duplicate natural articular function.

SUMMARY OF THE INVENTION

There is provided, in accordance with the invention, a knee-joint prosthesis that provides partial or total replacement of the engaging surfaces of the femoral and tibial condyles, affords relief from pain and restores function and load-bearing capability to the knee-joint. Although the knee-joint prosthesis of the invention represents an appropriate appliance for correction of various injuries and diseases of the knee joint, its use is particularly advantageous in cases of arthritis.

The prosthesis comprises a femoral condyle component and a tibial condyle component mounted, respectively, on the femoral and tibial condyles in positions so that the two components match and provide load transfer and motion capability. The femoral component includes an elongated, doubly curved member that is secured to one of the femoral condyles and extends from the anterior to the posterior of the femoral condyle. It has an external surface that is shaped in the anterior-posterior direction to match closely the anatomical shape of the femoral condyle and has in transverse cross-sections along its length a laterally outwardly located, essentially flat zone and a laterally inwardly located curved zone that is externally convex. The tibial component is an elongated member that extends from adjacent the anterior extremity to adjacent the posterior extremity of the tibial plateau and is secured to the tibial condyle in a position for engagement by and support of the femoral component of the prosthesis. The supporting or external surface of the tibial component is shaped closely to match, in transverse cross-sections along its length, the transverse shape of the external surface of the femoral component and is a surface generated by a generally straight, anterior-posterior line moved along a line matching the external transverse shape of the femoral component. The components are secured to the femoral and tibial condyles by cement-like bonding medium, the condyles being resected in the areas occupied by the components so that the components are received with their external surfaces generally contiguous to the anatomical surfaces of the condyles.

Preferably, the femoral component has a multiplicity of projections extending from its internal surface to enhance the anchoring of the component in place on the femoral condyle. Such projections may take various forms, but an advantageous construction involves the provision of a relatively massive, elongated main post or pin having its longitudinal axis generally aligned with the line of load transfer at the joint when the leg is straight and a multiplicity of relatively small pins spaced apart from each other and projecting only a small distance from the internal surface of the member. The surface of the main post may have several concavities disposed in generally transverse zones to provide a mechanical locking between the post and a layer or zone of cement between the post and the resected bone.

It is also advantageous to provide a mechanical interlock between the tibial component and the tibial condyle to augment the bond provided by the cement. A mechanical interlock may be obtained, for example, by forming undercut grooves in the internal surface of the tibial component. In addition, undercut grooves or oblique holes may be cut or drilled in the bone in positions underlyng the undercut grooves in the tibial component of the prosthesis. A body of cement received in the undercut grooves in the tibial component and in the grooves or holes in the bone affords a strong and durable mechanical connection between the prosthesis component and the bone.

The knee prosthesis of the invention may be placed in either one or both femoral-tibial condyle pairs, as may be required for a given patient. In a duo-condylar prosthesis, which will usually be preferred, it is desirable that the two femoral condyle components be interconnected by a crossbar extending between them and curved in the transverse direction to match the anatomical shape of the anterior intercondylar notch, the crossbar holding the spacing and a parallel relationship between the two femoral members. TThe femoral component of a duo-condylar prosthesis is preferably of one-piece construction and symmetrical so that it can be installed in either the right or left knee joint. Similarly, the tibial component for both the internal and external condyles of both left and right joints may be identical; in other words, only one form of tibial component need be provided, and two identical pieces used in a duo-condylar prosthesis.

Although various materials may be used for the prosthesis, the preferred materials are Type 316-L Stainless Steel or surgical cobalt-chrome alloy for the femoral component and a high-molecular weight polyethylene or other appropriate high-molecular weight plastic for
the tibial component. The femoral component should have a highly-polished surface to reduce friction to a minimum and provide minimum wear and thus long useful life.

A knee-joint prosthesis, in accordance with the invention, provides various significant advantages. For one thing, only the load-bearing surfaces of the joint are replaced, and the remainder of the joint is left intact. For example, the collateral and cruciate ligaments are not disturbed and afford retention of joint stability. There is a minimum of resection of the bone for placement of the prosthesis. Accordingly, in the event of failure of the prosthesis, which, though unlikely, is possible, there is still adequate bone available for another procedure. The areas of the load-bearing surfaces of the femoral and tibial components closely match those that exist in a natural joint. As already mentioned, it is appropriate to provide symmetry with respect to either the internal or external condyles, which means that one form of femoral component and one form of tibial component can be used in either left or right knee joints, or in either internal or external condyles of one knee joint in the case of a uni-condylar placement. (It is evident, of course, that various sizes of the components will be required to accommodate various sizes of joints for different patients.) The prosthesis components are securely fixed to the bones and are of strong, durable and long-wearing construction. The flatness in the anterior-posterior direction of the external or supporting surfaces of the tibial component permits anatomical movement of the femur on the tibia while the curvatures and orientations of the curvatures of the components limit rotational and lateral laxity. The result is a prosthesis that closely duplicates natural function.

DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be made to the following description of an exemplary embodiment, taken in conjunction with the figures of the accompanying drawings, in which:

FIG. 1 is an anterior view of a right knee joint having an embodiment of the knee prosthesis of the invention in place, the extremities of the femur and tibia being shown in cross-section;

FIG. 2 is a lateral view of the right knee joint, the view also showing the bone extremities in cross-section, with the cross-section taken at the outside edge of the prosthesis on the external side of the joint;

FIG. 3 is a pictorial view of the femoral component, viewing it from generally above, anteriorly of, and laterally inward of the component, as it would be positioned in the joint;

FIG. 4 is a pictorial view of the femoral component, the view being taken from generally below, posteriorly of, and laterally outward of the component, as it would be installed in a right knee joint;

FIG. 5 is a pictorial view of the tibial component, viewed from above, in front of, and laterally inward of a component placed at the internal condyle of a right knee joint; and

FIG. 6 is a pictorial view of the tibial component viewed from a posterior position, below and laterally inward of a tibial component in the internal position of a right knee joint.

The relative orientations of FIGS. 3 to 6 may be further understood by comparing them with FIGS. 1 and 2.

DESCRIPTION OF AN EXEMPLARY EMBODIMENT

Referring to FIGS. 1 and 2 of the drawings, the reference numerals 10 and 12 designate generally the femur (thigh bone) and the tibia (leg bone) of a human leg. Only the lower end of the femur and the upper end of the tibia are shown in the figures. Although the drawings illustrate the general outline of the portions of the femur and the tibia at the knee joint, the details of the bone shapes are not illustrated. Reference may be made to various appropriate standard references for descriptions and illustrations of the anatomy of a knee joint. For purposes of general orientation, reference numerals 14 and 16 designate, respectively, the external condyle and internal condyle of the right femur, reference numerals 15 and 17 designate, respectively, the exterior and interior tibial condyles, reference numeral 20 is applied to the lateral ligaments, and reference numeral 22 is applied to the cruciate ligaments. In FIG. 2 of the drawings, the anterior of the joint is to the right and the posterior is to the left.

The embodiment shown in the drawings is of the dual condylar form. The femoral piece of the prosthesis (see FIGS. 3 and 4), which is designated generally by the reference numeral 30, is composed of a pair of spaced-apart, doubly curved femoral condyle components 32 and 34 interconnected by a crossbar 36. The components 32 and 34 are of identical shape, but are reversed in orientation so that the piece is symmetrical about a vertical, anterior-posterior bisector plane. In transverse cross-sections along its length, each component 32 and 34 is generally flat along a laterally outward zone (relative to the center of the joint) and is externally convexly curved in a laterally inward zone. Viewed from the side, each member 32 and 34 is of varying curvature, with a relatively flat curvature along the anterior and bottom portions and a greater curvature in the posterior portion. The lateral profile of the femoral component thus conforms rather closely to the anatomical shape of the femoral condyles, which means that it may be placed with a minimum resection of the bone. Moreover, it provides articulation of the joint in a manner closely resembling the anatomical joint. The major axes or planes of the members 32 and 34 are parallel to each other and parallelism and proper spacing as placed are assured by the crosspiece 36.

As may be seen in FIGS. 1 and 2 of the drawings, the femoral piece is shaped and dimensioned such that the members 32 and 34 occupy the tibial-engaging surfaces of the femoral condyles, in other words, the areas of the femoral condyles that engage and are supported by the tibial plateau in the anatomical joint. The condyle components 32 and 34 are spaced apart so that there is no interference between the femoral piece and the cruciate ligaments. The crosspiece 36 is curved to present outwardly concave and inwardly convex surfaces, the curvature generally matching the intercondylar notch between the femoral condyles so that the crosspiece recesses into the intercondylar notch, such that it does not materially affect the action of the patella when the joint is in a flexed position.

Each of the condyle components 32 and 34 of the femoral piece 30 has a relatively massive, elongated post or pin 40 projecting from its internal surface and positioned and oriented so that its longitudinal axis is
generally coincident with the line of load transfer from the femur to the tibia with the leg in its normal straight or standing position. The surface of the post 40 is formed with several shallow concavities 42 located in zones oriented transversely of the longitudinal axis of the post. A number of small pins 43, say 1/16 inch in diameter and 1/16 inch high, project from the internal surfaces of the components 32 and 34 at appropriate spacing.

For strength and durability, it is best for the femoral piece 30 to be made of metal, such as Type 316-L Stainless Steel or surgical cobalt-chrome alloy. The external surfaces of the components 32 and 34 should be highly polished to ensure low friction and minimum wear.

The femoral piece is placed in the joint by resisting small amounts of bone in the regions that will underlie the condyle components 32 and 34 so that the external surfaces of the components 32 and 34 will be generally contiguous to the anatomical surfaces of the femoral condyles. In addition, a hole 44 is formed to receive the post 40, and holes 46 and 48 are also formed near the posterior and anterior extremities of the components 32 and 34 and extending generally perpendicular to the surface of the condyles at these points (see FIG. 2). The component is secured to the bone by an appropriate cement, such as polymethyl methacrylate. A layer of cement is applied at the interface between the internal surfaces of the components 32 and 34, and bodies of cement are packed in the holes 46 and 48 at the extremities of the components as well as in the hole 44 that receives the post 40. The cement in the holes 46 and 48 and around the post locks the femoral piece securely in place on the femur.

A dual-condylar prosthesis has two identical tibial condyle components 50, one for each tibial condyle, mounted in reverse orientation, laterally, on the respective medial and lateral tibial condyles. Each tibial component is generally rectangular in plan, although (as shown) it has rounded corners 51 that are located near the respective lateral extremities of the tibial plateau, when the component is in place. Each tibial component is mounted with its longer axis oriented in the anterior-posterior direction in the joint. The bottom surface 52 and the interiorly located side surface 54 of each component are generally flat. The upper surface 56 is a surface generated by moving a substantially straight line along a curve that matches the curve of the external surface of the femoral condyle component 32 (or 34) of the femoral piece. An undercut groove 58 is formed in the longitudinal direction along the center of the bottom of the tibial component, and two spaced apart, similarly undercut grooves 59 extend generally laterally across the bottom. The bone at the tibial plateau is resected to receive the respective tibial components so that their upper surfaces are generally contiguous to the anatomical surfaces of the tibial plateau. Holes 60 are drilled into the tibia in positions generally underlying the groove 56 near each end of each component, the holes being oblique to the bottom surface of the component. The tibial components are secured to the tibia by cement, bodies of cement extending into the undercut grooves 58 and 59 in the component and the holes 60 in the bone and providing cement keys to enhance the securing of the components in place.

In use, the flatness of the tibial components in the anterior-posterior direction allows relatively free sliding and rolling of the femoral component on the tibial component in a manner resembling the function of the anatomical joint. The transverse curvatures of the respective tibial components and the matching of the cross-sectional shapes of the tibial and femoral components in the areas in engagement limits rotation and lateral laxity in the joint. The tibial components provided relatively large surface areas for seating on the tibial plateau to ensure strength and durability in the joint and to provide a substantial load-bearing area, but these features are achieved without any undesirable restriction in the freedom of articulation.

The above-described embodiment of the invention is intended to be merely exemplary, and numerous variations and modifications may be made by those skilled in the art without departing from the spirit and scope of the invention. All such variations and modifications are intended to be included within the scope of the invention as defined in the appended claims.

I claim:

1. A knee-joint prosthesis comprising a femoral condyle component adapted to be secured to one of the femoral condyles, and a tibial condyle component adapted to be secured to the tibial condyle corresponding to said femoral condyle, the femoral condyle component being an elongated, doubly curved member shaped and dimensioned to extend from the anterior to the posterior of the femoral condyle and having a varying curvature in the anterior-posterior direction closely matching the anatomical shape of the femoral condyle and having in transverse cross-sections along its length a laterally outwardly located essentially flat zone and a laterally inwardly located curved zone that is externally convex, the tibial condyle component being an elongated member shaped and dimensioned to extend from adjacent the anterior extremity to adjacent the posterior extremity of the femoral-engaging surface of the tibial condylar plateau and adapted to be positioned for engagement by and support of the femoral component, and the tibial component having an external surface closely matching in transverse cross-sections along its length the transverse shape of the external surface of the femoral component and being a surface generated by a substantially straight anterior-posterior line moved along said transverse shape.

2. A knee-joint prosthesis according to claim 1 and further comprising a cement bonding medium adapted to secure the femoral and tibial components to the femoral and tibial condyles.

3. A knee-joint prosthesis according to claim 1 wherein he femoral condyle component further includes a multiplicity of projections extending from its internal surface and adapted to be received in a resected area of the condyles to anchor the femoral component in place thereon.

4. A knee-joint prosthesis according to claim 3 wherein the projections include an elongated relatively massive main post projecting from the internal surface of the femoral component and positioned on the component to have its major axis in the direction of elongation aligned generally with the line of load transfer that obtains at the knee joint when the leg is straight.

5. A knee-joint prosthesis according to claim 4 wherein the surface of the massive post has a multiplicity of concavities disposed in zones generally transverse to its longitudinal axis.
6. A knee-joint prosthesis according to claim 3 wherein the projections include a multiplicity of spaced-apart small pins.

7. A knee-joint prosthesis according to claim 1 wherein there are two femoral condyle components positioned in spaced relation to be secured to the lower extremity of each femoral condyle and two tibial condyle components adapted to be secured to each tibial condyle opposite the respective femoral components for engagement thereby and support thereof.

8. A knee-joint prosthesis according to claim 7 wherein the two femoral condyle components are interconnected by a crossbar to form a unit.

9. A knee-joint prosthesis according to claim 8 wherein the crossbar is integral with the said condyle components and has a curvature in the lateral direction, relative to the condyle components generally matching the anatomical shape of and adapted to be received in the anterior intercondylar notch of the femur.

10. A knee-joint prosthesis according to claim 1 wherein the tibial component has undercut grooves formed in its internal surface and adapted to receive a cement to enhance by mechanical locking the connection of the tibial component to the tibial condyle.

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