A prosthetic knee joint device of 'hingeless' form having femoral and tibial components held in mutual sliding and rolling bearing engagement by natural muscle and ligaments. The femoral component includes a generally U-shaped channel member having an outer surface with a generally convex curvature in the circumferential sense relative to the channel longitudinal axial direction, and a smooth form with a single curvature in the axial sense. This single curvature need not necessarily be convex. The tibial component includes a platform member having one of its major surfaces concavely dished in generally complementary manner to at least the convex curvature of the femoral component. The inner surface and the other major surface of channel and platform members are adapted for fixation with cement to the femur and tibia.
KNEE JOINT PROSTHESIS

This application is a continuation of our copending application Ser. No. 247,873, filed Apr. 26, 1972, which was abandoned upon the assigning of a serial number to the present application.

Various proposals have been made for knee joint prostheses in the past, but none of these appears to have proved generally satisfactory. Among the disadvantageous features found to arise with these prior proposals are the need to remove a relatively large amount of bone in the region of the natural joint together with, in many instances, removal of the patella and the natural ligaments, and the need to implant foreign matter for a relatively long distance along the medullary canals. These features in fact commonly arise with proposals for the use of prosthetic devices of mechanically coupled hinge form, and such devices normally bring their own disadvantage in the form of a requirement for the surgeon to assemble the hinge during implantation.

It is usual in any case, whether the device be of hinged form or not, for a knee joint prosthesis to be non-symmetrical so that different versions are required as between the left and right knees.

An object of the present invention is to provide an improved prosthesis which affords a reduction in the above disadvantages.

To this end there is provided a knee joint prosthetic device comprising a femoral component including a generally U-shaped channel member in which at least that part of the outer surface extending over one side wall of said channel member, and continuing partway across the base of said channel member, is of a form having a generally convex curvature in the circumferential direction relative to the longitudinal axis of said channel member, and of a form having a single sense of curvature, which is not necessarily convex, in the axial direction relative to said channel member; and a tibial component including a platform member having one of its major surfaces concavely dished in a form generally complementary to at least said form having generally convex curvature of said channel member for mutual sliding and rolling engagement therewith; and wherein the inner surface and other major surface of said members are respectively adapted for cement fixation to the femur and tibia.

In this connection it is to be noted that a U-shaped channel is regarded as having a base and two side walls to define the U-shaping, and that such a channel has a longitudinal or axial direction running along the base and spaced between the side walls, and also a circumferential direction which is that passing successively across one side wall, the base, and the other side wall, in a sense to wrap around the longitudinal axial direction. For clarity, these directions are indicated in FIGS. 1 and 3 of the drawings described hereinafter.

In practice the channel and platform members serve the respective roles of the femoral condyles on the one hand and the tibial condyles and menisci on the other hand, with said one channel side wall representing the posterior aspect, and are held in engagement by the relevant muscles and collateral ligaments. It will be appreciated that then the presently proposed prosthesis is of hingeless form and this serves to reduce the possibility of undesired and large moments which, in the context, can cause loosening of the prosthesis fixation. The more particular requirements of curvature expressed above also serve, in this connection, to reduce the possibility of undesirable torsional moments which can otherwise arise if an attempt is made to eliminate torsional movement.

In any event the present invention allows the prosthesis to be more compact than is the case with the use of a hinge device, with a consequent reduction in the requirement for removal of bone, and this advantage is enhanced by an associated reduction in the required intramedullary or other penetration for the purposes of fixation. At the same time, the proposed curvature for the mutual bearing surfaces is such that the components can bear over an area which is large enough to ensure, so far as is practicable, a rate of production of wear particles or solutes that will be biologically innocuous. Also, the proposed curvature for the mutual bearing surfaces and the absence of long intramedullary or other stems for fixation are such that both components can be symmetrical about a plane transverse to the lateral aspect, which plane is radial relative to the longitudinal axis of the channel member. This symmetry means that the usual requirement to produce differently handed components for the left and right knees is avoided.

The mutual bearing surfaces of the components are, of course, of generally rounded form in the lateral aspect. However, in a preferred form the bearing surface of the femoral component has a first lateral profile part around the posterior side wall and an adjacent portion of the channel base, which profile part is continuously curved, suitably in circular arcuate manner, while a second lateral profile part extends from the first such part across the remainder of the base in substantially rectilinear manner. The bearing surface of the tibial component intended for use with the above surface preferably has a central lateral profile part curved to conform with the first profile part of the femoral component, and extends into outer lateral profile parts of which at least one is substantially rectilinear. These profile parts co-operate so that the first part of the femoral component engages the central part of the tibial component during flexion and extension, and extension will be limited by engagement of the second part of the former component with the corresponding rectilinear outer part of the latter component. In fact it is preferred that this last engagement does not normally occur during walking, but that such engagement, together with natural muscular control limitations, provides stability with a small and limited amount of hyperextension. This can be achieved by orientating the relevant rectilinear profile parts relative to their respective curved profile parts so that the rectilinear parts are mutually divergent at a small angle when the curved parts are engaged in the position of zero flexion.

Conveniently, both of the lateral profile edge parts of the tibial component are of like substantially rectilinear form so that this component is also symmetrical in the lateral aspect, that is to say, symmetrical about the axial plane which is mutually orthogonal with the above-mentioned radial plane and passes between the side walls of the channel member. This avoids any difficulty which may otherwise arise in determining the antero-posterior disposition.

The bearing surface portions having the lateral profile parts discussed above are, in a presently preferred form of the invention, substantially rectilinear in the antero-posterior aspects, that is to say, rectilinear in the axial direction of the channel member.
The remaining third lateral profile part of the femoral component around the anterior side wall is also preferably curved, suitably to circular arcuate form having a higher degree of curvature than the first such part. This third part does not, in fact, bear on the tibial component, but a curved form is appropriate to its engagement with adjacent tissue and other relatively soft matter. However, the surface portion of the tibial component having this third lateral profile part can also bear on the patella, if retained, and for this purpose such portion is preferably grooved centrally in a vertical sense to retain the handed symmetry of the component. This grooving suitably has a circular arcuate sectional profile of intermediate degree of curvature between that of the first and third lateral profile parts.

It is also to be noted that the anterior side wall need not extend as far above the channel base as the posterior side wall.

Regarding fixation: the channel member is inherently shaped to assist fixation on a suitably sectioned femur and can be adapted to intramedullary fixation by way of a stem extending from the base portion and spaced between the side walls of the relevant major surface. This stem can be relatively short in length and need not extend beyond the posterior side wall. The platform member is preferably adapted for cement fixation by way of a subsidiary platform depending therebelow and which has undercut edges, or by way of ribs or studs formed on its lower surface, or by way of an equivalent relatively shallow formation providing a good key. Fixation of the tibial component can also involve the use of a stable having one arm driven into the lower part of the component, suitably in the anterior aspect, and the other arm into the tibia therebelow.

Lastly among the more general and preferred features of the present invention: the anterior wall of the femoral component can extend axially along the channel member to a lesser extent than the posterior wall, and the base is then of suitably symmetrical divergent form from the former to latter wall; the various bearing surface parts preferably join without forming discontinuities and so provide generally smooth overall surfaces; and all of the external angles are generally rounded.

In order that the above and other features may be better understood the same will now be described, by way of example, with reference to embodiments of the invention as illustrated in the accompanying drawings, in which:

FIGS. 1, 2 and 3 respectively show the femoral component of a presently preferred embodiment in side, front and plan views (lateral, anterior and superior aspects),

FIGS. 4 and 5 show sectional detail taken at IV—IV and V—V in FIG. 3,

FIGS. 6 and 7 respectively show the associated tibial component of the presently preferred embodiment in side and underneath views (lateral and inferior aspects),

FIGS. 8 to 11 illustrate modifications of the presently preferred embodiment.

Considering the illustrated femoral component of FIGS. 1 to 5: this comprises a generally U-shaped channel member 1 with a base 2, a higher anterior side wall 3, a lower posterior side wall 4, and a step 5 extending upwardly from the base between the side walls to an intermediate height therebetween. The channel member 1 has a major outer surface and a major inner surface, which surfaces are respectively represented in lateral profile by the outermost and innermost U-shaped boundaries of the member (minus the stem 5) as shown in FIG. 1. FIG. 1 further shows the major outer surface to have a generally convex first profile which is constituted by a succession of a first convexly curved first profile part, a rectilinear second profile part, and a convexly curved third profile part. More specifically in FIG. 1 these successive profile parts are respectively shown and identified as a first circular arcuate part 6 extending around the wall 3 and across the base 2 to approximately the centre of the latter; a second substantially rectilinear part 7 extending smoothly from the part 6 to below the wall 4; and a third circular arcuate part 8 extending around the wall 4. The curvature of profile part 6 is lower than that of part 8, and has its centre of curvature located to afford stability at or about zero flexion.

In the superior aspect, the wall 4 is seen to be grooved vertically at 9, the groove having a circular arcuate section of greater curvature than profile part 6 but less than part 8. Also, this aspect shows the wall 4 to extend less in the longitudinal axial direction of the channel member than the wall 3, and that the base diverges symmetrically from the former to the latter.

The stem 5 is of circular cross-sectional shape and is slightly tapered towards its free end. It is also seen from the anterior and superior aspects that the femoral component is symmetrical about a plane which is radial relative to the longitudinal axis of the channel member.

Turning to the tibial component of FIGS. 6 and 7: this comprises a platform member 10 having a major upper surface and a major lower surface, which surfaces are respectively represented in lateral profile by the uppermost and lowermost boundaries of the platform member as seen in FIG. 6. FIG. 6 further shows the major upper surface to have a generally convex second profile which is constituted by a succession of a rectilinear outer profile part 11, a concavely curved central profile part 11, and a further rectilinear outer profile part 12. More specifically, the central profile part 11 is of circular arcuate form equal in curvature to the femoral first profile part 6 mentioned above, and the outer profile parts 12 extend smoothly from the central profile part 11.

It is to be noted that, in the lateral aspects of the two components, the second profile 7 is inclined at a greater angle to the horizontal than the edge profile parts 12 when the components are disposed for zero flexion. The difference of angle here is in fact small relative to the overall angular range of movement between maximum flexion and extension.

A subsidiary platform 13 with undercut edges 14 depends from the other major surface of the platform 10.

It will be seen that, when the two components are disposed for zero flexion, the tibial component is symmetrical about the above-mentioned radial plane and the mutually orthogonal axial plane which passes between the side walls of the channel member.

While the embodiment as so far described is presently preferred, it is not intended that this should limit the scope of the invention. This will be clear from the introductory discussion of the invention, and variations from the preferred embodiment are possible and may be advantageous in the light of further study. For example, it may be considered that the femoral component should be fixed by way of a longer intramedullary
stem, but this will normally involve angling the stem with a consequent need for handed components. The tibial component can be fixed by way of an intramedullary stem, and this also may be of longer angled form.

Also, the patella reception groove may be off-set from the presently preferred symmetrical disposition, or it may pass further across the channel base.

A further possible variation is that the mutual bearing surfaces of the femoral and tibial components be rounded in complementary manner in the antero-posterior aspects, that is in the axial direction, to assist in lateral stability. Normally such rounding will involve respectively convex and concave lateral curvatures for the femoral and tibial component bearing surfaces as illustrated in FIG. 8, but these curves can equally well be interchanged.

As one alternative to the preceding variation, lateral stability can be enhanced by the provision of a peg projecting upwardly from the tibial component to engage a groove formed centrally along the bearing surface of the femoral component at least between the positions of full flexion and extension, as illustrated by FIG. 9.

In yet another alternative, the possibility of enhancing lateral stability is provided by allowing for retention of the cruciate ligaments. In this case, both the femoral and tibial components are respectively centrally slotted partway thereacross from their posterior peripheral edges. These slots should extend sufficiently to clear the cruciate ligaments in the position of full extension, as shown in FIGS. 10 and 11 in which the femoral and tibial component slots are respectively denoted at 22 and 23. The tibial component of FIG. 11 is also modified by the provision of two subsidiary platforms 13 on opposite sides of the slot 23.

Lastly the question of materials should be mentioned. The present preference is for the femoral component to be made of appropriate cobalt-chromium alloy and the tibial component to be made of high density polyethylene, although there may be advantage in interchanging these component materials. However, other materials also appear suitable, such as stainless steel and titanium alloys of appropriate forms. Moreover, the use of a metal other than a cobalt-chromium alloy, which alloys are difficult to work in the forms needed to prosthetic devices, may allow the use of simpler working techniques. For example, it may be practicable to form the femoral component by bending from plate, followed by grinding and polishing, with fixation being afforded by the provision of inturned peripheral portions as shown at 24 in FIG. 10.

We claim:

1. A prosthetic knee joint device comprising: a femoral bearing member of generally U-shaped form having a first side wall, a base, and a second side wall, defining relative to said U-shape a major outer surface and a major inner surface, said outer surface having a convex first profile extending in a circumferential direction around said U-shape and including a convexly curved first profile part extending over said first wall and partway across said base, a rectilinear second profile part continuing across said base from said first profile part, and a convexly curved third profile part continuing across said second wall from said second profile part; and a tibial bearing member in the form of a platform having a major upper surface and a major lower surface, said upper surface being dished in one direction thereacross to provide a concave second profile generally complementary to said convex first profile, said concave second profile including a concavely curved central profile part of the same order of curvature as and in mutual articulatory bearing engagement with said first profile part, and a rectilinear outer profile part continuing from said central profile part in similar angular relationship therewith to that between said femoral first and second profile parts, said femoral second and tibial outer profile parts engaging to limit said articulatory engagement.

2. A device according to claim 1 wherein said first and central profile parts are both curved in circular arcuate manner with the same radius of curvature.

3. A device according to claim 2 wherein said third profile part is curved in circular arcuate manner with a lesser radius of curvature than said first profile part.

4. A device according to claim 1 wherein said concave second profile comprises a further rectilinear outer profile part continuing from said central profile part in similar manner to and symmetrical relationship with the first-mentioned rectilinear outer profile part.

5. A device according to claim 1 wherein said outer surface is formed with a first groove extending across said second wall in said circumferential direction.

6. A device according to claim 1 wherein said first wall extends further from said base in said circumferential direction than said second wall.

7. A device according to claim 1 wherein said first side wall is of greater extent in a direction orthogonal to said circumferential direction than said second wall, and said base is symmetrically convergent between said differing first and second side wall extents.

8. A device according to claim 1 wherein said outer surface is formed with a second groove extending across said first wall and partway across said base in said circumferential direction, and said platform member is provided with a peg upstanding from said upper surface and slidably engaged in said second groove.

9. A device according to claim 1 wherein said femoral bearing member is slotted therethrough in said circumferential direction wholly across said first side wall and partway across said base, and said platform member is correspondingly slotted partway thereacross from its periphery.

10. A device according to claim 1 wherein said femoral bearing member is adapted for fixation to the femur by the provision of an intramedullary stem extending from said inner surface across said base to an extent intermediate that of said first and second side walls.

11. A device according to claim 1 wherein said femoral bearing member is adapted for fixation to the femur by the provision of inturned portions around at least part of the periphery thereof communicating said inner and outer surfaces.

12. A device according to claim 1 wherein said tibial bearing member is adapted for fixation to the tibia by the provision of a subsidiary platform extending from said lower surface, which subsidiary platform has undercut edges.

13. A device according to claim 1 wherein said femoral bearing member is symmetrical about a first plane wholly including said U-shaping, and said tibial bearing component is symmetrical about both said first plane and a second plane which is mutually orthogonal with said first plane and said upper and lower surfaces.

14. A prosthetic knee joint device comprising: a femoral bearing member of generally U-shaped form hav-
3,924,277

A device according to claim 14 wherein said first side wall is of greater extent in a direction orthogonal to said circumferential direction than said second wall, and said base is symmetrically convergent between said differing first and second side wall extents.

20. A device according to claim 14 wherein said outer surface is formed with a second groove extending across said first wall and partway across said base in said circumferential direction, and said platform member is provided with a peg upstanding from said upper surface and slidably engaged in said second groove.

21. A device according to claim 14 wherein said femoral bearing member is slotted therethrough in said circumferential direction wholly across said first side wall and partway across said base, and said platform member is correspondingly slotted partway thereacross from its periphery.

22. A device according to claim 14 wherein said femoral bearing member is adapted for fixation to the femur by the provision of an intramedullary stem upstanding from said inner surface across said base to an extent intermediate that of said first and second side walls.

23. A device according to claim 14 wherein said femoral bearing member is adapted for fixation to the femur by the provision of inturned portions around at least part of the periphery thereof communicating said inner and outer surfaces.

24. A device according to claim 14 wherein said tibial bearing member is adapted for fixation to the tibia by the provision of a subsidiary platform extending from said lower surface, which subsidiary platform has undercut edges.

25. A device according to claim 14 wherein said femoral bearing member is symmetrical about a first plane wholly including said U-shaping, and said tibial bearing component is symmetrical about both said first plane and a second plane which is mutually orthogonal with said first plane and said upper and lower surfaces.

* * * *

A device according to claim 14 wherein said first side wall, a base, and a second side wall, defining relative to said U-shape a major outer surface and a major inner surface, said outer surface having a convex first profile extending in a circumferential direction around said U-shape and including a convexly curved first profile part extending over said first wall and partway across said base, a relatively flat second profile part continuing across said base from said first profile part, and a convexly curved third profile part continuing across said second wall from said second profile part;

and a tibial bearing member in the form of a platform having a major upper surface and a major lower surface, said upper surface being dished in one direction thereacross to provide a concave second profile generally complementary to said convex first profile, said concave second profile including a concavely curved central profile part of the same order of curvature as and in mutual articulatory bearing engagement with said first profile part, and a relatively flat outer profile part continuing from said central profile part in similar angular relationship therewith to that between said femoral first and second profile parts, said femoral second and tibial outer profile parts engaging to limit said articulatory engagement.

15. A device according to claim 14 wherein said concave second profile comprises a further relatively flat outer part continuing from said central profile part in similar manner to and symmetrical relationship with the first-mentioned relatively flat outer profile part.

16. A device according to claim 14 wherein said first and central profile parts are both curved in circular arcuate manner with the same radius of curvature.

17. A device according to claim 14 wherein said outer surface is formed with a first groove extending across said second wall in said circumferential direction.

18. A device according to claim 14 wherein said first wall extends further from said base in said circumferential direction than said second wall.