United States Patent [19]

Marmor

[11] **3,852,830**

[45] **Dec. 10, 1974**

[54] **KNEE PROSTHESIS**

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[73] Assignee: **Richards Manufacturing Company,** Memphis, Tenn.

[22] Filed: **Feb. 15, 1973**

[21] Appl. No.: **333,127**

[52] **U.S. Cl.** ..... **3/1,** 128/92 C

[51] **Int. Cl.** **A61f 1/24**

[58] **Field of Search** .... 3/1; 128/92 C, 92 CA, 92 R; 32/10 A

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Primary Examiner—Ronald L. Frinks

Attorney, Agent, or Firm—John R. Walker, III

[57] **ABSTRACT**

Knee prosthesis for permitting total or partial replacement of the articulating surface portions of the knee. Two cooperating components are disclosed, one is a femoral component for attachment to one of the condyles of the femur and the other is a tibial component for attachment to the tibia. The tibial component has a uniform and slightly concave upper surface and the femoral component has a curved polycentric lower face that engages the upper face of the tibial component for closely approximating the natural articulating action of the knee. The femoral component includes this and an anchoring spike extending remote from its lower face. A femoral template is disclosed for use in preparing the femoral condyles for reception of the femoral components.

9 Claims, 14 Drawing Figures

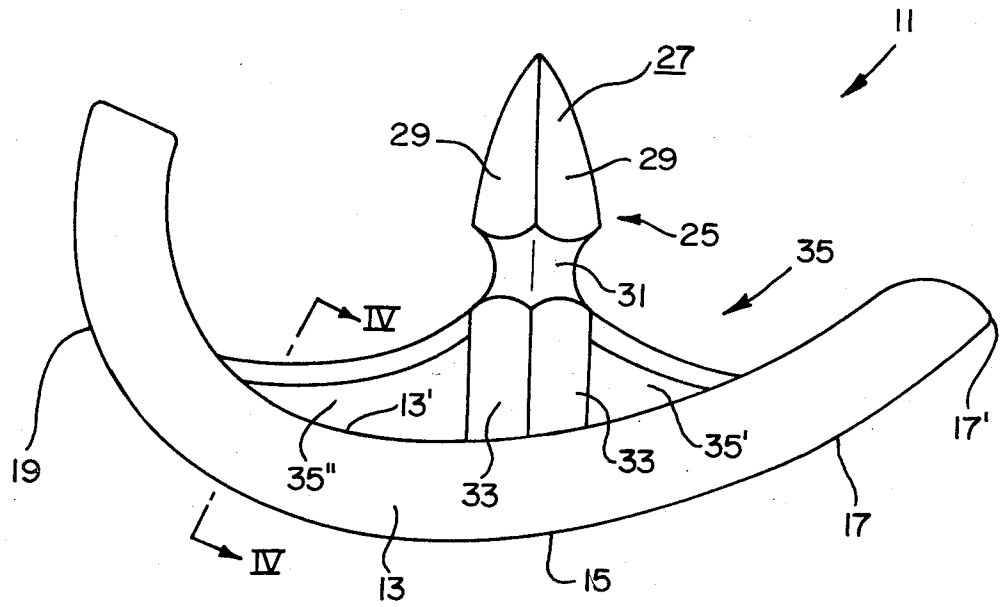

FIG. 1

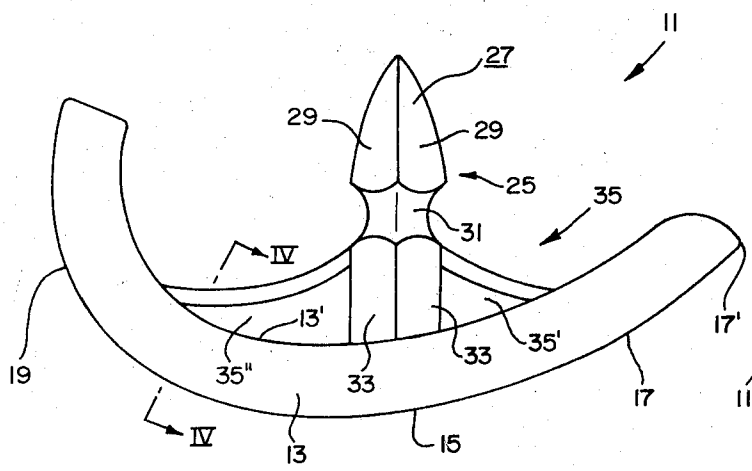

FIG. 2

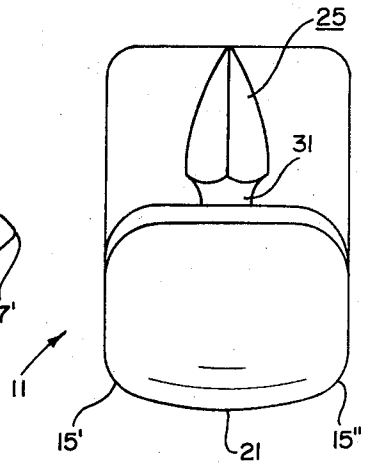

FIG. 3

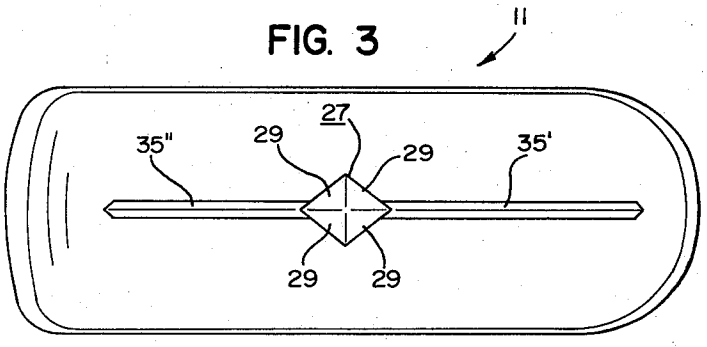

FIG. 4

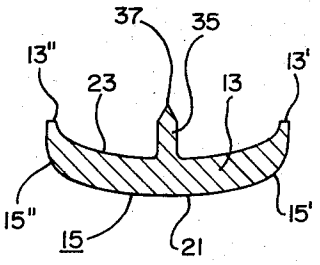

FIG. 5

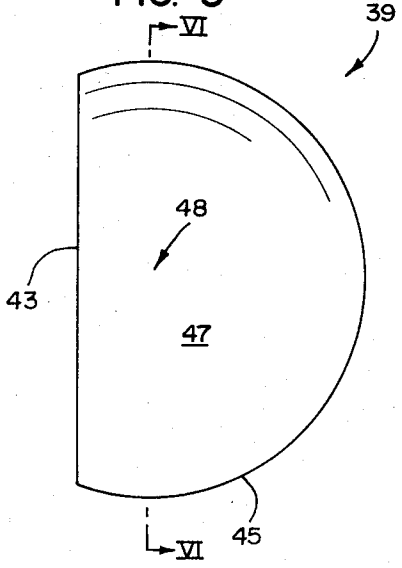

FIG. 6

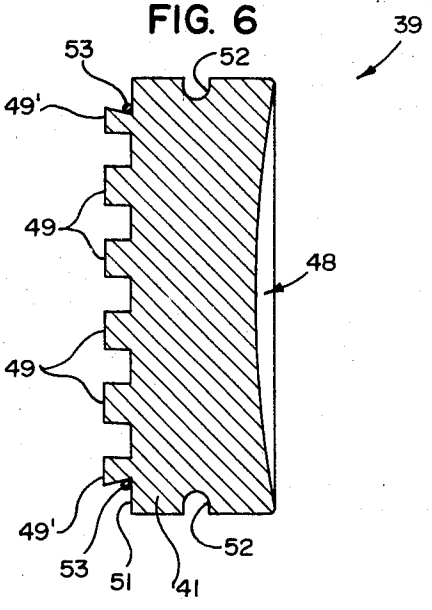

FIG. 7

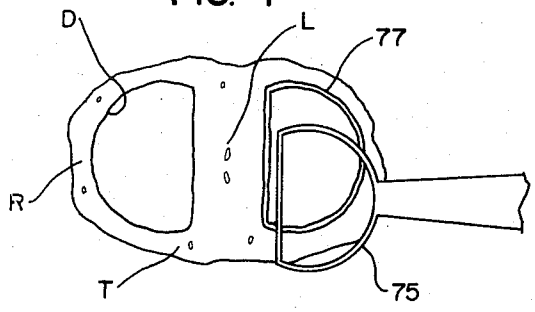

FIG. 8

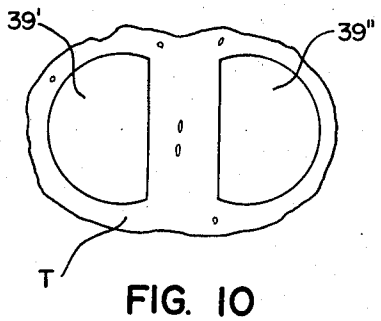

FIG. 9

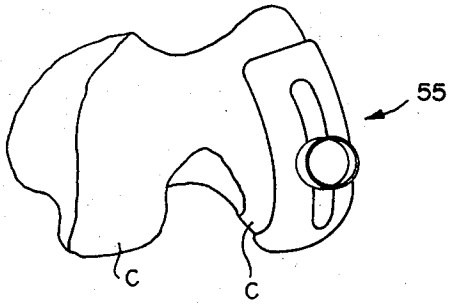

FIG. 10

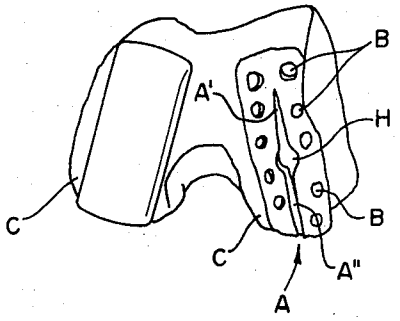

FIG. 11

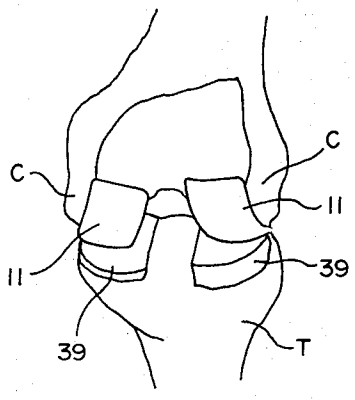

FIG. 12

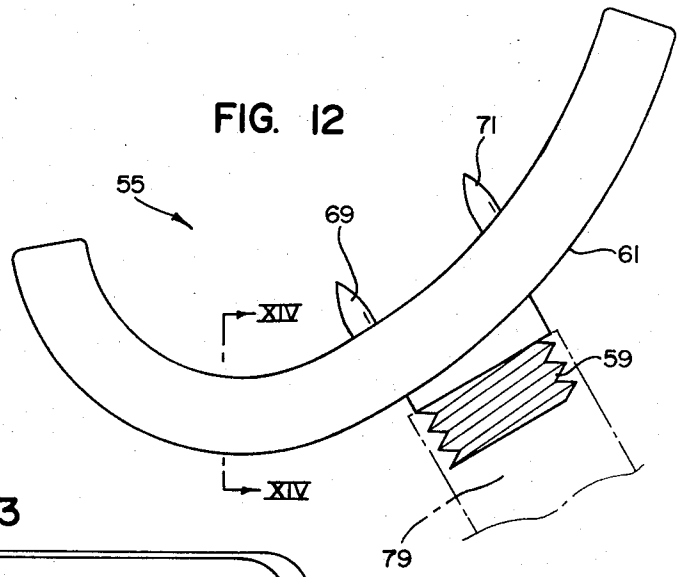

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FIG. 13

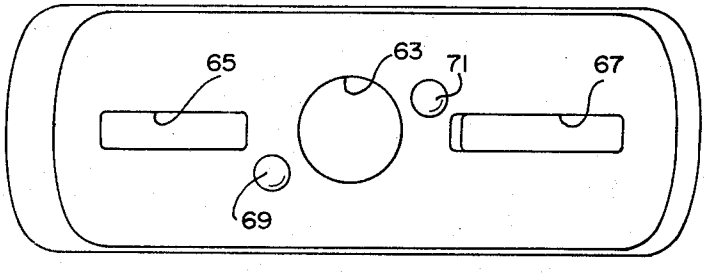
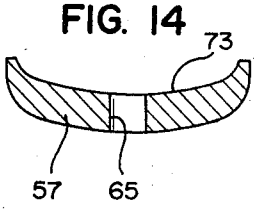


FIG. 14



KNEE PROSTHESIS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of prostheses for the human knee.

2. Background of the Invention

In the field of prostheses for the knee, there has been the problem of providing a prosthesis which has the same action as the human knee. The difficulty of this problem is apparent when it is realized that the action of the knee is a very complex one. Thus, it is not a true hinged joint about a single center but there are pivoting, rocking and sliding movements. During the first part of the knee movement from full extension of the leg towards flexion, there is pivotal rotation of the tibia about the femur, which is then converted to a rocking movement wherein the femoral condyles roll on the tibial plateaus. This rocking movement then changes to a combined sliding and pivoting movement. In other words, the flexion movement is polycentric, that is, about different or instant centers which are not fixed in one position but rather lie in a somewhat spiral or polycentric pathway.

Heretofore there have been various knee prostheses, but these have not been ideal for one reason or another or have had certain disadvantages. Some of these prostheses have been physically coupled together as for example by spindles or ball and socket types of arrangements (see for example, German Pat. No. 2,114,287, and U.S. Pat. Nos. 3,694,821; 3,506,982; and 3,696,446), many of which are complex, difficult to align, set properly in place, etc. Another type of prior device has been that having a pair of femoral components which are denominated polycentric and have the appearance of substantially one-half of a circular disk, and which respectively ride in grooves or tracks in a pair of tibial components. This type is marketed by Howmedica, Inc., Rutherford, N.J., and others. With this type of prosthesis, jigs are utilized and the components must be aligned for correct movement of the femoral component in the track of the tibial component. Also, there is a possibility of dislocation of the component out of the track. In addition, the track limits normal rotation, that is, normal twisting rotation of the tibia substantially along its longitudinal axis relative to the femur.

It should be pointed out also, that with many of the prior prostheses it is necessary to remove a substantial or excessive amount of bone, which is undesirable since as much of the bony stock should be preserved as possible.

Another prior prosthesis utilizes a pair of tibial components each having a flat upper surface coacting with arcuate femoral components that appear to be curved upwardly at the anterior and posterior ends thereof by substantially the same amount of curvature with a somewhat flatter curve intermediate the ends. (See FIG. 3 of German Pat. No. 1,964,781). These femoral components appear to extend straight across when viewed in a transverse cross section thereof. In other words, the side edges are not turned up.

Another problem involved in the field of knee prostheses is the anchoring problem of the prostheses into the bone. It will be understood that if the prosthesis is not anchored properly or if the stresses are two great that the prosthesis could be twisted loose from its anchoring. At the same time, it is desirable that a small amount of cement be used to anchor the prosthesis for obvious and well-known reasons.

Also, there are many problems brought about by the fact that there are different types of knee problems, for example varus and valgus deformities.

SUMMARY OF THE INVENTION

The present invention is directed towards overcoming the heretofore mentioned and other problems by providing a highly effective knee prosthesis that closely approximates the natural action of the human knee, that is, it permits the polycentric pivoting, rocking and sliding movements of the knee. In addition, it permits the normal twisting or rotational movement of the tibia, and flexion of the knee from a hyperflexion position to a position beyond 90°. Further, the present invention provides an anchoring means which provides optimal stability yet with a small amount of cement. Additionally, the present invention, since there are no grooves or tracks, eliminates the alignment problems associated with such types of prostheses. Also, the prosthesis of the present invention has the following advantages: (1) Interchangeable prosthetic components may be used in nearly any combination to custom fit anatomical variances. (2) Availability of tibial components in varying heights permits correction of varus or valgus deformities without cement "layering." (3) Four-part design allows independent restoration of either compartment of the knee when only one side is affected. (4) The components are designed to approximate natural joint surfaces so that there are no grooves or tracks to dislocate. (5) Since there are no grooves to dislocate, motion can be instituted soon after surgery. (6) Normal rotation may occur in the joint without placing undue stress upon the cement in the tibia. (7) Plastic tibial components are easily replaceable should they become worn. (8) Simple insertion procedure requires no precision jig-cutting of bone: Retains all natural ligaments intact. (9) Minimal bone removal and cement usage leaves the widest possible surgical latitude.

The means by which the foregoing and other objects and advantages of the present invention are accomplished as follows:

The knee prosthesis of the present invention includes a femoral component which has a curved body portion having a lower face including a posterior section and an anterior section with the posterior section extending rearwardly and upwardly from the anterior section on a substantially sharper curve than the anterior section. In other words, the lower face is polycentric or is formed on instant centers so that the anterior section is formed on a substantially flat curve having a substantially greater radius or radii than that of the posterior section, which is a substantially sharper curve. Also, the knee prosthesis includes a tibial component including a base portion having a uniform and slightly concave upper face which is engaged by the curved lower face of the femoral component to permit the complex motions of the knee heretofore mentioned. The tibial component is in outline in the shape of the letter "D" so that there is a maximum amount of articulating surface while at the same time not disturbing the cruciate ligaments.

The femoral component includes a single anchoring spike and fins to provide optimal stability and the use of a small amount of cement. Also, the body portion of

the femoral component is provided with upturned side edges to trap the cement to prevent it from leaking out as much as possible and to obtain better fixation.

The femoral template is provided with a center drill hole whereby a central fixation hole may be drilled in the condyle, and the template is also provided with slots whereby a power tool may be utilized to remove the bone so that the fins of the femoral component may be received.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of the femoral component of the present invention.

FIG. 2 is an end elevational view thereof.

FIG. 3 is a top plan view thereof.

FIG. 4 is a sectional vhew taken as on the line IV—IV of FIG. 1.

FIG. 5 is a top plan view of the tibial component of the present invention.

FIG. 6 is a sectional view saken as on line VI—VI of FIG. 5.

FIGS. 7–10 show various steps in the installation of the prosthesis of the present invention.

FIG. 11 shows the prosthesis in place.

FIG. 12 is a side elevational view of the femoral template of the present invention.

FIG. 13 is a top plan view thereof.

FIG. 14 is a sectional view taken as on the line XIV—XIV of FIG. 12.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. 1–4, the femoral component 11 of the present invention comprises a curved body portion 13 having a curved lower face 15, which for purposes of identification are divided into two portions or sections, namely an anterior section 17 and a posterior section 19. Lower face 15 is polycentric, that is, the surface lies in arcs of circles having more than one center and more than one radius to approximate the natural articulating surface of a condyle of the femur. As is best seen in FIG. 1 the lower face 15 in the anterior section 17 curves somewhat gradually and the posterior section 19 curves relatively sharply. In other words, the radius of an imaginary circle in which the anterior section 17 lies is substantially greater than the radius of the imaginary circle in which the posterior section 19 lies.

The opposite side edges of body portion 13 are curved or turned upwardly as at 13', 13'' for reasons yet to be disclosed so that in cross section, as best seen in FIG. 4, lower face 15 is rounded and particularly at the side edges as at 15', 15'' where the edges are curved sharply upwardly. It will be noted that lower face 15 is somewhat arcuate or convex in the intermediate portion 21 between the side edges 15', 15''.

Body portion 13 is rigid, as for example, preferably being made of stainless steel which has been microfinished on the lower face 15 thereof. Also, body portion 13 is relatively thin and of substantially constant thickness so that the inner face 23 thereof conforms substantially to the shape of the lower face 15.

Femoral component 11 includes a spike 25 which is integrally and fixedly attached centrally of body portion 13 on the inner face thereof for anchoring the femoral component 11 to a condyle, as will be better understood in the description to follow later in the specification. Spike 25 extends upwardly from inner face 23 in a direction remote from lower face 15 and substantially perpendicular to intermediate portion 21. Spike 25 preferably has an enlarged arrow-shaped head that has a plurality of substantially flat faces 29, the adjacent ones of which preferably intersect along lines which extend in imaginary planes extending through the longitudinal center line of the body portion 13 and transversely thereof. Spike 25 is preferably narrowed at an intermediate portion as at 31 and adjacent the lower portion is substantially boxlike in construction with a plurality of flat faces 33.

A fin 35 is integrally formed with body portion 13 and extends upwardly from inner face 23 along the middle of body portion 13 for a purpose later to be described. Fine 35 has a forward portion 35' integrally formed with the lower part of spike 25 and extending forwardly therefrom, and the fin has a rearward portion 35'' integrally formed with the lower part of spike 25 and extending rearwardly therefrom. Fin 35 is preferably wedge-shaped or somewhat sharpened along its upper edge as at 37. As viewed from the side, as in FIG. 1, forward portion 35' and rearward portion 35'' are preferably arcuate and are tapered respectively towards the forward and rearward ends of the body portion 13.

From the foregoing, it will be apparent that femoral component 11 is preferably of one-piece construction and preferably formed of stainless steel. The femoral component 11 of the present invention is preferably provided in several sizes, and the following dimensions are given by way of illustration and not limitation:

	small	medium	large
width across body 13	19.0 mm	22.5 mm	27.0 mm
height from lowest point of body 13 to tip of spike 25	27.0 mm	31.0 mm	31.0 mm

The tibial component 39 of the present invention comprises a base portion 41 which is preferably in the shape of a section of a disc, that is, in a shape as if a portion of a disc were cut away to leave the flat wall 43. The remaining wall 45 is preferably cylindrical, that is, a portion of a cylinder, and as viewed from above as in FIG. 5 extends for more than one-half of a circle. Thus, as viewed from above (FIG. 5), the outline of tibial component 39 is substantially in the shape of the letter "D." Having the wall 43 straight rather than continuing the wall 45 around to form a complete cylinder is advantageous since, when the component is placed on the tibia (as will be better understood in the description to follow later in the specification) the component will not interfere with the cruciate ligaments which may be left fully intact. Also, the rounded wall 45 will be disposed just inside the outline of the tibia with a ridge of bone therearound, as will be more apparent later in the specification. The D-shape is important since it gives the advantage of having the maximum amount of articulating surface on the tibia where the condyle or condyle component may come into play without losing any supporting bone, which is mainly around the circular portion of the tibia. The upper face 47 of base portion 41 is preferably uniform and slightly concave. Thus, upper face 47 is disposed in a section of an imaginary sphere of a relatively large diameter. In other words,

the upper face **47** provides a slightly curved plateau which coacts with the lower face **15** of the femoral component **11** to provide a smooth, uniform, and ungrooved surface so that the femoral component **11** can perform all of the natural functions of the knee thereon, that is, rocking, sliding, turning and rotation. This coaction permitted by the construction of the lower face **15** of the femoral component and the upper face **47** of the tibial component **39** is an important feature of the present invention, which permits a closer simulation of the actual complex movements of the knee than was heretofore possible. Not only are advantages derived relative to the movements corresponding to that of a natural knee, but also other advantages flow from this type of coacting surface, as for example as opposed to a groove, since any twisting forces on the femoral component **11** cannot be translated to the tibial component **39,** as for example as would occur with a grooved or tracked construction. Thus, there is not the danger of either of the components **11, 39** being torn loose from their mounting in the bone. Also, the slightly concave upper face **47** provides a universal self-aligning feature since there is a tendency when weight is applied, as when the person is standing, for the femoral component **11** to gravitate towards the lowest point **48** of concave face **47.** It will be understood that such is not the case with a tibial component having a flat face such as shown in the German Pat. No. 1,964,781.

Tibial component **39** also includes anchoring means, preferably in the form of a plurality of supports **49** integrally attached to base portion **41** along the lower face **51** thereof. The supports **49** are preferably disposed in a gridlike pattern over the entire lower face **51** and are spaced apart. Additionally, the outer ones **49'** adjacent the peripheral edge of the base portion **41** are preferably flared outwardly. The above-described arrangement of the supports **49** permits the acrylic bone cement, which is used to mount the tibial component **39,** as will be better understood later to follow in the specification, to flow up and around each individual support so that the tibial component **39** is securely anchored in cement in many points when implanted. Additionally a groove **52** is preferably provided around base portion **41.** A circumferential marker **53,** preferably of stainless steel wire, surrounds the outer supports **49'** adjacent lower face **51** to provide an accurate reference for radiographic determination of position and wear rates in the tibial component **39.** Except for the stainless steel marker **53,** which is optional, the tibial component **39** is preferably one-piece integral construction of an ultra-high molecular weight polyethylene. The tibial component **39** is utilized either singly with a corresponding single femoral component **11,** as when either the medial or lateral compartment of the knee joint is replaced, or in pairs as when both compartments are replaced. The tibial components **39** are provided in different heights, as for example, 6mm, 9mm, 12mm, and 15mm, but the remaining dimensions are the same in each size, as for example 38.1mm across the flat wall **43** and 25.4mm as measured horizontally from wall **43** to the farthest extension of wall **45.** Thus, the set of different sized components **39** is modular so that each of the four sizes may be used interchangeably in either medial or lateral compartments of left or right knees.

A femoral template **55** is preferably provided for use in preparing the femur for placement of the femoral component **11.** Femoral template **55** includes a body portion **57,** which is shaped similar to body portion **13** of femoral component **11.** A threaded stud **59** is fixedly attached to body portion **57** on the lower face **61** thereof. An opening **63** is provided through threaded stud **59** and through body portion **57** and is adapted to receive a twist drill and act as a guide therefor when the template **55** is utilized, as will be described later in the specification. A pair of slots **65, 67** are provided through body portion **57** on either side and spaced from hole **63** to correspond to fin portions **35', 35''** of femoral component **11.** A pair of prongs **69, 71** are fixedly attached to body portion **57** on the upper face **73** thereof. The prongs **69, 71** are disposed diagonally relative to opening **63** and extend upwardly from upper face **73.**

In utilizing the present invention, the tibia is first prepared, preferably in general as follows:

Referring first to FIG. **7,** wherein a tibia T is shown, by utilizing a tibial marking template **75,** the position where the tibial component **39** is to be placed, is marked with methylene blue as shown as at **77** on the right side of the tibia. It should be noted that the straight portion of the marking **77** is placed inwardly of the tibia so that when component **39** is later placed, the straight wall **43** thereof will be adjacent the cruciate ligaments which are attached in the area L and the component **39** will not interfere therewith. In other words, the cruciate ligaments may be left fully intact and the components **39** will not interfere therewith. The plateau is next deepened by suitable instruments to form the depression ready to receive a tibial component **39.** The left side as shown in FIG. **7** has thus been prepared and the depression is shown as at D. It will be noted that a ridge R of bone is left around the depression D and which partially defines the depression so that when the component **39** is placed in the depression the ridge R will surround wall **45** and prevent lateral movement of the component. Next, trial tibial components of appropriate size or sizes, and as indicated as at **39'** and **39''** in FIG. **8** are inserted in the depressions D and the stability of the knee is tested in a medial-lateral manner with the knee extended to see if it will be stable. If there is any instability, a thicker trial tibial component may be inserted on either the medial or lateral side as necessary. The trial tibial components **39', 39''** are similar to the tibial component **39** and they are preferably used rather than the actual tibial component to be implanted, so as to prevent unwanted damage to the actual component to be used. The knee is then brought into full extension and the femoral condyles C are marked with methylene blue dye at the point where they come in contact with the leading edges of the trial tibial components **39', 39''.** This is a landmark for positioning the femoral components **11.** The knee is then brought into 90° of flexion, the trial tibial components **39', 39''** are removed and set aside for later use and a femoral template **55** of appropriate size is selected and screwed onto a femoral template driver/extractor shown in phantom lines as at **79.** When the anterior edge **17'** touching the dye mark on the condyle C, the femoral template **55** is driven into place on the femoral condyle C. The femoral template driver **79** is removed from the femoral template **55** leaving the template in place as shown in FIG. **9.** Then, a twist drill is employed

to place the main cement anchoring hole H approximately 1½ inches deep into the condyle (see FIG. 10). The outline of the femoral template **55** is traced onto the condyle C with methylene blue and the template **55** is removed. Using a small osteotome or power tool, a narrow trench A is formed having portions A', A'' running anterior and posterior from the hole H. The trench A will accommodate the fin **35** of the femoral component **11** and should be wide enough to accommodate cement on either side. The area within the outer perimeter of the femoral template markings is cleared of all soft tissue and a series of shallow cement anchoring holes B is placed alongside either side of the central cement trench A.

Next, utilizing a suitable instrument, as a femoral condyle driver/impactor, a femoral trial component, not shown, of appropriate size is seated into position on the prepared condyle C. The trial tibial component **39'**, **39''**, for that side of the joint is reinserted and the joint is tested for stability, and position of the components. The femoral trial component, not shown, which is a substantial duplicate of the femoral component **11** will protrude slightly over the anterior edge of the trial tibial component **39'** or **39''** and will glide smoothly over the new tibial surface.

If the medial compartment functions satisfactorily, and if the total joint is being replaced, the lateral condyle should be marked, prepared and tested by the same procedure. At the completion of the second side, a careful check should be made to determine if the preexisting joint deformity has been satisfactorily corrected and to insure that the femoral and tibial components remain in good contact as flexion and extension occur. Any discrepancies should be corrected at this point by the substitution of trial tibial components **39'**, **39''** of appropriate thickness. When the joint functions satisfactorily, the trial components are removed and the joint is thoroughly irrigated with antibiotic solution and dried. Next, the bed and walls of the prepared depression D are lined with a thin layer of acrylic bone cement. The undersurface of each tibial component **39** is coated with bone cement and utilizing a suitable instrument, as a tibial plateau impactor, each tibial component **39** is seated in its appropriate depression D. Excess cement is removed from around each tibial component **39,** and the leg is brought into extension while the bone cement hardens. It is possible at this point to adjust for any varus or valgus discrepancy which might still be present by manipulating the leg to the desired amount of correction while the cement is still soft.

Next, the trench A of one of the condyles is filled with bone cement. Then the undersurface of the first femoral component **11** is coated with cement, the femoral component is properly oriented with the anterior section pointing up, and the femoral component **11** is then seated in the condyle by utilizing a suitable instrument, with the spike **25** extending into hole H and with the fin **35** extending into trench A. The process is repeated with the remaining condyle and the excess cement is removed from the implant surfaces and the margins of the femoral condyles. It should be noted that if varus or valgus correction is still required at this stage of the procedure, it may still be obtained by the simple expedient of seating one or the other of the femoral components **11** more deeply into the cement than the other. The leg is then brought up into extension as the cement sets.

Although the invention has been described and illustrated with respect to a preferred embodiment thereof, it is to be understood that it is not so limited since changes and modifications may be made therein which are within the full intended scope of the invention.

I claim:

1. A knee prosthesis comprising a pair of femoral components for attachment to the condyles of a knee with which used and a pair of corresponding tibial components for attachment to the tibia and respectively engaging said femoral components; each of said tibial components being substantially in the shape of a "D" as viewed in plan and including a base portion having a substantially cylindrical outer wall, and said base portion having a uniform and slightly concave ungrooved upper face disposed in a portion of an imaginary sphere, said outer wall being of a size slightly smaller than the outside circular portion of the tibia with which used whereby a supporting ridge of bone may be left in the knee with which used around said outer wall of said body portion, cement means on said base portion for holding said base portion to the tibia with which used, each of said femoral components including a body portion having a curved lower face engaging said upper face of a corresponding one of said tibial components, said lower face including a posterior section and an anterior section, said femoral component including anchoring means attached to said body portion remote from said lower face for anchoring said body portion to one of the condyles of the knee with which used, cement means on said body portion for aiding in holding said body portion to the condyle with which used, said posterior section extending rearwardly and upwardly from said anterior section on a substantially sharper curve than said anterior section, said body portion being provided with upturned side edges for trapping said cement means under said body portion and said anchoring means including a spike attached to said body portion and extending upwardly therefrom, said spike being greater in height than the width of said body portion.

2. A knee prosthesis femoral component comprising a curved body portion having a lower face including a posterior section and an anterior section, anchoring means attached to said body portion remote from said lower face for anchoring said body portion to one of the condyles of the knee with which used, said anchoring means including a single spike fixedly attached centrally of said body portion and fin means extending in a forwardly and rearwardly direction relative to said body portion for preventing rotation of said body portion relative to the condyle with which used, cement means being provided on said body portion for aiding in holding said body portion to the condyle with which used and in which said body portion is provided with upturned side edges for trapping said cement means.

3. A knee prosthesis femoral component comprising a curved body portion having a polycentric curved lower face including a posterior section and an anterior section, anchoring means attached to said body portion remote from said lower face for anchoring said body portion to one of the condyles of the knee with which used, said posterior and anterior sections being respectively disposed on imaginary curves with the curve of said posterior section having a predetermined radius substantially smaller than the predetermined radius of the curve of said anterior section, said body portion

being provided with upturned side edges, said anchoring means including a single spike attached to said body portion centrally thereof and extending upwardly therefrom, and fin means attached to said body portion and extending in a forwardly and rearwardly direction away from said spike for engaging one of the condyles of the knee with which used for preventing rotation of said body portion relative to the condyle.

4. The knee prosthesis femoral component of claim **3** in which said fin means has a sharpened edge.

5. The knee prosthesis femoral component of claim **4** in which said fin means is tapered downwardly, forwardly and rearwardly from said spike.

6. A knee prosthesis comprising a femoral component for attachment to a condyle of the knee with which used and a tibial component for attachment to the tibia and engaging said femoral component, said femoral component including a lower face having a posterior section and an anterior section, said posterior section extending rearwardly and upwardly from said anterior section on a substantially sharper curve than said anterior section, said lower face being transversely curved along its entire length, said tibial component including an upper face disposed in a portion of an imaginary sphere, and said femoral component being less in width than said tibial component.

7. The prosthesis of claim **6** in which said femoral component includes anchoring means attached to said body portion remote from said lower face for anchoring said body portion to one of the condyles of the knee with which used and said anchoring means including a spike attached to said body portion and extending upwardly therefrom, said spike being greater in height than the width of said body portion.

8. A knee prosthesis femoral component comprising a curved body portion having a polycentric curved lower face including a posterior section and an anterior section, anchoring means attached to said body portion remote from said lower face for anchoring said body portion to one of the condyles of the knee with which used, said posterior and anterior sections being respectively disposed on imaginary curves with the curve of said posterior section having a predetermined radius substantially smaller than the predetermined radius of the curve of said anterior section, said anchoring means including a single pointed spike attached to said body portion centrally thereof and extending upwardly therefrom, and narrow fin means attached to said body portion and elongated in a direction extending radially of said spike for engaging one of the condyles of the knee with which used for preventing rotation of said body portion relative to the condyle.

9. A knee prosthesis comprising a femoral component for attachment to a condyle of the knee with which used and a tibial component for attachment to the tibia and engaging said femoral component, said femoral component including a lower face having a posterior section and an anterior section, said posterior section extending rearwardly and upwardly from said anterior section on a substantially sharper curve than said anterior section, said lower face being transversely curved along its entire length, and said tibial component including an upper face disposed in a portion of an imaginary sphere of a greater radius than the transverse curvature of said lower face.

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