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(72) Inventors JOHN WILLIAM GOODFELLOW
JOHN JOSEPH O'CONNOR

(19)

(54) PROSTHETIC JOINT DEVICES

(71) We, NATIONAL RESEARCH DEVELOPMENT CORPORATION, a British Corporation established by Statute, of Kingsgate House, 66–74 Victoria Street, London, S.W.1., do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

The invention concerns prosthetic joint devices and is a development of that described in U.K. Patent Specification No. 1,534,263.

Specification No. 1,534,263 is specifically concerned with endoprosthetic knee joint devices and proposes such a device comprising a femoral condylar component for securement to the femur and having a convexly curved articulatory bearing surface, a tibial condylar component for securement to the tibia and having a relatively flattened articulatory bearing surface compared to that of said femoral component, and a meniscal component having two articulatory bearing surfaces in opposed disposition and of individual forms respectively substantially complementary to said femoral and tibial articulatory surfaces. The meniscal component is located between the other two with the complementary surfaces respectively engaged and simulates the natural meniscal role in allowing various modes of both rotational and translational movement to occur between the other components while maintaining a reasonably uniform distribution of load through the device and without significant disturbance to continued natural function of the muscles and ligaments.

Further study of the mechanics of such a device indicates that similar devices are advantageously applicable to other prosthetic joint situations. In the result there is provided a prosthetic joint device comprising a first component having a convexly curved articulatory bearing surface, a second component having a substantially planar articulatory bearing surface, and a third component for location between said first and second components and having two articulatory bearing surfaces in opposed disposition and of individual forms substantially complementary to said curved and planar surfaces for engagement therewith.

One application of the present invention is as an endoprosthetic bone joint device, and particularly as a replacement for a natural joint of non-congruous form involving two bones with mutually co-operating articular surfaces which are respectively convexly shaped and relatively flattened or somewhat concavely shaped. In addition to the knee, such joints are found in the shoulder, the wrist, the ankle, the fingers and the toes.

The relevance of this application of the invention is based on a particular view of the form and function of the basic elements of the joints in question, these elements being the articular surfaces and adjacent bone, the ligaments, and the tendons through which the muscles act on the bones. This view holds that the articular surfaces allow substantially all movements except mutual interpenetration, with the adjacent bone serving predominantly to transmit compressive forces, and that the other elements control and limit the surface movements while themselves serving to resist and transmit tensile forces. Thus, there is an interdependence between the elements of a joint, and this interdependence is vital to the overall performance of a joint having incongruent surfaces which can provide little inherent stability.

There is support for the above view in the following facts:

(a) The incongruous joints in question each involve at least one elongated bone and such bones have their articular surfaces on bulbous regions at the ends of shafts.

(b) The bulbous regions are formed predominantly of trabecular bone with a relatively thin casing of cortical bone, while the shafts comprise thick tubular structures of cortical bone.

(c) The traberculae of the bone adjacent to the articular surfaces are aligned generally perpendicularly thereto and this alignment continues to the shaft. This structure is singularly well adapted to resist and transmit compressive stress and contrasts with that of the shaft which has a general ability to transmit compressive, tensile and shear stresses.

(d) The ligament connections to an elongate bone in a joint are generally found at the region where the shaft joins the bulbous region.

Application of the invention in this context is advantageous in that substantially only compressive force is transmitted by the device, and the first and second components can be substituted for the convex and relatively flattened articular surfaces for optimum compatibility with the adjacent bone structure. At the same time, the third component can be selected from a range having differing thicknesses to ensure that there is no undue laxity in the ligaments and tendons such as would otherwise render the prosthesis unstable.

As in the above-mentioned specification No. 1,534,263, the advantages of this more general application of the invention to endoprosthetic devices can be obtained while employing simple articulatory bearing surface shapes which facilitate manufacture. More specifically the relevant co-operating surfaces of the first and third components can be of complementary shapes having circular arcuate cross-section in at least one direction, and are suitably spherically shaped to conform to the associated natural bone.

Another application of the invention is as an exoprosthetic joint device in an artificial limb. The basis for this application is that, in comparison with prior art devices, the present invention provides greater motion capability and simplicity of construction with ease of maintenance such as by replacement of the third component to take account of bearing surface wear.

Considering, for example, the case of an artificial leg: many such legs have been made with a hinge-like device at the level of the knee. In its simplest form this has allowed flexion-extension movement about a fixed transverse axis, but this is unsatisfactory in failing to take account of the fact that the transverse axis of the natural knee joint moves posteriorly as flexion progresses. In practice the simple joint device lacks stability in extension if the fixed axis is located anteriorly, and the device is difficult to flex if the axis is located posteriorly. In an attempt to overcome these defects, other devices with variable transverse axes have been employed: in one form a toothed cog is made to roll around or across another cog, and in another form a four bar linkage is employed. However, these other devices suffer from one or more disadvantage including mechanical complication, high cost, and difficulty in maintenance. More importantly, these other devices are disadvantageous in that they allow only anterior-posterior variation of the axis of rotation. Normal walking involves rotatory movements of bones in the leg, predominantly at the hip, ankle and subtalar joints, and also significantly at the knee joint. Most currently available artificial legs allow no rotation at the knee or ankle, and as a consequence rotation must occur between the "foot" of the limb and the grounds, or between the live leg stump and its associated socket in the limb.

Naturally, since there are no ligaments and tendons at a joint in an artificial limb, this further application of the invention involves prosthetic replacements for the relevant functions and this preferably comprises the provision of flexible tension-bearing elements interconnecting the first and second components.

Application of the invention as an exoprosthesis is also appropriate where the device assists rather than replaces anatural joint function. Devices for this purpose are now increasingly referred to as orthoses.

Given the description of the endoprosthetic knee joint devices in Specification No. 1,534,263, the above discussion of wider application of the mechanics of such devices in other endoprosthetic bone joint devices, and the general knowledge of existing matters such as surgical procedures and securement techniques for endoprosthetic bone joint devices, it seems unnecessary to describe the first application of the present invention further by way of example. However, it does seem appropriate to clarify the application of the invention as an exoprosthesis and, for this purpose, reference is made to the accompanying drawing which schematically illustrates one example of an exoprosthetic knee joint device for incorporation in an artificial leg.

The illustrated device comprises first, second and third components respectively denoted 10, 20 and 30. The first component 10 defines a convex circular cylindrical articulatory bearing surface 11, the second component 20 defines a planar articulatory bearing surface 21, and the third component 30 defines an opposed pair of articulatory bearing surfaces 31 and 32 of respectively concave circular cylindrical and planar forms complementary with the surfaces 11 and 21. These components are held together as shown, with their complementary surfaces engaged, by elongate flexible members 40 connected under tension between the first and second components 10 and 20. There are four of the members 40 disposed in two pairs on opposite sides of the engaged components, with each pair being in a cruciform configuration extending in a transverse radial plane relative to the common longitudinal axis of the cylindrical surfaces 11 and 31.

Two further elongate flexible members 50 interconnect the first and second components 10 and 20. The members 50 extend in a transverse radial plane relative to the surfaces 11 and 31 midway between the planes of the members 40, and the members 50 are respectively located to the front and rear of the components 10 and 20.

The components 10 and 20 are also respectively adapted for connection to the upper and lower limb portions of an artificial leg. In the present instance this adaption comprises the provision of stems 60 projecting from the uppermost and lowermost surface portions of the components 10 and 20, these stems serving

to key a cement securement, or as part of a screw or other securement mechanism.

The application and operation of the illustrated device, at least so far as the components 10, 20 and 30 are concerned, is similar to those of said Specification No. 1,534,263. Thus these components serve respectively as femoral, tibial, and meniscal components affording relative motions including rolling, gliding, twisting, and combinations thereof, while maintaining uniform compressive load distribution through the components. The members 40 serve, as noted above, to hold the articulatory bearing components in engagement and so simulate a function of the ligaments. In addition, appropriate siting of the connections of the members can be such that they bias the device to a particular configuration at rest which may suitably be chosen as that corresponding to full extension. The members 50 also simulate a ligamentous function by respectively limiting the extent of the movements corresponding to flexion and extension. In this last connection, the stems 60 can be relatively positioned other than coaxially in the fully extended configuration of the device to enhance the compatability and stability of the leg vis-a-vis the associated natural function at the hip.

Again, as with endoprosthetic applications, the illustrated device suitably employs metal for the components 10 and 20, and plastics material for the component 30, with the latter component being replaceable to facilitate maintenance.

Clearly the illustrated device is but one example of a variety of possible specific applications of the invention. Wide variation is possible in terms of the movement controls and limitations exerted by the ligament-simulating members. Also variation of the articular components is possible since, as in the endoprosthetic devices, the convex surfaces may be spherically shaped. Moreover, such devices can be applied to "passive" exoprostheses which operate under the influence of gravity, or "active" exoprostheses which are powered by some artificial mechanism.

These last comments regarding variations are also generally relevant to application of the invention in orthoses which comprise external assistory mechanisms for use in association with natural limbs.

Lastly, it is to be noted that, while the appendant claims are directed more generally to prosthetic joint devices, endoprosthetic knee joint devices as claimed in said Specification No. 1,534,263 are to be specifically excluded.

WHAT WE CLAIM IS:—

1. A prosthetic joint device comprising a first component having a convexly curved articulatory bearing surface, a second component having a substantially planar articulatory bearing surface, and a third component for location between said first and second components and having two articulatory bearing surfaces in opposed disposition and of individual forms substantially complementary to said curved and planar surfaces for engagement therewith.

2. A device according to Claim 1 wherein said curved surfaces have respective substantially complementary circular accurate cross-sectional shapes in at least one direction.

3. A device according to Claim 2 wherein said curved surfaces are spherically shaped.

4. A device according to any preceding claim wherein said first and second components are adapted for securement to respective bones of a natural joint.

5. A device according to any one of Claims 1 to 3 wherein said first and second components are adapted for connection to, or are connected to, respective members of an artificial limb, and said first and second members are interconnected by flexible tension-bearing elements.

6. A prosthetic joint device substantially as herein described with reference to the accompanying drawing.

G. PARKER
Chartered Patent Agent
Agent for the Applicants

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1603833 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*