2005

PATENT ATTORNEYS

EXAMINATION

PAPER E

Patent Attorney Practice in New Zealand
Including the
Interpretation and Criticism of Patent Specifications

Regulation 158 (1) (e)

Duration: 4 hours (plus 10 minutes for reading)

2005

PATENT ATTORNEYS EXAMINATION

PAPER E

PATENT ATTORNEY PRACTICE IN NEW ZEALAND INCLUDING THE INTERPRETATION AND CRITICISM OF PATENT SPECIFICATIONS

All questions should be attempted.

Time allowed: 4 hours (plus 10 minutes for reading)

Candidates are required to give reasons for their answers. The marks awarded depend on the reasoning displayed rather than the particular conclusions reached. Candidates should discuss fully all issues that appear to them might reasonably arise (even though some of the issues might not have to be decided if the candidate's conclusions on other issues should be correct). Candidates should presume that they are giving their advice to the client on the date of the examination.

Candidates should not write a précis of each specification referred to or of its claims. If part of a specification needs to be referred to it can be done by page/line or column/line reference or by paragraph numbers, as appropriate. The prior art may be referred to by letter or number. Case law need not be detailed as marks are awarded only for a clear statement of the points of interpretation of the client's invention and the patent at issue, the prior art considered, and for the reasoning leading to the conclusions reached.

INSTRUCTIONS TO CANDIDATES

Yesterday, you received an email from David Perry, patent counsel for US company DeviceDesign Inc (DDI). You have provided several opinions for DDI in recent years and he now has another project that he would like you to help with.

DDI is a significant player in the medical device market. The company has developed an improved hip replacement prosthesis. The hip replacement prosthesis has been the subject of some successful clinical trials in the US and DDI now plans to launch the product at a major orthopaedic conference being held in about 3 months time.

DDI's improved hip replacement prosthesis is described in the attached patent specification, marked "A" (filed earlier this year). In specification A, Figure 1 shows DDI's existing product, which has been on sale in New Zealand and elsewhere for more than ten years. Figure 2 shows DDI's improved hip replacement prosthesis. It is the hip replacement prosthesis shown in Figure 2 that DDI is planning to launch at the orthopaedic conference.

New Zealand Patent Number 654321

David's investigations (conducted in the US prior to commencement of the clinical trials) have revealed a relevant patent publication. This is WO 99/11111, in the name of The New Haven Society for the Ruptured and Crippled.

WO 99/11111 has a priority date of 16 September 1997 and an international filing date of 15 September 1998.

David has determined that WO 99/11111 entered the national phase in New Zealand and is the subject of New Zealand Patent No 654321 (NZ 654321). NZ 654321 was granted on 15 August 2004 and is currently in force until 15 September 2005. A copy of its complete specification is attached, marked "B".

The Prior Art

David has conducted a prior art search. He provides you with a list of relevant documents, which are:

US 5 387 244 (marked "C")
US 4 969 910 (marked "D")
US 3 924 275 (marked "E").

The only other relevant prior art is DDI's existing product, shown in Figure 1 of the specification marked A.

Your Opinion

David has asked you to provide your opinion on the following:

1. Will the sale and use in New Zealand of DDI's new product infringe any of the claims of NZ 654321?

(30 marks)

2. Are the claims of NZ 654321 valid?

(50 marks)

3. Regardless of your conclusions for questions 1 and 2, David wants to know what options are available to The New Haven Society for the Ruptured and Crippled to strengthen its patent.

David is not interested in a detailed description of procedures, but wants your advice on possible amendment of the claims and how that impacts on the issues of infringement and validity.

(20 marks)

Total – 100 marks

PATENT SPECIFICATION

A

Implant, and Articular Prosthesis Comprising Said Implant

The invention relates to the field of articular prostheses, such as hip or shoulder prostheses.

It is standard to use hip prostheses composed of:

- a metal stem and an essentially spherical, ceramic, femoral head, which the surgeon substitutes for the upper part of the patient's femur, and
- an acetabular implant to receive said femoral neck, which the surgeon implants, e.g. by cementing, in the patient's pelvis, at the site of the natural acetabulum.

In a preferred example of such a prosthesis known in the art, the acetabular implant is composed of a first part, made of a polymer material such as polyethylene, whose general shape is that of a cup, and a second part, made of a ceramic material such as alumina, which lines the interior of the first part. This second part defines a socket whose shape corresponds to that of the femoral head of the prosthesis. The inside edge of this socket is chamfered so as not to present a sharp edge, and so as to permit a given maximum angle of inclination of the metal stem during movements of the patient's thigh.

A problem with this configuration is that when the metal stem is at its maximum inclination, it strikes the chamfered inside edge of the socket formed by the ceramic part. This is a cause of wear to the ceramic material, leading to undesirable dispersal of particles in the joint-region, or even to breakage of the ceramic part affected by such impacts. Furthermore, the stem then comes to bear on the edge of the socket, and if the relative movement of the thigh and the pelvis tends to continue, the normal geometry of acetabular means that there is considerable risk that the femoral head will come out of its socket, due to a "cam effect", leading to dislocation of the hip.

The objective of the invention is to propose a new acetabular implant design enabling the above-mentioned problems to be solved.

To achieve this, the invention has as its subject matter an implant for a joint prosthesis, of the type comprising a first part, made of polymer material, which defines a cavity that accommodates a second part, made

of ceramic material, which defines an essentially hemispherical cavity for receiving the femoral head of a second implant, said second implant comprising also a stem; characterized in that:

– the rim of said second piece is embedded in the first part, which is fabricated by overmoulding on the second part; and

– the rim of said first part has a chamfer serving as a limit stop for the stem of the second implant to be able to abut against.

Said first part preferably comprises—right above the upper bound of the cavity in the second part—a portion of wall designed to serve as a limit stop for the head to abut against during movements liable to result in dislocation of the joint.

A further subject-matter of the invention is a joint prosthesis of the type comprising a first implant and a second implant, the latter comprising a stem terminated by an essentially spherical head turning in a correspondingly-shaped cavity in the first implant, characterized in that said first implant is of the above-mentioned type.

This joint prosthesis may be, in particular, a hip prosthesis or a shoulder prosthesis.

As will have been understood, the invention consists in producing an overmoulding on the ceramic part of the first implant, said overmoulding consisting of a polymer material, and covering the entirety of the upper edge of said ceramic part. The chamfer limiting the angular range of inclination of the stem of the second implant is provided on the overmoulding, with the result that the stem, which is generally made of metal, never comes into contact with a ceramic part. The only contacts that can occur in the joint prosthesis of the present invention are thus ceramic-to-ceramic and metal-to-polymer. There is consequently no longer any metal-to-ceramic contact liable to lead to heavy wear or breakage of the ceramic. In addition, the invention enables the geometry of the first implant to be modified so as to make it more difficult for dislocation of the joint to occur.

In the preferred example applying the invention to a hip prosthesis, the first implant is an acetabular implant, and the second implant replaces the terminal part of the patient's femur.

The invention will be better understood by reading the following description, which refers to the appended drawings, in which:

Fig. 1 is a diagrammatic representation of a prior-art hip prosthesis, shown in cross-section; and

Fig. 2 is a diagrammatic representation of a hip prosthesis according to the invention, also shown in cross-section, which is derived from the prosthesis in Fig. 1.

The prior-art hip prosthesis shown in Fig. 1 comprises the following elements:

- an implant constituted by a metal stem 1, made of a biocompatible metal (e.g. stainless steel, or titanium), bearing on its extremity an essentially-spherical femoral head 2 made of a ceramic such as alumina, this head-and-stem unit 1, 2 serving to substitute for the terminal part of the patient's femur;
- an acetabular implant to receive the femoral head 2 and to substitute for the patient's femoral joint, composed of two parts (a first part and a second part), as follows:

  the *first part* 3 is made of a polymer material such as polyethylene; its general external shape is approximately hemispherical, and it has a cavity 4 in it, which defines an essentially spherical surface; this first part is to be implanted into the patient's pelvis, e.g. by cementing it in; to facilitate the gripping and fastening thereof in the pelvis, the outer surface 5 of the first part 3 comprises various grooves and recesses 6;

  the *second part* 7, made of a ceramic such as alumina, lines the cavity 4 in the first part and defines the socket 8 for the femoral head 2; said socket 8 therefore has a spherical surface corresponding to the geometry of the femoral head 2.

It will be noted that the rims 9, 10 of the first 3 and second 7 parts, facing the exterior of the articulation, are aligned so as to define a single rim on the acetabular implant. The rim 10 of the second part 7 has a chamfer 11, on which, as shown, the metal stem 1 comes to bear at the femur's maximum permitted range of movement in the joint (indicated by the arrow 12). As mentioned, this metal-to-ceramic contact causes wear to the ceramic—and even a risk of breakage—at the chamfer 11. In addition, the chamfer 11 then constitutes a bearing zone for the stem 1. If the movement of the stem 1 tends to continue, there is a risk that this will

result in the femoral head 2 coming out of its socket 8 in the direction indicated by the arrows 13—i.e. dislocation of the patient's hip.

In the example of a hip prosthesis in accordance with the invention, shown in Fig. 2, the implant constituted by the above-mentioned head-and-stem unit 1, 2 is again used. Here again, the acetabular implant consists of:

– a first part 3, made of polymer, with a general shape similar to that in Fig. 1, and with the same grooves and recesses 6 on its outer surface 5; and

– a second part 7, made of ceramic, defining the socket 8 for the femoral head 2.

The essential difference compared with the prior-art configuration shown in Fig. 1 is that, according to the invention, the upper rim 9 of the first part 3 alone constitutes the upper rim of the acetabular implant. The upper rim 10 of the second part 7 is thus embedded within the first part 3, which is fabricated by overmoulding on the second part 7. The main consequence of this is that the chamfer 11' which serves as the limit for the movement of the stem 1, thereby fulfilling the same function as the chamfer 11 in the prior art, is no longer provided on the second part 7, made of ceramic, but on the upper edge 9 of the first part 3, made of polymer. The contacts between the stem 1 and the chamfer 11' are thus metal-to-polymer contacts, with which there is no risk of causing release of particles or pieces of ceramic into the patient's body.

Fabricating the first part 3 by overmoulding on the second part 7 provides excellent complementarity of the two parts, and hence excellent retention of the second part 7 by the first part 3. This is crucial due to the fact that the first part is affixed directly in the patient's pelvis.

Another advantage of the invention is that, as can be seen in Figures 1 and 2, if the dimensions of the essential parts of the prosthesis are kept similar (overall dimensions of the entire joint unit, thickness of the different parts), it becomes possible to give the chamfer 11' a greater angle of inclination from vertical than in the prior art. The angle of maximum possible range of movement of the stem 1 is thus increased. This, together with the relative distancing of the centre of curvature of the stem's movement in relation to the edge of the socket accommodating the head 2 when the stem comes to bear on the chamfer 11' makes it possible to reduce the risk of a cam effect being produced as described above. Moreover, it is possible to provide—right above the upper bound of the

cavity 8 in the second part 7—a portion of wall 14 on the first part 3 that extends into said cavity 8 and serves to form a limit stop for the head 2 to abut against when the stem 1 would tend to continue its movement after having come to bear against the chamfer 11'. Dislocation of the joint thus becomes more difficult.

It is accepted that the thickness of the polymer covering the edge 10 of the second part 7 must be at least 0.5 mm. It can, of course, be considerably more.

By way of indication and example, a hip prosthesis in accordance with the invention can have the following dimensions:

- overall outside dimensions of first part 3, made of polymer: 30 x 50 mm
- thickness of first part 3, made of polymer: 6 mm
- thickness of second part 7, made of ceramic: 4 mm
- radius of curvature of socket 8 for head 2: 14 mm
- angle of chamfer 11' from vertical: 60°
- height of vertical portion of wall 14: 4 mm

The invention has been described and illustrated as embodied in the form of a hip prosthesis. But it is also applicable to other types of similarly-functioning joint prostheses, such as shoulder prostheses.

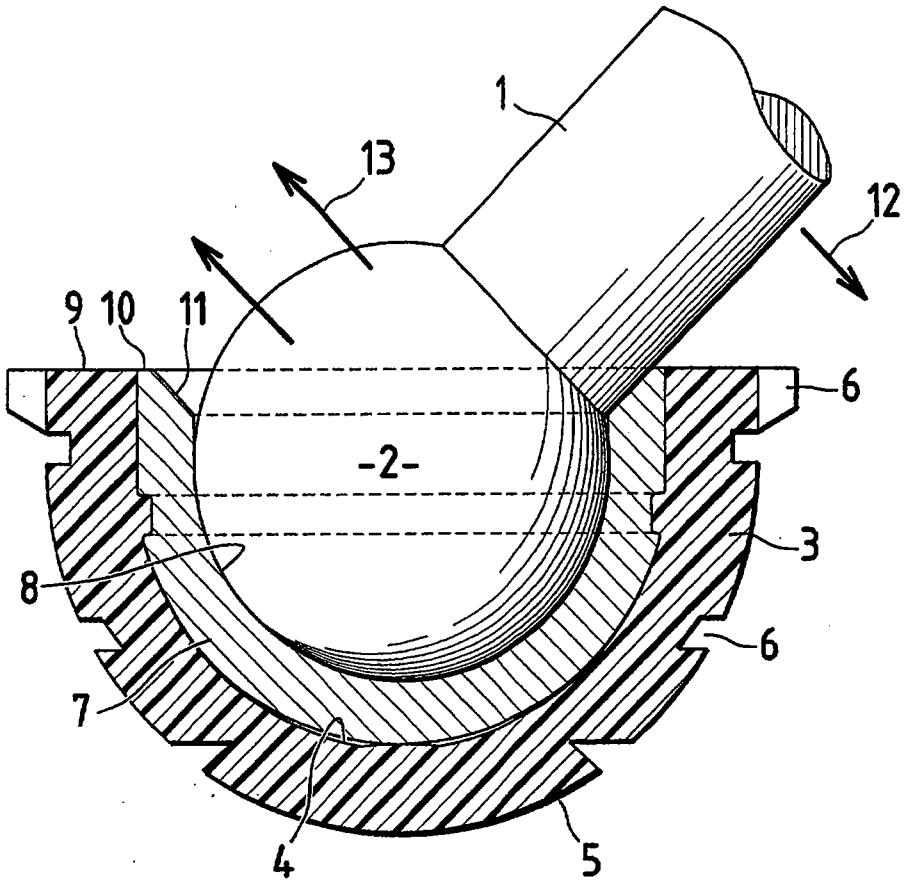

FIG.1

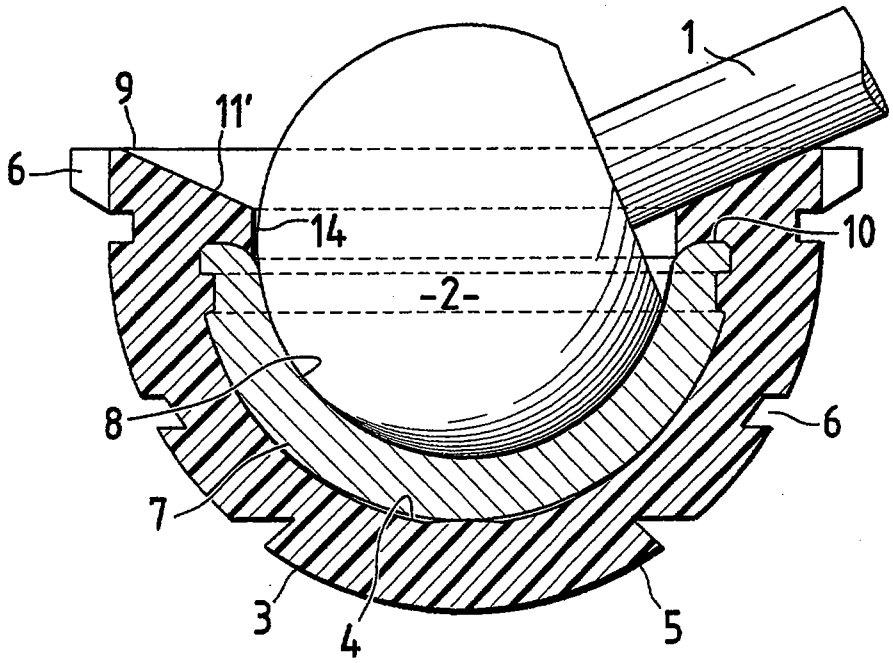

FIG.2

PATENT SPECIFICATION

B

HIP REPLACEMENT

Field of the Invention

[01] The invention relates to prostheses, and more particularly an acetabular cup and femoral component configured for a hip replacement system to reduce the likelihood of dislocation during flexing of the joint.

Background of the Invention

[02] Artificial joints provide patients having arthritic or otherwise dysfunctional skeletal features with an alternative treatment for the chronic pain and discomfort often associated with such problems. Correction of the condition generally involves surgically replacing one or more of the natural components making up the joint with an artificial equivalent.

[03] One of the more widely implemented artificial joints serves as a substitute for hips. A typical hip replacement system generally includes a femoral prosthesis implanted in the upper end of the femur when the femoral head requires replacement. The replacement is formed with a spherically shaped head and an elongated narrow neck extending from the head for attachment to the femur. The femoral head is complementally formed to pivotally nest within the socket of an acetabular cup. The cup includes a hemispherical base for mounting to the pelvis, and an outwardly opening socket to receive the femoral head. The prosthesis components are generally implanted during a surgical procedure well known to those skilled in the art.

[04] While the typical hip replacement system described above provides a moderate range of mobility, the acetabular cup generally has limited clearance with respect to the neck of the femoral prosthesis. As a result, attempts by the patient to forcefully move the joint beyond the designed range of motion may cause the femoral head to pop out of the cup, resulting in dislocation that ultimately may require subsequent surgery for correction.

[05] Therefore, the need exists for a hip replacement system configured to minimise the occurrence of dislocation of the femoral component and the cup. Moreover, the need also exists for such a system to provide an expanded range of motion for the connected joint. The hip replacement of the present invention satisfies these needs.

Summary of the Invention

[06] The hip replacement system of the present invention provides patients the capability of carrying out everyday tasks with reduced likelihood of component dislocation. This minimises the complications and expense arising from reassembling the joint through subsequent surgery or the like. It also reduces the accumulation of wear debris caused by impacts between the hip components. Additionally, the design of the hip replacement expands the range of flexion for the joint to correspondingly create a wider range of mobility for the patient.

[07] To realise the advantages described above, the present invention, in one form, comprises an acetabular cup for mating to a femoral component comprising a ball-shaped head and reduced-diameter neck. The component neck extends axially from the head and has a contact surface. The cup includes a socket adapted to pivotally capture and secure the femoral component head. The socket is bounded by an engagement surface to define a stop for engaging the contact surface to establish an initial contact point corresponding to a predetermined motion limit. As the hip joint moves beyond this motion limit, the contact point shifts radially outwards along the surface to reduce the likelihood of dislocation.

[08] Other features and advantages of the present invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings.

Brief Description of the Drawings

[09] FIGURE 1 is a lateral sectional view of a conventional hip replacement system;

[10] FIGURE 2 is a view similar to Figure 1 showing a maximum degree of deflection before dislocation;

[11] FIGURE 3 is a lateral sectional view of the present invention according to a first embodiment;

[12] FIGURE 4 is a view similar to Figure 3 showing a greater degree of deflection;

[13] FIGURE 5 is a lateral sectional view of the present invention according to a second embodiment; and

[14] FIGURE 6 is a view similar to Figure 5 showing a greater degree of deflection.

Detailed Description of the Invention

[15] A human hip joint typically comprises a socket portion formed in the pelvis to rotatably capture a ball-shaped head portion projecting inwardly from the femur bone. Severe dysfunction of the joint often requires hip arthroplasty, involving a surgical substitution of the socket portion, the head portion, or both.

[16] Referring now to Figures 1 and 2, a conventional hip replacement system for substituting a human hip joint, generally designated 10, includes an acetabular cup 12 and a femoral element 18. The acetabular cup is configured with a curved (for example, hemispherical) shape and is formed with a central cavity 14 (Figure 2) that opens radially outwardly to define a socket. The socket is bounded radially by a chamfered anterior rim 16 that extends radially outwardly to define a flat liner. During the arthroplasty procedure, the cup is typically implanted in the pelvis.

[17] Further referring to Figures 1 and 2, the femoral component 18 is typically implanted into the femur bone and includes a formed mushroom shaped head 20 for rotatably nesting in the cup socket 14. Projecting axially outwardly from the head is a formed neck that angles radially outwardly to define a shaft 22. The neck forms an engagement surface for impinging the radial contact edge during extreme movement of the joint.

[18] Dislocation of the components comprising a conventional hip replacement system typically results from an overabundance of leverage caused by extreme movement. Figure 1 illustrates the cup 12 and the femoral element 18 oriented with the neck initially impinging on the anterior rim, but with the head 20 still securely nested in the socket 14. Continued flexure of the joint beyond the orientation shown in Figure 1 results in the head popping out of the socket, as shown in Figure 2, due to the fixed leverage created at the constant contact point.

[19] Referring now to Figures 3 and 4, the hip replacement system of the present invention, according to a first embodiment, and generally designated 30, avoids the dislocation problem described above by providing an acetabular cup 32 that cooperates with a femoral component 40 to establish decreasing leverage on the femoral component during extreme movement of the joint.

[20] With continuing reference to Figure 3, the acetabular cup 32 may be substantially crescent-shaped in cross-section, with a centrally formed cavity 34 (Figure 4) defining the hemispherical socket (for

example) and bounded radially by an anterior rim 36. The rim extends radially outwardly at an angled orientation to form a convex liner 38 defining a stop.

[21] The femoral component 40, which may be the same as the femoral component shown in Figures 1 and 2, comprises a ball-shaped head 42 and a reduced-in-diameter neck 44 extending axially from the head and having a formed contact surface 46.

[22] During the arthroplasty procedure, the acetabular cup 32 is implanted into the pelvis (not shown), while the femoral component 40 is implanted into a surgically modified femur bone (not shown). Following the surgical procedure, the joint is fully operative to allow relative rotation between the two components.

[23] As shown in Figure 3, operation of the hip replacement will often involve movement to an orientation such that the contact surface 46 of the neck 44 abuts the liner 38 at an initial contact point 50 corresponding to a predetermined motion limit. The initial contact orientation, according to a first embodiment, comprises 57 degrees of deflection as compared to a socket central axis 52. Further flexing of the joint places an increasing load on the femoral component. This results from leverage being exerted at the initial contact point.

[24] However, as shown in Figure 4, due to the unique declining angular convex configuration of the liner 38, as the hip joint moves beyond this motion limit, the contact point shifts radially outwardly along the liner to a peripheral contact point 54 allowing a maximum deflection of 69 degrees, while reducing the dislocation leverage acting on the femoral component. Additionally, by decreasing the dislocation leverage acting on the femoral component, an oppositely-directed correction leverage is increased to maintain the component within the socket.

[25] Referring now to Figure 5, a second embodiment of the present invention, generally designated 60, implements an acetabular cup 62 formed substantially similarly to that of the first embodiment, but having a less pronounced angular decline for the convex liner 64. A femoral component 66 is also included which is formed substantially similarly to that of the first embodiment.

[26] It has been discovered that by making the angle of decline less pronounced for the liner 64 with respect to the angle implemented for the liner according to the first embodiment of the present invention, during operation, the contact point shifts radially outwardly, while allowing an unexpected advantage in relative mobility from 69 degrees to 73 degrees.

[27] The present invention contemplates any surface configurations that enable the contact point between the neck and the liner to move outwardly or toward the periphery of the liner as motion of the femoral component increases.

[28] It is also envisioned that the present invention may be individually packaged and sold as a kit of unassembled components to reduce any unnecessary costs associated with purchasing an entire system, should only the need for one component of the system arise.

[29] Those skilled in the art will appreciate the many benefits and advantages realised by the present invention. Of paramount importance is the shifting contact point feature that minimises leverage acting upon the femoral component to pop it from the cup socket. As a direct result, severe dislocations that may degrade the performance of the joint are substantially reduced. Moreover, by greatly reducing the number of dislocations between the hip joint components, subsequent costly surgical corrections are dramatically minimised.

[30] While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.

What We Claim Is:

1. An acetabular cup for implanting within a pelvis and mating to a femoral component, said femoral component comprising a ball-shaped head with a neck extending axially therefrom and having a contact surface, said cup including:

a socket adapted to pivotally capture and secure said femoral component head, said socket bounded peripherally by a liner to define a stop for engaging said contact surface,

said contact surface and said liner operable, when assembled, to prevent dislocation.

2. An acetabular cup according to claim 1 wherein said liner is generally hemispherical and formed with an inwardly angled convex surface of a predetermined curvature.

3. A hip replacement system including:

a femoral component comprising a ball-shaped head with a neck extending axially therefrom and having a contact surface; and

an acetabular cup formed with a hemispherically formed socket adapted to pivotally capture and secure said femoral component head, said socket bounded peripherally by a liner to define a stop for engaging said contact surface,

said contact surface and said liner operable, when assembled, to prevent dislocation.

4. A hip replacement system according to claim 3 wherein:

the neck is a reduced-in-diameter neck.

5. A hip replacement system according to claim 3 or claim 4 wherein:

said contact surface is formed with a predetermined concave curvature; and

said liner is formed with a predetermined convex curvature.

6. A hip replacement system according to claim 3 or claim 4 wherein:

said contact surface is formed with a predetermined convex curvature; and

said liner is formed with a predetermined concave curvature.

7. A hip replacement system according to claim 3 wherein:

said femoral component is formed substantially symmetrically about a central longitudinal axis.

8 A hip replacement kit including:

a femoral component comprising a ball-shaped head with a neck extending axially therefrom and having a contact surface; and

an acetabular cup adapted for assembly to said femoral component, said cup formed with a hemispherically formed socket adapted to pivotally capture and secure said femoral component head, said socket bounded peripherally by a liner to define a stop for engaging said contact surface,

said contact surface and said liner operable, when assembled, to prevent dislocation.

9. A method of reducing the likelihood of dislocation in a hip replacement having a femoral component comprising a spherical head and an attached neck, and an acetabular cup formed with a socket for receiving the component head and bounded by an annular liner, said method including the steps of:

establishing an initial contact point between said femoral component neck and said liner corresponding to a predetermined motion limit; and

shifting said contact point radially outwardly along said liner in response to increasing movement beyond said predetermined motion limit.

10. A hip replacement system according to claim 3 substantially as described with reference to the drawings.

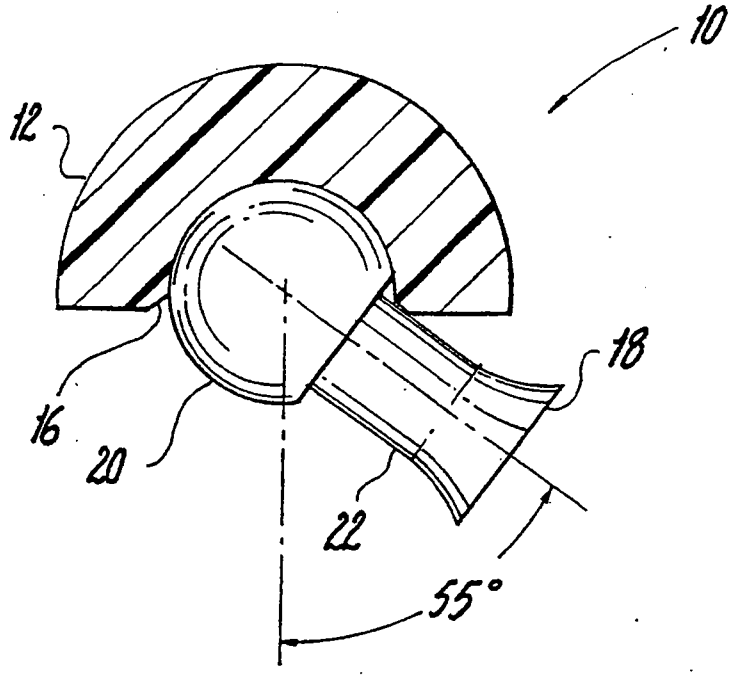

Fig. 1
(Prior Art)

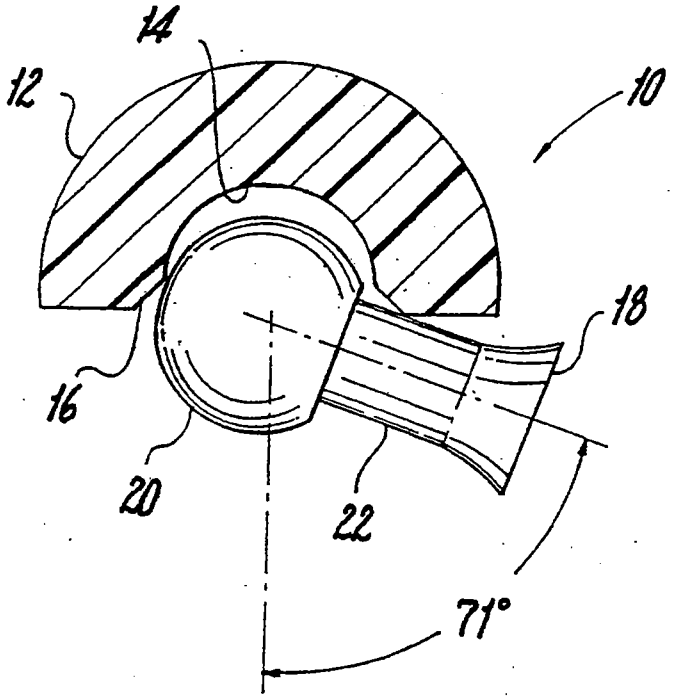

Fig. 2
(Prior Art)

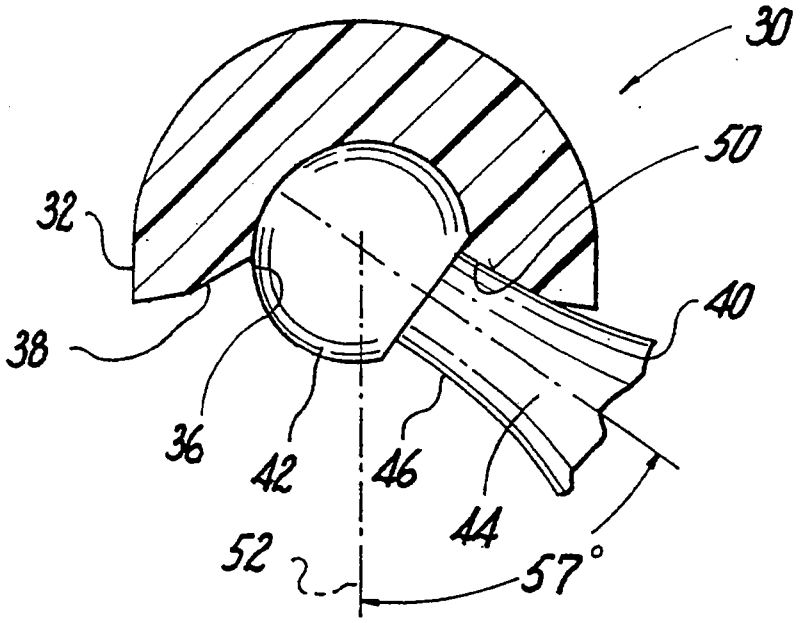

Fig. 3

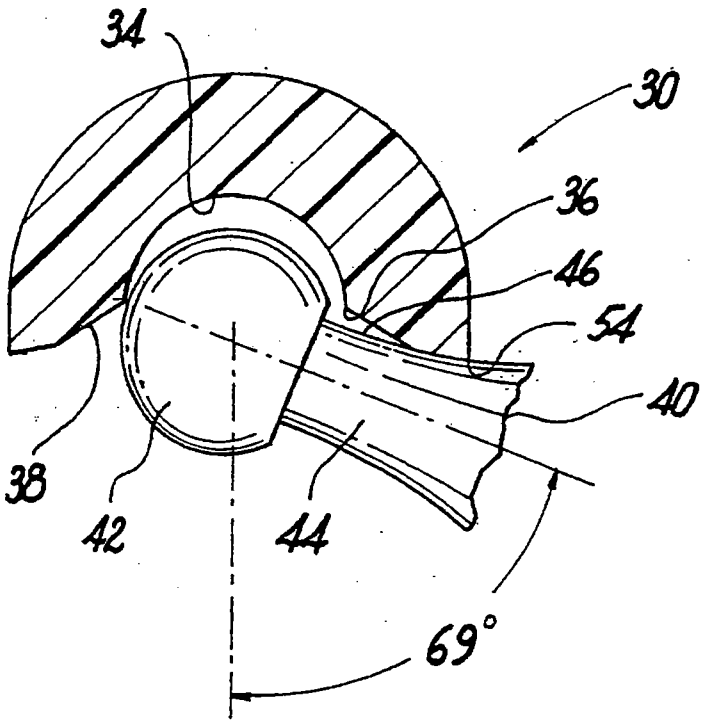

Fig. 4

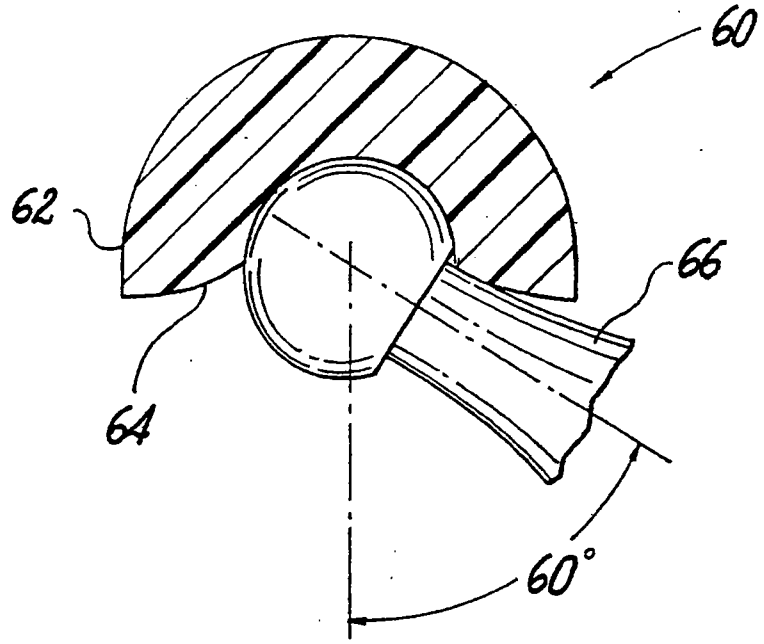

Fig. 5

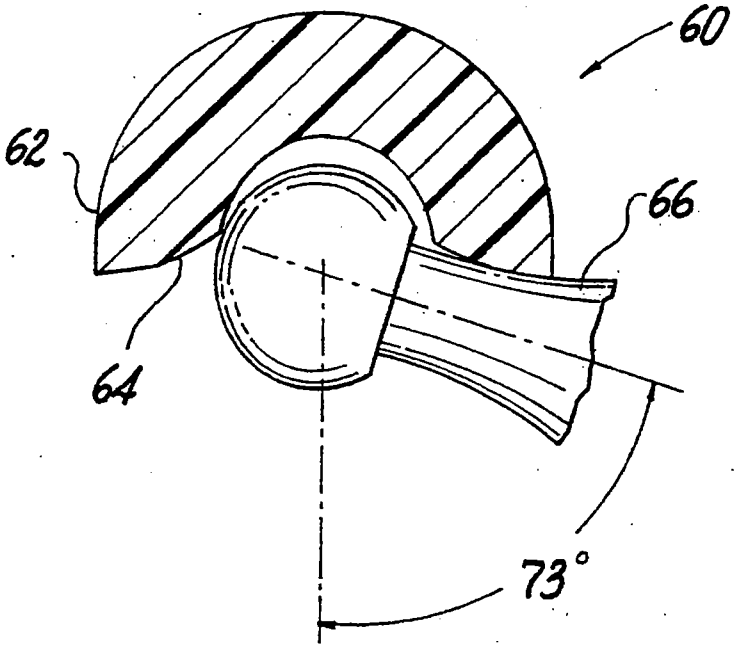

Fig. 6

PATENT SPECIFICATION

C

US005387244A

United States Patent [19]

Breard

[11] **Patent Number: 5,387,244**

[45] **Date of Patent: Feb. 7, 1995**

[54] **ARTIFICIAL HIP JOINT**

[75] Inventor: **Francis Breard**, Paris, France

[73] Assignee: **Science et Medecine (SEM)**, Montrouge, France

[21] Appl. No.: **23,205**

[22] Filed: **Feb. 25, 1993**

[51] **Int. Cl.**[6] **A61F 2/34**

[52] **U.S. Cl.** **623/23**; 623/18

[58] **Field of Search** 623/16, 18, 22, 23

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Primary Examiner—David Isabella
Attorney, Agent, or Firm—Collard & Roe

[57] **ABSTRACT**

An artificial hip joint between a femur and a pelvis having increased rotational clearance on an internal side of the joint, including an acetabular cup for anchoring to the pelvis. The hip joint includes a femoral prosthesis having an elongated stem for anchoring to the femur with an upper end. A collar extends outwardly from the upper end and terminates in an end part opposite the upper end of the stem. A head portion is supported on the end part and pivotally mounted within the acetabular cup. The head and the end part have a common central axis. The collar includes a surface on the internal side that contacts the acetabular cup. The surface is offset from the common central axis in a direction away from the internal side so that the acetabular cup has increased rotational clearance on the interior side.

18 Claims, 1 Drawing Sheet

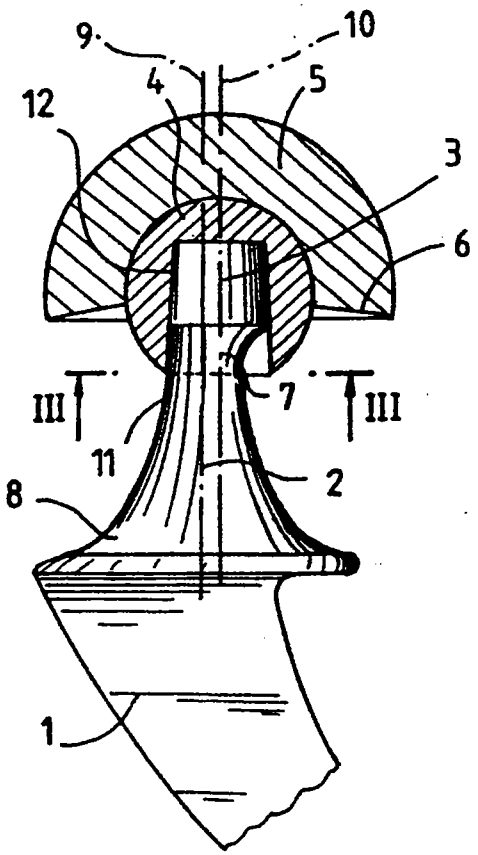


FIG.1

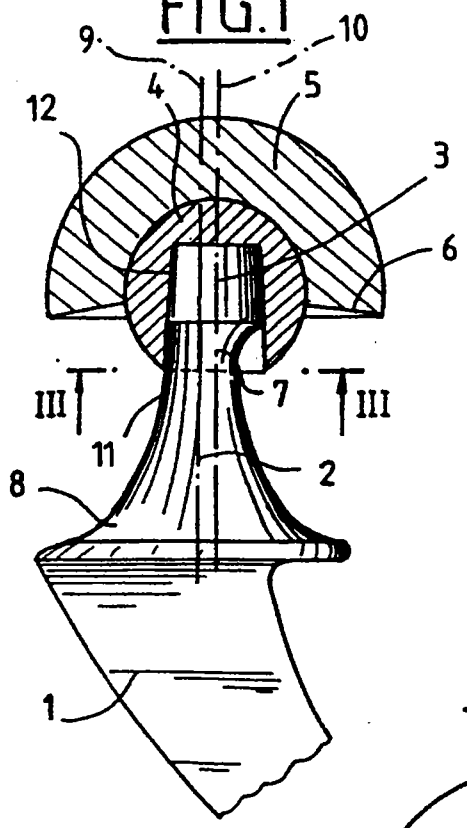


FIG.2

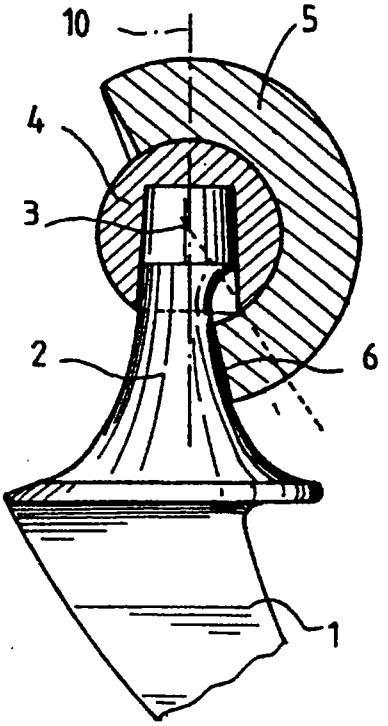


FIG.3

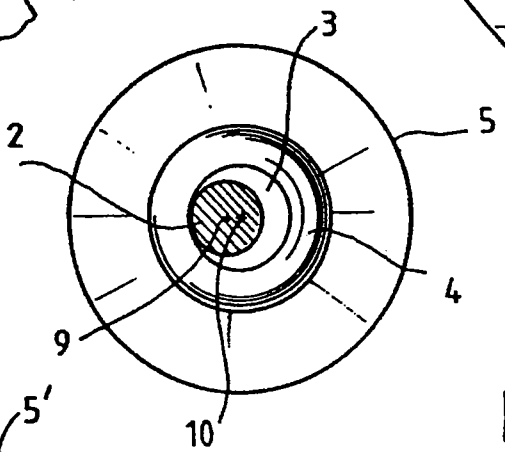


FIG.4

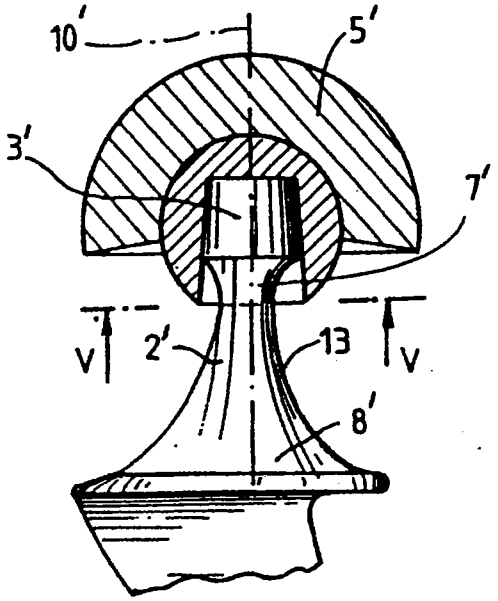
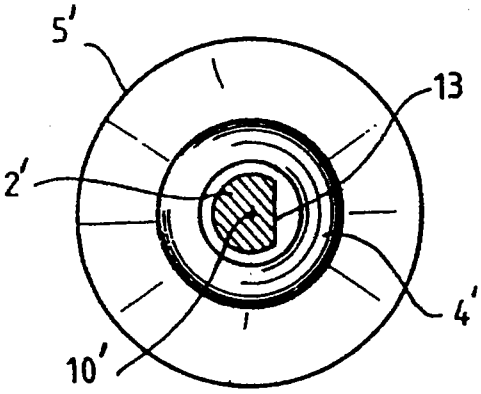


FIG.5



ARTIFICIAL HOP JOINT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an artificial hip joint having increased rotational clearance on the internal side of the joint. More specifically, it relates to a femoral prosthesis in which the collar is offset from the head portion.

2. The Prior Art

Artificial hip joints or prosthesis are known for replacing defective hip joints. The known hip prosthesis have a limitation in that the acetabular cup has limited clearance with respect to the collar of the femoral prosthesis. This can highly restrict the patient's movement if, for example, the patient were to assume a sitting position with one leg crossed over the other.

One attempt at solving the aforementioned drawback involved using rare metals, such as titanium, which has a sufficient strength to provide a collar with a reduced diameter. However, collars with reduced diameters less than 10 mm restrict the patient from walking which may cause the joint to luxate, i.e., dislocate.

SUMMARY OF THE INVENTION

It is an object of the present invention to overcome the drawbacks of the prior art and to provide an artificial hip joint which provides the patient with a greater range of motion.

It is yet another object of the present invention to provide an artificial hip joint which would allow the patient to walk without luxating.

These and other related objects are achieved according to the invention by an artificial hip joint between a femur and a pelvis having increased rotational clearance on an internal side of the joint and including an acetabular cup for anchoring to the pelvis. The hip joint includes a femoral prosthesis having an elongated stem for anchoring to the femur with an upper end, a collar extending outwardly from the upper end and terminates in an end part opposite the upper end of the stem. A head portion is supported on the end part and pivotally mounted within the acetabular cup. The head and the end part have a common central axis. The collar includes a surface on the internal side that contacts the acetabular cup. The surface is offset toward from the common central axis in a direction away from the internal side, so that the acetabular cup has increased rotational clearance on the internal side.

Although the offset of the collar limits rotational clearance in other planes, particularly the external side, the human anatomy only permits limited movement to the external side.

According to a preferred embodiment of the invention, the section of the collar between where it is connected to the upper end and the head portion, has rotational symmetry about its longitudinal, central axis. The central axis of the collar is offset from the common central axis of the head and end part in a direction away from the internal side. Since the collar has rotational symmetry across the majority of its length, it can be simply manufactured.

According to a further embodiment of the invention, the collar has rotational symmetry about its central axis and includes a plane surface on the internal side. The head, the end part and the collar have a common central axis. This embodiment may also be simply manufactured or may be utilized to redesign existing prosthesis. The end part of the collar is shaped as a truncated cone, and is contiguous with an exterior surface of the collar on the external side.

The acetabular cup includes a bevelled edge which contacts the plane surface of the collar in the maximum rotated position. In this manner, the contact surface between the acetabular cup and the collar is no longer a point but rather a line. This prevents wear and tear on the acetabular cup.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and features of the present invention will become apparent from the following detailed description considered in connection with the accompanying drawings, which disclose two embodiments of the present invention. It should be understood, however, that the drawings are designed for the purpose of illustration only and not as a definition of the limits of the invention.

In the drawings, wherein similar reference characters denote similar elements throughout the several views:

FIG. 1 is a side elevational view, in part cross section, of the artificial hip joint according to the invention;

FIG. 2 is a side elevational view, in part cross section, with the acetabular cup in its maximum rotated position;

FIG. 3 is a cross-sectional view taken along the line III—III from FIG. 1;

FIG. 4 is a side-elevational view, in part cross section, of another embodiment of the artificial hip joint; and

FIG. 5 is a cross-sectional view taken along the line V—V from FIG. 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and, in particular, FIGS. 1, 2 and 3, there is shown an artificial hip joint according to the invention made from metal, for example, titanium. The hip joint includes an elongated stem 1 for anchoring to the femur and having an upper end attached to a collar 2 which terminates in an end part 3 formed as a truncated cone. The larger end of the truncated cone faces stem 1. End part 3 is covered by a metallic head 4. An acetabular cup 5 is located in the pelvis and is configured and dimensioned to receive metallic head 4 and is generally made of plastic material. Acetabular cup 5 is hemispherically-shaped and limited on its lower end by a bevelled edge 6.

Collar 2 includes an upper connecting zone 7 connected to end part 3 and a lower connecting zone 8 connected to stem 1. The area between upper connecting zone 7 and lower connecting zone 8 has rotational symmetry about a central axis 9 of collar 2. End part 3 and head 4 have a common central axis 10. As can be seen in FIG. 3, axis 9 of collar 2 is displaced to the left or to the external side of axis 10.

As can be seen in FIG. 2, acetabular cup 5 is rotated to the internal side to the maximum rotated position. Bevelled edge 6 of acetabular cup 5 contacts collar 2 along a line rather than at a point. The leading bevelled edge 6 of the acetabular cup 5 was previously limited to the dotted line position. This dotted line represents the maximum rotational position of acetabular cup 5 intersecting with axis 10. Surprisingly, it was found that acetabular cup 5 can rotate up to an additional 10° beyond the dotted line, until it contacts collar 2. This additional 10° of rotation, affords the patient comfort

and considerable safety while preventing any risk of the joint luxating.

An external surface **12** of end part **3** and an external surface **11** of collar **2** are aligned or contiguous with each other on the external side of the joint.

FIGS. **4** and **5** show an another embodiment of the hip joint in which end part **3'** and collar **2'** have a common central axis **10**, as is typical with conventional prostheses. The middle region between upper connecting zone **7'** and lower connecting zone **8'** is formed as a plane surface **13** on the internal side of the collar. Existing prostheses can be provided with a plane surface **13** so as to provide an increased rotational clearance on the internal side of the joint. In the maximum rotated position, acetabular cup **5'** contacts collar **2'** along a surface not at a single point. Collar **2'** can be simply manufactured since it has rotational symmetry along its length, with plane surface **13** being cut into the cylindrical collar **2'**.

While only two embodiments of the present invention has been shown and described, it is to be understood that many changes and modifications may be made thereunto without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An artificial hip joint adapted for placement between a femur and a pelvis having a large rotational clearance on a medial side of the joint, comprising:

an acetabular cup for anchoring to the pelvis;

a femoral prosthesis having a proximal end and an elongated stem for anchoring to the femur; a neck extending outwardly from said proximal end and terminating in an end part opposite said proximal end of said stem; and a head portion configured to be supported on said end part and shaped to be pivotally mounted within said acetabular cup, said head and said end part having a common central axis, said neck including a surface on the medial side that is laterally offset toward said common central axis in a direction away from the medial side; and

wherein said acetabular cup is rotatable in the medial direction to a maximum rotated position in which it contacts said laterally offset surface with said stem fully anchored in the femur.

2. An artificial hip joint adapted for placement between a femur and a pelvis with a large rotational clearance on a medial side of the joint, including an acetabular cup adapted for anchoring to the pelvis, comprising:

(a) a femoral prosthesis having a proximal end and an elongated stem for anchoring to the femur;

(b) a neck extending outwardly from said proximal end and terminating in an end part opposite said proximal end of said stem, wherein said neck includes;

(i) an upper section adjacent to said end part;

(ii) a lower section adjacent to said elongated stem and;

(iii) a central region between said upper section and said lower section having a longitudinal axis, said central region having rotational symmetry about said longitudinal axis and including a planar surface formed on the medial side of the joint; and

(c) a head portion configured to be supported on said end part and shaped to be pivotally mounted within the acetabular cup, said head and said end part having a common central axis; and

(d) said planar surface being laterally offset toward said common central axis in a direction away from the medial side, so that the acetabular cup has a large rotational clearance on the medial side.

3. An artificial hip joint adapted for placement between a femur and a pelvis with a large rotational clearance on a medial side of the joint, including an acetabular cup adapted for anchoring to the pelvis, comprising:

(a) a femoral prosthesis having a proximal end and an elongated stem for anchoring to the femur;

(b) a neck extending outwardly from said proximal end and terminating in an end part opposite said proximal end of said stem;

(c) a head portion configured to be supported on said end part and shaped to be pivotally mounted within the acetabular cup, said head and said end part having a common central axis;

(d) said end part being disposed completely within said head; and

(e) a contact surface on said neck, located at the periphery of said head on the medial side facing said head, and adapted for contacting the acetabular cup with said stem fully anchored in the femur, said contact surface is laterally offset toward said common central axis in a direction away from the medial side, so that the acetabular cup has a large rotational clearance on the medial side.

4. An artificial hip joint adapted for placement between a femur and a pelvis having a large rotational clearance on a medial side of the joint, comprising:

(a) an acetabular cup for anchoring to the pelvis, said acetabular cup having an outer rim periphery with a bevelled edge;

(b) a femoral prosthesis having an elongated stem for anchoring to the femur and including;

(i) a proximal end;

(ii) a neck extending outwardly from said proximal end and terminating in an end part opposite said proximal end, said end part being formed as a truncated cone having a first exterior surface, said neck having a second exterior surface contiguous to said first exterior surface, said cone having a first side with a diameter and a second spaced opposite side with a diameter smaller than said first side diameter, said first side facing said stem, said neck further including a contact surface located on a medial side of said neck adapted for contacting said acetabular cup, an upper section adjacent to said end part, a lower section adjacent to said elongated stem, and a central region between said upper section and said lower section having a longitudinal axis, said central region having rotational symmetry about said longitudinal axis;

(c) a head portion configured to be supported on said end part and shaped to be pivotally mounted within said acetabular cup, said head and said end part having a common central axis;

(d) said end part being disposed completely within said head; and

(e) said longitudinal axis being offset from said common central axis in a direction away from said medial side;

(f) wherein said contact surface is laterally offset toward said common central axis in a direction away from the medial side so that said acetabular cup is rotatable in the medial direction to a maximum rotated position wherein said bevelled edge

contacts said contact surface with said stem fully anchored in the femur.

5. The device according to claim 3, wherein said neck includes an upper section adjacent to said end part and a lower section adjacent to said elongated stem and a central region between said upper section and said lower section having a longitudinal axis, said central region having rotational symmetry about said longitudinal axis, said longitudinal axis being offset from said common central axis in a direction away from said medial side.

6. The device according to claim 5, wherein said end part of said neck is formed as a truncated cone.

7. The device according to claim 6, wherein said truncated cone upper end includes a first side with a diameter and a second spaced opposite side with a diameter smaller than said first side diameter, said first side facing said stem.

8. The device according to claim 7, wherein said truncated cone end part has a first exterior surface and said neck has a second exterior surface contiguous to said first exterior surface.

9. The device according to claim 2, wherein said end part of said neck is formed as a truncated cone and is covered by said head portion.

10. The device according to claim 9, wherein said truncated cone upper end includes a first side with a first diameter and a second spaced opposite side with a second diameter smaller than said first diameter, said first side facing said stem.

11. The device according to claim 10, wherein said truncated cone end part has a first exterior surface and said neck has a second exterior surface contiguous to said first exterior surface.

12. The device according to claim 11 further comprising an acetabular cup rotatable in the medial direction to a maximum rotated position and having a bevelled edge which contacts said neck surface on said medial side of said neck in the maximum rotated position.

13. The device according to claim 12, wherein said femoral prosthesis is made from titanium.

14. The device according to claim 3, wherein said end part of said neck is formed as a truncated cone.

15. The device according to claim 6, wherein said truncated cone end part has a first exterior surface and said neck has a second exterior surface contiguous to said first exterior surface.

16. The device according to claim 1, wherein said end part of said neck is formed as a truncated cone;

said truncated cone end part has a first exterior surface and said neck has a second exterior surface contiguous to said first exterior surface.

17. The device according to claim 2, further comprising an acetabular cup rotatable in the medial direction to a maximum rotated position and having an outer rim periphery With a bevelled edge which contacts said neck surface on said medial side of said neck in the maximum rotated position.

18. The device according to claim 3, further comprising an acetabular cup rotatable in the medial direction to a maximum rotated position and having an outer rim periphery with a bevelled edge which contacts said neck surface on said medial side of said neck in the maximum rotated position.

* * * * *

PATENT SPECIFICATION

D

United States Patent [19]

Frey et al.

[11] **Patent Number: 4,969,910**

[45] **Date of Patent: Nov. 13, 1990**

[54] **ACETABULAR CUP PROSTHESIS**

[75] Inventors: **Otto Frey**, Winterthur; **Roland Willi**, Stadel, both of Switzerland

[73] Assignee: **Sulzer Berothers Limited**, Winterthur, Switzerland

[21] Appl. No.: **257,285**

[22] Filed: **Oct. 13, 1988**

[30] **Foreign Application Priority Data**

Nov. 11, 1987 [CH] Switzerland 04398/87

[51] **Int. Cl.**[5] **A61F 2/34**

[52] **U.S. Cl.** **623/22**

[58] **Field of Search** 623/16, 18, 20, 22, 623/23

[56] **References Cited**

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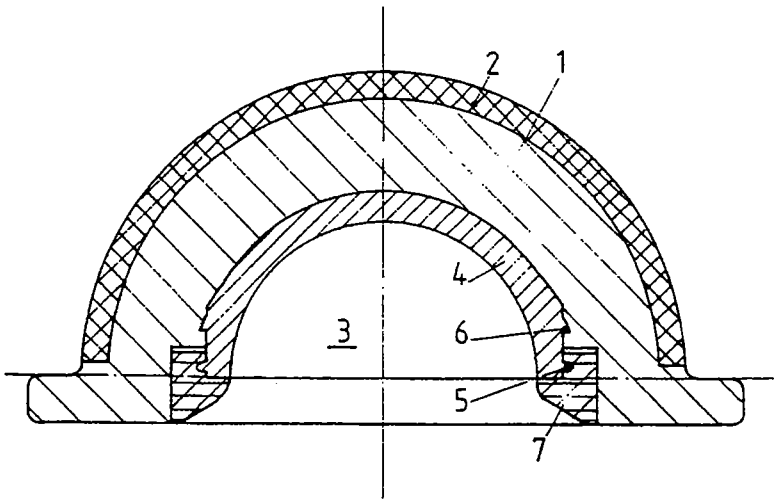
Primary Examiner—David J. Isabella
Attorney, Agent, or Firm—Kenyon & Kenyon

[57] **ABSTRACT**

The acetabular cup prosthesis has a metal socket having a socket shell for receiving a spherical joint head as well as a plastic ring which covers the equatorial edge surface of the metal socket and which has an inner diameter corresponding to the inner diameter of the shell. In the event of a dislocation of the joint head, the polished surface of the joint head contacts the plastic ring to deform the ring without imposing a point load on the metal joint head.

11 Claims, 1 Drawing Sheet



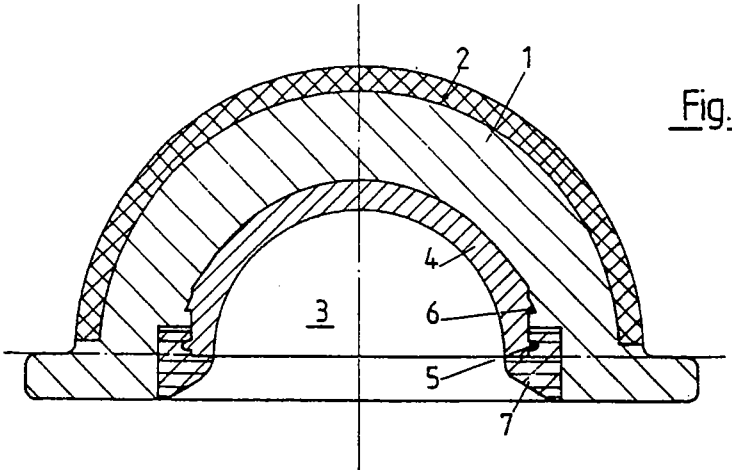


Fig.1

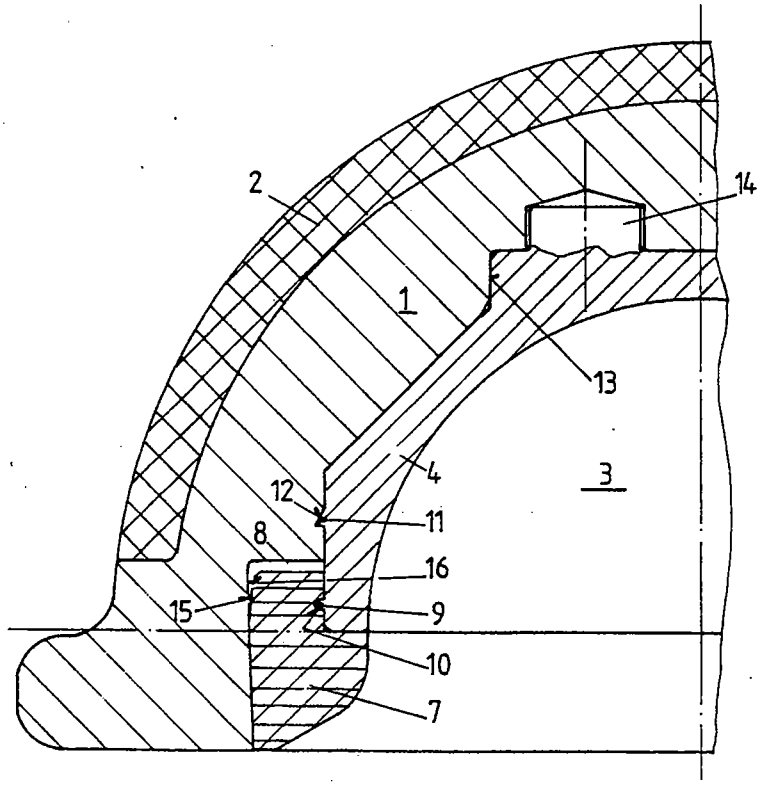


Fig.2

ACETABULAR CUP PROSTHESIS

This invention relates to an acetabular cup prosthesis.

Heretofore, various types of acetabular cup prostheses have been known for implantation in a pelvic bone. At the present time, total prostheses have been constructed with pairs of rubbing surfaces in which a metal joint head is mounted in a socket shell which is also in the form of a polished metal surface because of the good sliding properties provided by such surfaces. Examples of acetabular cup prostheses having metal cups or sockets in which a shell is fashioned are described in German Patent No. 3446048 and U.S. patent application Ser. No. 07/204,108.

In the "normal operation" of such a total prosthesis, the pressures which exist between the joint head and the socket shell are distributed over relatively large zones of the surfaces of the two elements. However, in the event of dislocations in which the joint head is "dislocated" from the socket shell, the spherical surface experiences very limited linear or point loads locally which may easily damage the polished spherical surface.

Accordingly, it is an object of the invention to reduce the risk of damage to a metal joint head surface in the event of a dislocation in a polished metal socket shell.

It is another object of the invention to dissipate a local load peak in an acetabular cup prosthesis caused by a dislocation of a joint head.

Briefly, the invention provides an acetabular cup prosthesis which is comprised of a metal socket having a socket shell for receiving a joint head and an equatorial edge surface as well as a plastic ring which is disposed over the equatorial edge surface of the socket with an inner diameter of the ring corresponding to an inner diameter of the shell.

The plastic ring which is of a material relatively softer than the metal socket ensures that the spherical surface of a joint head is not attacked and damaged by local load peaks, particularly when subjected to point loads as a result of a dislocation of the joint head.

Conveniently, in order to reduce damage of the plastic ring as far as possible and to assist automatic replacement, that is, "jumping back", of a dislocated joint head into the socket shell, the inner surface of the plastic ring widens outwardly of the shell, that is, the inner diameter of the ring widens outwardly.

Very advantageously, the metal socket can be introduced into a plastic main member having a multi-layer wire mesh in an opposite side to define a porous surface for tissue ingrowth or embedment in bone cement. However, the plastic main member can also be introduced into a metal shell which is operative as an impact damping element.

In order to simplify the construction of the connection between the plastic ring and the metal socket, the plastic main member has a circumferential recess receiving the plastic ring while the plastic ring is snap-fitted externally onto the metal socket. The socket may also be snap-fitted into the plastic main member.

In order to prevent body fluid from penetrating into gaps between the plastic ring and the metal socket or the main member respectively, the outer envelope of the plastic ring and/or the mating surface of the main member is made conical. That is, at least one of the plastic ring and the main member has a conically shaped annular surface foor deformable mounting of the plastic ring in the member.

These and other objects and advantages of the invention will become more apparent from the following detailed description taken in conjunction with the accompanying drawings wherein:

FIG. 1 illustrates a cross sectional view of an acetabular cup prosthesis constructed in accordance with the invention; and

FIG. 2 illustrates an enlarged view of a part of the cross section of the prosthesis of FIG. 1.

Referring to FIG. 1, the acetabular cup prosthesis has a plastic main member 1 formed with a hemispherical outside surface which is covered by a multi-layer porous wire mesh 2. The wire mesh 2 serves to define a porous surface for anchorage, for example either for the invasion of bone tissue from a pelvic bone or for a mechanical joining to a joint cement bed within a surgically prepared pelvic bone.

The prosthesis also has a metal socket 4 which is received within the plastic main member, for example by means of a snap-fastening 6 and which has a socket shell 3 for receiving a metal joint head (not shown) of a femur head prosthesis. In addition, a plastic ring 7 is disposed over the metal socket 4 and is snap-fitted externally onto the metal socket 4 by a snap fastening 5.

Referring to FIG. 2, the shell 3 is of hemispherical shape while the metal socket 4 has an equatorial edge surface over which the plastic ring 7 is disposed. In addition, the plastic ring 7 has an inner diameter corresponding to the inner diameter of the shell 3 thereby providing a smooth continuity between the inside surfaces of the shell 3 and ring 7. As indicated, the inner surface of the ring 7 widens outwardly of the shell 3. To this end, the inner surface of the ring 7 first widens on a convex curve, than rectilinearly during advancement outwards from the shell 3 until forming the outer closure of the shell 3 in which the joint head bears in the event of a dislocation.

The plastic main member 1 has a circumferential recess 8 receiving the plastic ring 7 such that a portion of the ring 7 lies within the recess 8 between the metal socket 4 and the plastic member 1. In addition, the snap-fastening 5 which is defined by an annular projection 9 on the outside of the metal socket 4 and a corresponding groove 10 in the ring 7 is disposed within the confines of the recess 8.

As also indicated in FIG. 2, the snap-fastening 6 for the metal socket 4 within the main member 1 includes an annular projection 11 on the metal socket 4 and a corresponding annular recess 12 within the main member 1.

The metal socket 4 is also provided with a cylindrical guide 13 in an apex zone of the socket 4 or main member 1 in order to prevent the socket 4 from tilting relative to the main member 1 when being pressed in to the main member 1. In order to secure the socket 4 and member 1 against rotation, the apex zone is also provided with a pin or the like 14 which projects from the socket 4 into a matching bore in the main member 1.

In order to prevent any penetration of body fluid into the recess 8 of the main member 7, the plastic ring 7 and/or the recess 8 is provided with a conically shaped annular surface 15, 16, respectively, for deformable mounting of the plastic ring 7 in the main member 7. That is, the conicity of the annular surface is such that the plastic ring 7 deforms inwardly upon being inserted into the main member 7 so as to produce a press fit relationship over some height of the ring 7.

During the assembly of the prosthesis, the plastic ring 7 is first snap-fitted over the metal socket 4. Thereafter, both are pressed together into the plastic main member 1 until the snap fastening 6 catches.

Instead of constructing the prosthesis with a separate main member 1 and a separate socket 4, the prosthesis may also have a shell 3 disposed directly in a socket which can, if required, have an anchorage ring or an outer shell extending around the exterior.

When in use, should a dislocation of a joint head take place, the joint head may bear on the plastic ring 7 which, being relatively soft, deforms under any localized point load so that the spherical surface of the joint head is not subjected to a local load peak.

The invention thus provides an acetabular cup prosthesis which reduces the risk of damage to a joint head surface in the event of a dislocation of the joint head within the prosthesis.

What is claimed is:

1. An acetabular cup prosthesis comprising

a plastic main member having a hemispherical outside surface;

a metal socket received within said plastic main member and having a socket shell for receiving a metal joint head and an equatorial edge surface recessed within said main member; and

a plastic ring disposed over said equatorial edge surface on said socket with an inner diameter corresponding to an inner diameter of said shell, said ring being received within said member in recessed relation.

2. A prosthesis as set forth in claim 1 wherein said ring has an inner surface which widens outwardly of said shell.

3. A prosthesis as set forth in claim 1 which further comprises a plastic main member receiving said metal socket on one side and a multi-layer wire mesh in an opposite side of said main member to define a porous surface for anchorage.

4. A prosthesis as set forth in claim 3 wherein said plastic main member has a circumferential recess receiving said plastic ring and said plastic ring is snap-fitted onto said metal socket.

5. A prosthesis as set forth in claim 4 wherein said socket is snap-fitted into said plastic main member.

6. A prosthesis as set forth in claim 3 wherein at least one of said plastic ring and said main member has a conically shaped annular surface and said plastic ring is deformally mounted in said member.

7. In an acetabular cup prosthesis the combination comprising

a plastic main member;

a metal socket received within said main member and having a socket shell defining a hemispherical surface for receiving a spherical joint head and an equatorial edge surface recessed within said main member; and

a plastic ring disposed over said equatorial edge surface of said socket and within said main member, said ring having an inner surface extending from said hemispherical surface on a diameter corresponding to an inner diameter of said shell.

8. The combination as set forth in claim 7 wherein said inner surface of said ring widens outwardly of said shell.

9. The combination as set forth in claim 7 wherein said plastic main member has a circumferential recess receiving said plastic ring and wherein said plastic ring is snap-fitted onto said metal socket.

10. The combination as set forth in claim 9 wherein said socket is snap-fitted into said plastic main member.

11. The combination as set forth in claim 9 wherein at least one of said plastic ring and said main member has a conically shaped annular surface and said plastic ring is deformably mounted in said member.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,969,910

DATED : November 13, 1990

INVENTOR(S) : OTTO FREY, et al

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 1, line 67 change "foor" to -for
Column 2, line 61 change "main member 7" to -main member 1-
Column 2, line 64 change "main member 7" to -main member 1-
Column 2, line 67 change "main member 7" to -main member 1-
Column 4, line 12 change "deformally" to -deformably-

Signed and Sealed this

Seventh Day of July, 1992

Attest:

DOUGLAS B. COMER

Attesting Officer

Acting Commissioner of Patents and Trademarks

PATENT SPECIFICATION

E

United States Patent [19]

Heimke et al.

[11] **3,924,275**

[45] **Dec. 9, 1975**

[54] **ARTIFICAL JOINT PROSTHESIS USING Al_2O_3 MATERIAL**

[75] Inventors: **Gunther Heimke**, Mannheim; **Peter Griss**, Plankstadt; **Hanns Frhr. von Andrian-Werburg**, Ilvesheim, all of Germany

[73] Assignee: **Friedrichsfeld GmbH Steinzeug-und Kunststoffwerke**, Mannheim, Germany

[22] Filed: **May 3, 1974**

[21] Appl. No.: **466,640**

[30] **Foreign Application Priority Data**

May 17, 1973 Germany 2324865
May 19, 1973 Germany 2325585

[52] **U.S. Cl.** ..... **3/1.912**; 3/1.913; 128/92 C; 128/92 CA

[51] **Int. Cl.²** **A61F 1/24**

[58] **Field of Search** ..... 3/1, 1.9–1.913; 128/92 C, 92 CA, 92 R, 92 BC

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Primary Examiner—Ronald L. Frinks

[57] **ABSTRACT**

Prosthesis made of biologically compatible material, such as Al_2O_3, can be directly implanted in bone tissue without cement and without biologically deleterious effects. At least one surface is provided by means of which the load forces are transmitted directly between the prosthesis and the bone tissues. A socket may be polygonally shaped, or may be cylindrical with a helically exterior screw thread. Exterior grooves are provided, into which bone tissue grows to firmly bond the prosthesis in place and means is provided to prevent rotation prior to bone tissue growth.

14 Claims, 9 Drawing Figures

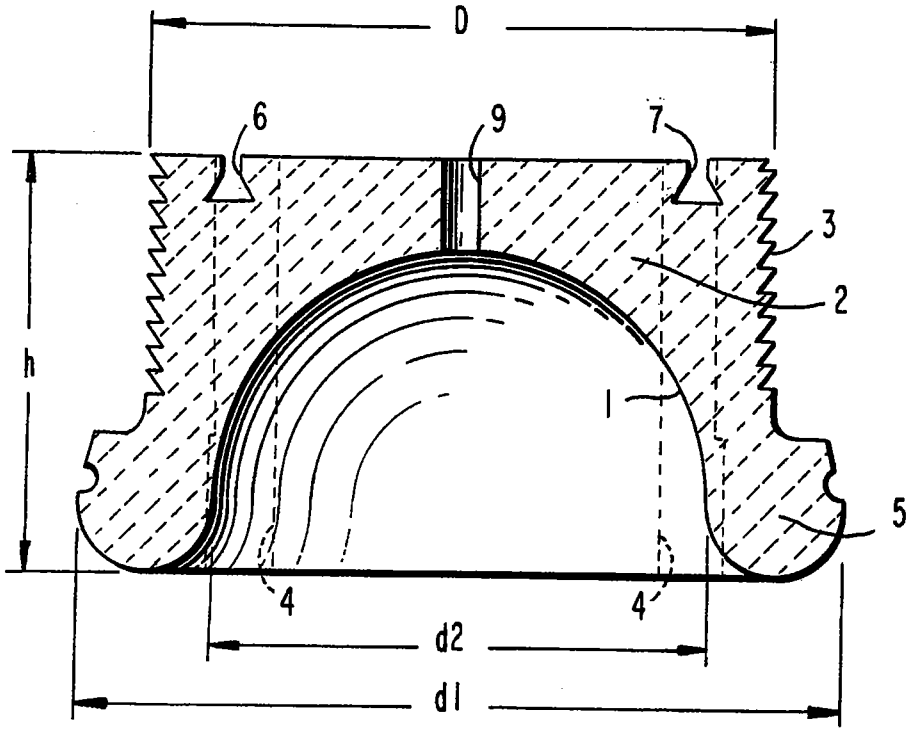
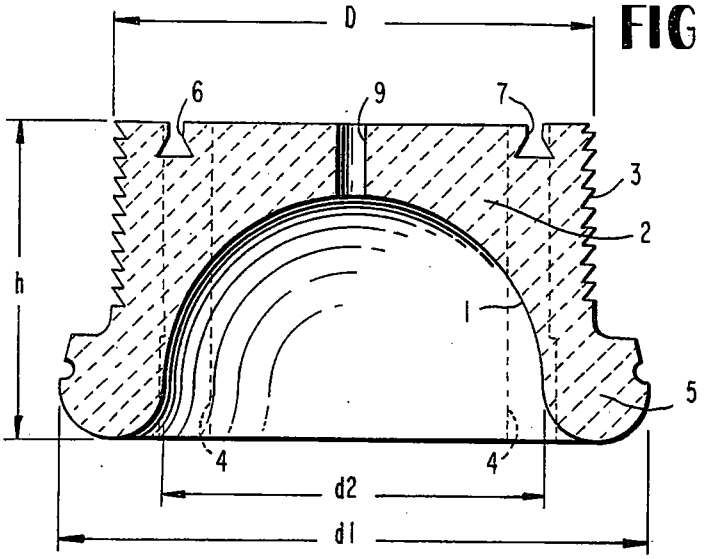


FIG. 1



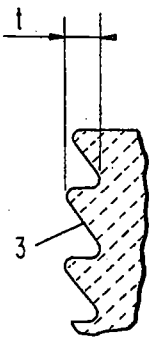


FIG. 2

FIG. 3

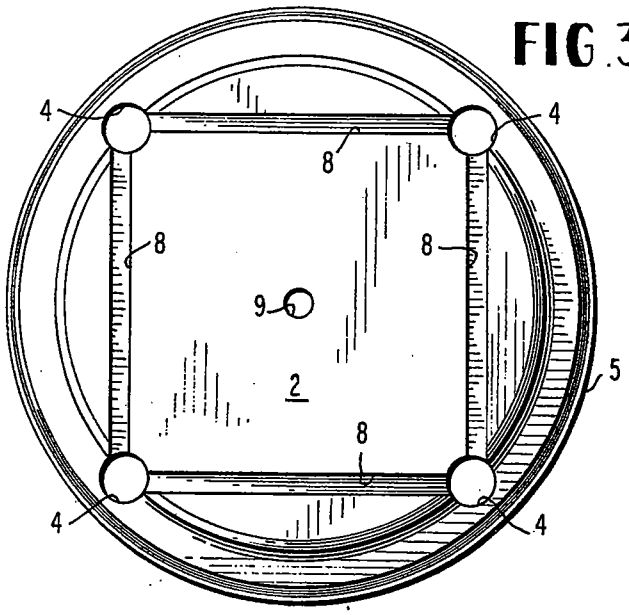


FIG. 4

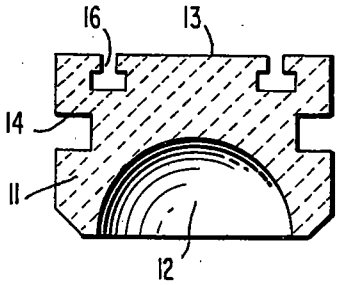


FIG. 5

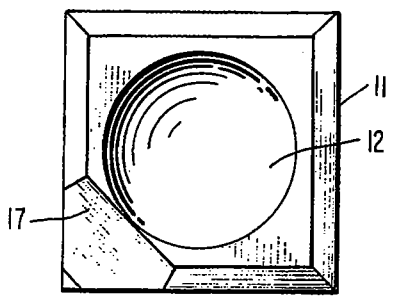
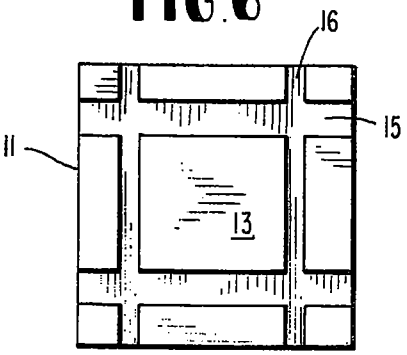


FIG. 6



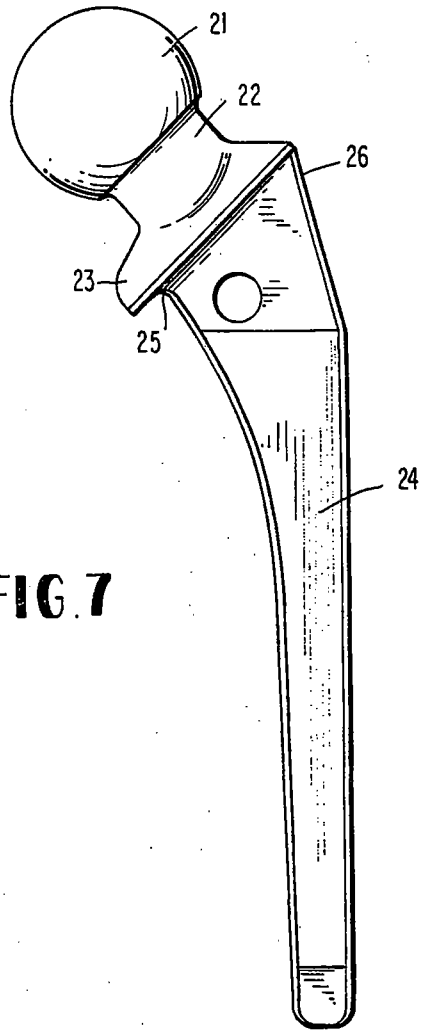


FIG. 7

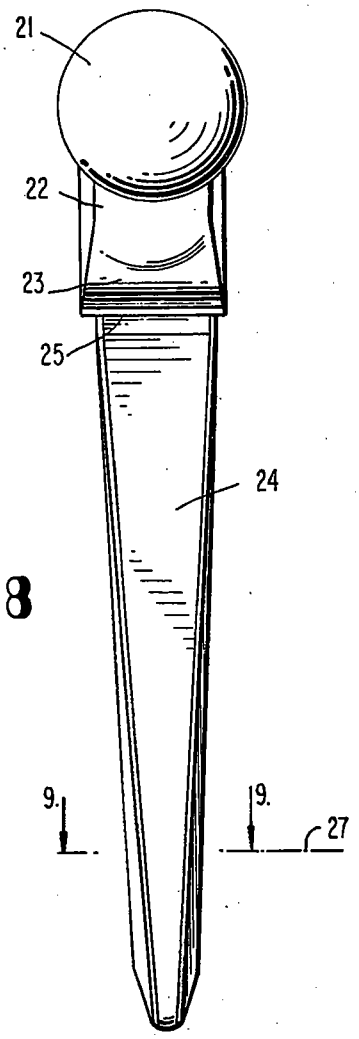


FIG. 8

FIG. 9

ARTIFICAL JOINT PROSTHESIS USING Al_2O_3 MATERIAL

The invention relates to a socket for a hip joint prosthesis of ceramic material for implantation without cement.

The hip joint prostheses used hitherto generally consist of plastic sockets and a metal part for the replacement of the head of the femur, or of metal sockets and a plastic part as a replacement of the head of the femur. These parts and especially the sockets, hitherto were mostly anchored and fixed in the hip bone with bone cement.

Hip joint prostheses made of ceramic, especially of a compact aluminum-oxide-ceramic, have also been proposed already. These ceramic prostheses have the advantage, as compared to the metal and metal-plastic combination prostheses, that the friction, gliding and wear characteristics of ceramic, especially of aluminum oxide ceramic, are much superior to those of the metals and plastics. Moreover the ceramic has a much better body compatibility than plastics and metals.

In order to be able to utilize this greater body compatibility of the ceramic implants, it is however necessary, to implant and secure them without the use of plastic cements. The sockets of hip joint prostheses used hitherto for implantation without cement, consisted essentially in imitations of the socket shapes, which had been known from plastic socket constructions. The surface facing the bone, was generally essentially hemispherical or cup shaped and had grooved patterns of various kinds. The disadvantage of this construction consisted in the fact that for a firm anchoring in the bone, either complicated puncture patterns had to be chiselled into the hip bone, or else the growing of bone into the grooved structure took some time, so that patients were exposed to a relatively long period of immobilization. This is however undersirable because of the danger of thrombosis.

In the case of the metal sockets for hip joint prostheses, a screw-type fastening is already known. (Total endoprosthesis according to Ring). In the case of this construction, however, the overall height amounts to several times the diameter of the socket, the diameter of the thread is considerably smaller than the diameter of the hemispherical cavity of the socket. This construction however, can not be used for a ceramic socket, especially one of compacted aluminum-oxide-ceramic, since it does not take into consideration the material characteristics of ceramic and since there would be the danger of breaking of the long screw during fastening.

According to the present invention, the construction described in the following pages in more detail, and which at the same time has a number of advantages, is provided for the socket of hip joint prostheses made of aluminum-oxide-ceramic. It has been discovered that the socket of the invention will permit a load to be applied, even in case of cement-free implantation, very soon after the operation and nevertheless grows very firmly into the body even in the succeeding period, while under strain, and is completely integrated into the bone connection mechanism.

Sockets made of various metal alloys for cement-free implantation have also been proposed already. Screws or else long pegs served for their attachment, which are screwed or driven into the adjacent bone space.

However it turned out that the bio tolerance of plastic cements, plastics and metals is not very favorable.

Therefore, the danger exists of a loosening of the socket after the cemented-in socket has remained in the body for some time. This danger of loosening is particularly great in case of the metallic sockets implanted without cement.

For some time it has been known, that certain types of ceramic and a few types of glass ceramic have a considerably more favorable body compatibility as compared to metals and plastics. This is particularly true for Al_2O_3 ceramic, whereby we understand by Al_2O_3 ceramic, a ceramic which contains 95% aluminum-oxide or more, especially 99% Al_2O_3. Extensive animal experiments and first results of cement-free implantations of parts of joint prostheses made of compact Al_2O_3 ceramic, show that a firm anchoring of such parts without the help of cement is possible. In case of favorable conditions, for example, after an immobilization of the respective joint for a few weeks to months, a mechanically very strong connection develops between the implant and the surrounding bone tissue.

For the cement-free implantation of hip joint sockets for total prostheses made of Al_2O_3 ceramic, sockets of various other shapes have also been proposed and used already; one socket construction of this type has at its rear an essentially hemispherical shape, into which deep grooves have been worked in. It carries a peg at its crest, which is round and which likewise has deep grooves. This socket construction is similar to known sockets made of plastic and, in case of cement-free implantation, it has the disadvantage that there is no genuine protection against twisting. Until such time that the tissue has grown firmly to the surface, or the bone tissue has grown into the grooves and channels, there exists the danger of twisting of this type of socket in case of even slight movement in the joint, as a result of which this growing-in, or -on, can be delayed or even prevented.

One form of socket for total hip joint prostheses made of Al_2O_3 ceramic, according to the invention for cement-free implantation, has an angular shaped rear portion. It can be triangular, square, pentagonal or hexagonal. This angular rear portion is provided with grooves and channels, a part of which can also have some dovetailed or similar reverse tapering, and can grow into the bone tissues for a better anchoring of the socket.

The invention also relates to the thigh part of a total hip joint prosthesis for the cement-free implantation, especially prostheses consisting of Al_2O_3 ceramic and prostheses made of a combination of a ceramic head with a metal shaft, in which case, the metal shaft is covered with a vitreous material such as a glaze, enamel or a glass ceramic, as described and claimed in the copending application of Gunther F. A. Heimke and Peter Griss, Ser. No. 440,444, filed Feb. 7, 1974, corresponding to German Application No. P 23 06 552.3.

The thigh parts of total hip joint prostheses are attached, at present, mostly by means of plastic cement in the marrow space of the femur. These prostheses consist of metal alloys, the composition of which is selected such that they will show the least possible corrosion phenomena in a biological environment. The transfer of a load from the thigh prosthesis to the femur takes place in the case of these prostheses essentially by the intermediation of the bone cement, which in its plastic state, closely follows the inside contour of the femur. During shaping the shaft of a metal thigh prosthesis for implantation with the aid of bone cement, no

special attention need be given to the load transfer from the prosthesis to the femur. Since this part of the prosthesis is surrounded entirely by bone cement, aspects of tissue tolerance and avoiding of movements between bone tissue and the implant are of no consequence during shaping of said part. Therefore, in case of the metal prostheses for implantation with plastic cements, one needs to consider only mechanical aspects for the shaping of the shaft of the prosthesis.

Prior to the general introduction of bone cements for the attachment of joint prostheses in the adjacent bone space, it was also customary to introduce or drive into the marrow space of the femur thigh parts of hip joint prostheses even without bone cement. This method of attachment however, was unsatisfactory. In many cases these parts of prostheses sunk deeper and deeper into the femur, since the bone decomposed in areas where the load was too high. In many other cases, the prosthesis became loose after a time, since a firm connection between the shaft of the prosthesis and the bone tissue did not occur because of the unfavorable biological tolerance of the metals.

Because certain types of ceramic, for example compacted Al_2O_3 ceramic with 99% Al_2O_3 content, as well as certain glass ceramics have an excellent tissue compatibility, especially in regard to bone tissue, it has been found that under certain conditions, a mechanically firm connection between the surfaces of such implants and the bone tissue develops.

This now results in the possibility of anchoring the thigh parts of total hip joint prostheses without cement and mechanically solidly in the marrow space of the femur. This cement-free implantation is very desirable, since the plastic bone cements available hitherto had many and serious drawbacks.

However, up to now there did not exist any prosthesis constructions for this cement-free implantation, in the case of which the introduction of the load from the implant into the femur is accomplished in such a way, that bending and tension strains in the adjacent surfaces between the implant and the bone are avoided as much as possible, and high pressure loads are eliminated. In the case of the use of total ceramic prostheses, one must naturally also take the characteristics of compact Al_2O_3 — ceramic into consideration.

Other objects and advantages will be apparent to those skilled in the art by reading the following specification in connection with the annexed drawings, in which;

FIG. 1 is a cross-section of a preferred form of hip joint socket made in accordance with the invention;

FIG. 2 is a fragmentary cross-section of a detail of FIG. 1;

FIG. 3 is a top view of the socket;

FIG. 4 is a cross-section of a modified form of socket;

FIG. 5 is a bottom view of the socket of FIG. 4;

FIG. 6 is a top view of the socket of FIGS. 4 and 5;

FIG. 7 is a side elevation of a preferred form of the thigh portion of the prosthesis;

FIG. 8 is a side elevation as viewed from the left of FIG. 7, and

FIG. 9 is a cross-section on the line 9—9 of FIG. 8.

A socket made in accordance with a preferred form of the invention made of aluminum-oxide-ceramic for implantation without cement will be explained in more detail on the basis of FIGS. 1–3. FIG. 1 shows a section through the socket; FIG. 2 the anchoring thread and FIG. 3, a view of the socket from above. The socket contains the approximately hemispherical cavity 1, the surface of which is polished and on which the spherical head, likewise polished on its surface and consisting of the same ceramic, of the thigh element of the hip joint prosthesis, anchored in the femur, is mounted in a swivel-type manner. The body of the socket consists of aluminum-oxide-ceramic 2. According to the invention, this socket body is cylindrically-shaped in its upper part which faces the hip bone, with a cylinder diameter D, which is smaller than the total diameter *d* 1 of the socket, but larger than the diameter of the hemispherical cavity *d* 2 in the inside of the socket. The overall height *h* of the socket according to the invention is smaller than the diameter of the hemispherical cavity *d* 2.

The cylindrical part of the socket is provided on its outside surface with a thread 3. This thread 3 is made in such a manner that it can transfer forces, which act from the thigh on the socket, particularly favorably to the hip bone. These forces are, directed from below to above in the representation shown in FIG. 1. An example for a thread made in this way is shown in FIG. 2. On the outside of the cylindrical part having the diameter D, axially parallel grooves are worked in transverse to the thread. These grooves can be of a semicircular shape for example. They are designated by 4 in FIG. 3, which shows a view of the socket from above. These grooves interrupt the thread, whereby it appears to be particularly useful, to make this break as sharp-edged as possible. In FIG. 3, four such grooves have been drawn but, their number can also be greater or smaller than four. In the extension of these grooves there are holes which extend through the bead-shaped part 5 of the socket up to the front side of the socket. On the topside of the socket, that is, of the side projecting into the hip bone, a series of grooves is provided. In FIG. 1, these grooves consist of the dove-tailed grooves 6 and 7, which, in the view of FIG. 3, are represented by the grooves 8. Naturally, other arrangements of the grooves may also be selected according to the invention, but it will be particularly useful to provide the grooves existing on the topside with reverse-tapering, as given by the dovetail of the grooves 6 and 7. In the middle of the socket cavity, a hole 9 is provided.

During implantation of the socket according to the invention, for hip joint prostheses, one proceeds as follows: first an approximately round part is chiselled out, having a diameter which is still noticeably smaller than the diameter of the cylindrical part of the socket. Its depth is chiselled out to the point which approximately corresponds to the later seat of the socket. Subsequently, the preprocessed cavity is filed out further with a rasp, the diameter of which, measured across the outside teeth of the rasp, corresponds to the diameter D less twice the depth *t* of the thread. In the wall of this cylindrical hole, a thread is cut with a suitably shaped set of threading tools into the now cylindrical wall of the bone. At the same time the threading tool is dimensioned such that, after the last cutting process, the thread is about ½ to 1mm smaller in its diameter, than would correspond to the thread on the socket.

The grooves 6 and 7 or 8 are partly filled with the bone ships produced during the chiselling out of this cavity. Then the socket is moved close to pre-cut turns of the thread and is turned into the preprocessed thread with a tool which reaches into the continuous holes 4 or their extensions. Since the pre-cut thread was a little smaller than corresponds to the thread of the socket,

the application of some force is necessary for this, as a result of which, the socket thread forces itself firmly into the bone. This "forcing into" is assisted by the four grooves **4**, which cut the thread. This assistance is the more favorable, the more sharp-edged these breaks are, as has already been explained further back.

By this screwing in of the sockets into a somewhat smaller thread, the socket will be firmly anchored in the hip bone immediately after implantation. At the same time, it has been discovered to be particularly favorable, surprisingly, that the bone particles which were still separated during this screwing in, collect and remain in the grooves **4**. It also turns out, that these bone chips collecting there considerably favor the growing-in of the live bone into the spaces **4**.

After screwing in of the socket, it will be desireable to drill a hole of about half the socket height from the outside with a drill inserted into at least one of the holes, which are located in extensions of the grooves **4**. A ceramic peg is pushed into this hole, the outside diameter of which corresponds to the inside diameter of these holes, and the length of which is similar to half the height of the socket. This peg serves as an additional protection against twisting until the socket has completely grown in.

The hole **9** serves for one thing, for letting the air, which is compressed during screwing in of the socket, escape, and for another, for the improvement of the admittance of synovia into the hemispherical cavity of the socket during subsequent use of the joint.

The construction of the socket for hip joint prostheses made of aluminum-oxide-ceramic, according to the invention, thus has the advantage that it results in a firm seat of the socket in the hip bone immediately after the implantation, so that it can withstand a strain very soon after the operation. Beyond that, it causes an acceleration of the growing-in process into the bone tissue, whereby the well known stimulation of the adhesion of bone tissue to the aluminum-oxide-ceramic will be favored additionally through the presence of bone particles belonging to its own body, precisely at those places where the growing together is particularly desirable for the attachment of the prosthesis.

Another form of socket according to the invention is shown in FIGS. **4** and **5** in the form of a square socket. This socket consists of a socket body **11**, the inside of which contains the approximately hemispherical hollow space **12**, in which the complementary shaped head of the thigh part of the total prosthesis is seated. The rear **13** of this prosthesis is made square as the top view shown in FIG. **6** shows. On the side, the socket has grooves **14**. Grooves and indentations are also worked into the rear, which are designated by **15** and **16** in FIG. **6**. Part of these grooves in FIGS. **4** and **6**, the grooves designated by **16**, have reverse tapers. Such grooves, channels or other indentations serve for the purpose of anchoring the socket firmly by means of growing-in tissue in the adjacent bone space. These grooves, channels and indentations can be filled with bone chips from the same patient during the operation and prior to the insertion of the socket in the hip bone.

Various polygonal configurations for the socket body can be used, but in case of square, pentagonal or hexagonal sockets, at least one corner on the front of the socket may be bevelled in order to avoid a chafing of the "iliopsoas." This bevelling is designated by **17** in the lower part of FIG. **5** for a square socket.

The socket according to this modification of the invention, has the advantage, as compared to hitherto known sockets made of Al_2O_3 ceramic, that it can be inserted without a special set of instruments. The space needed for the socket in the hip bone, can be worked out and prepared with the instruments customary in orthopedic surgery. Implantations of sockets of this type into large animals, such as sheep, have shown that these sockets have such a firm seat immediately after implantation, that they will not become loose even in the case of an immediate load on the joint, but that a mechanically firm connection develops with the surrounding bone tissue.

A preferred form of construction for the thigh part of a hip joint prosthesis is shown in FIGS. **7–9**, in which the prosthesis is made of compacted Al_2O_3 ceramic. It consists of the spherical head **21**, the transition part **22** with the collar **23** and the shaft **24**. FIG. **8** shows a view of the same prosthesis viewed from the side of the center of curvature *p* of the shaft **24**. The prosthesis is supported by the surface, designated by **25**, and with the fillet there on the front side of the wall of the femur. It is favorable to make this surface **25** as broad as possible, in order to avoid any increase in pressure during introduction of the load from the prosthesis to the femur. The corresponding surface on the reverse side **26**; the side facing away from the center of curvature of the shaft of the prosthesis, merely has to have the width which is required for reasons of strength. The widths of the shaft of the prosthesis at its upper end at the point where it joins surfaces **25** and **26**, should therefore either be the same on both sides, or else the width on side **25**; on the side facing the center of curvature, should be larger than on side **26**, which is the side facing away from the center of curvature. At the same time, experience shows it to be particularly advantageous to select the width on the side of the shaft of the prosthesis, facing the center of curvature, to be no smaller than 10mm. According to the invention, the downward tapering of the shaft of the prosthesis is accomplished in such a manner, that the width on the side facing the center *p* of the curvature decreases more rapidly than on the side facing away from said center of curvature. In the lower part of the shaft, about at the level **27** of the FIG. **8**, the width on the inside, that is, on the side facing the center of curvature, is smaller than on the outside of the shaft facing away from the center of curvature. Here, the width on the inside can amount to between 5 and 7mm and, on the outside, to between 8 and 9mm. The ratio between the inside and outside widths at the upper end of the shaft should be about 1.0 to 1.0. At the lower part of the shaft of the prosthesis, the ratio should however, be at the most 0.9 to 1.0.

In animal experiments and in experiments where the load transmission ratios were simulated as they exist in the human body, it turned out that prostheses according to the invention, are capable of bearing the usual overall loads without, at the same time, incurring pressures at any places which are higher than those corresponding to the pressure load in the natural bone. Thus, in the case of use of the prosthesis according to the invention, there is no danger of degeneration of the bone as a result of pressure necrosis.

As in the case of the sockets made of Al_2O_3 ceramic, the shaft of the thigh portion of the prosthesis made from this material will, over a period of time, become securely fixed within the femur due to the affinity of

this ceramic for the growing tissues, and because the ceramic is biologically compatible with these tissues.

We claim:

1. A socket for hip joint prostheses for cement-free implantation in bone tissue, comprising a biologically compatible material such as compacted Al_2O_3 ceramic, said socket being provided with an internal hemispherical cavity, an exterior upper load bearing surface portion of the socket being provided with at least one elongated groove to provide a direct physical connection with bone tissue grown after implantation and an exterior surface portion including means to prevent rotation of the socket directly after implantation, the overall height of the socket being less than the diameter of the hemispherical cavity, the transverse dimensions of the upper portions of the socket being less than the largest diameter of the socket but, larger than the diameter of the hemispherical cavity.

2. The invention defined in claim 1, wherein the upper exterior surface of said socket is provided with at least one groove having an undercut transverse profile to receive bone tissue grown after implantation.

3. The invention defined in claim 1, wherein an upper exterior surface of said socket is defined by a cylinder of revolution, and said elongated groove comprises a helical thread provided in said exterior surface.

4. The invention defined in claim 3, wherein the transverse profile of said thread includes one face disposed generally normal to the direction of the force of the load to be supported by the socket.

5. The invention defined in claim 3, wherein said means to prevent rotation comprises at least one elongated groove provided in said upper surface, and transversely intersecting at least some of the turns of said thread.

6. The invention defined in claim 3, wherein said socket is provided with a bore extending between the interior of the cavity and the upper exterior surface of the socket.

7. The invention defined in claim 3, wherein said socket includes an annular flange flaring outwardly from the hemispherical cavity.

8. The invention defined in claim 7, wherein said means to prevent rotation comprises a peg to be inserted in an axial direction through an opening provided in said annular flange and the bone tissue in alignment therewith.

9. The invention defined in claim 7, wherein the transverse profile of said elongated groove intersecting said threads is defined by a semi-cylindrical surface in axial alignment with said opening in the annular flange.

10. A socket for hip joint prostheses for cement-free implantation in bone tissue, comprising a biologically compatible material such as compacted Al_2O_3 ceramic, said socket being provided with an internal hemispherical cavity, an exterior upper load bearing surface portion of the socket being provided with at least one elongated groove to provide a direct physical connection with bone tissue grown after implantation and an exterior surface portion including means to prevent rotation of the socket directly after implantation, the overall height of the socket being less than the diameter of the hemispherical cavity, the transverse dimensions of the upper portions of the socket being at least substantially equal to the largest diameter of the socket and larger than the diameter of the hemispherical cavity, the exterior side surface of at least the upper portion of said socket being defined by a series of intersecting planes.

11. The invention defined in claim 10, wherein a lower portion of the exterior surface of the socket is defined by a plane intersecting an adjacent pair of said first mentioned planes and angularly related thereto.

12. The invention defined in claim 10, wherein said intersecting planes define a regular polygon.

13. The invention defined in claim 12, wherein said regular polygon has four sides.

14. The invention defined in claim 13, wherein a lower portion of the exterior surface is defined by a plane intersecting an adjacent pair of said first mentioned planes and angularly related thereto.

* * * * *