United States Patent

Michele

[15] **3,641,590**

[45] **Feb. 15, 1972**

[54] ACETABULAR REPLACEMENT PROSTHESIS AND METHOD OF ASSEMBLING

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[21] Appl. No.: **3,353**

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

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

[58] **Field of Search**.....3/1; 128/83, 92 R, 92 B, 92 BA, 128/92 BB, 92 C, 92 CA, 92 D, 92 E, 92 EB, 92 F, 92 G

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Primary Examiner—Richard A. Gaudet
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[57] **ABSTRACT**

A selective individualized technique for acetabulum socket replacement per se, or in conjunction with a hip replacement prosthesis (Michele U.S. Pat. No. 3,228,393) for a total hip replacement, designed for all ages including the very young. A selective anchorage for a cup prosthesis of a size selected from the limited number of differently sized cups is made available. Anchorage of the acetabular socket replacement conforms to variations in dimensions, shapes and positions of the (medullary) canals of the acetabulum pelvis of the individual patient and includes at least two elongated and convergent or divergent fasteners. The bone is preferably drilled for a main pin fastener of the appropriate length at the proper inclination and site. There is then arranged in the acetabulum socket a selected cup prosthesis having a preformed hole determined by and corresponding to the drilled hole, into which the main pin is driven after passing through the prosthesis hole. The spherical cup is quite thick and has generally keyhole or T-shaped slots penetrating its rim and its outer surface at various inclinations but avoiding penetration of its inner surface. A relatively wide fastener drift of T-shaped or other appropriate cross-sectional shape, designed to be inserted with part of its width in the slot and the remaining part projecting transversely as well as longitudinally beyond the cup and out of the slot is driven into and through a selected slot at the inclination and site most advantageous to the recipient patient.

11 Claims, 13 Drawing Figures

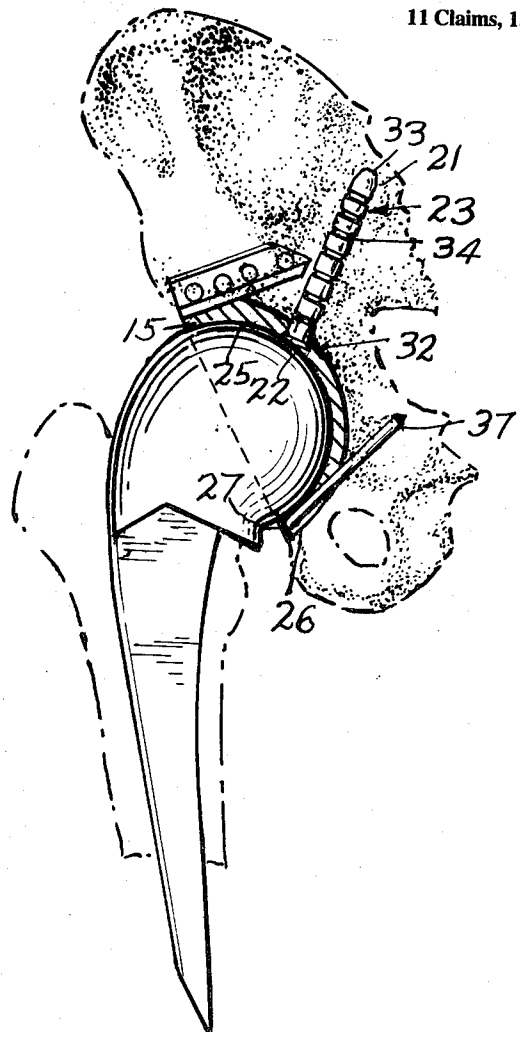


Fig. 1

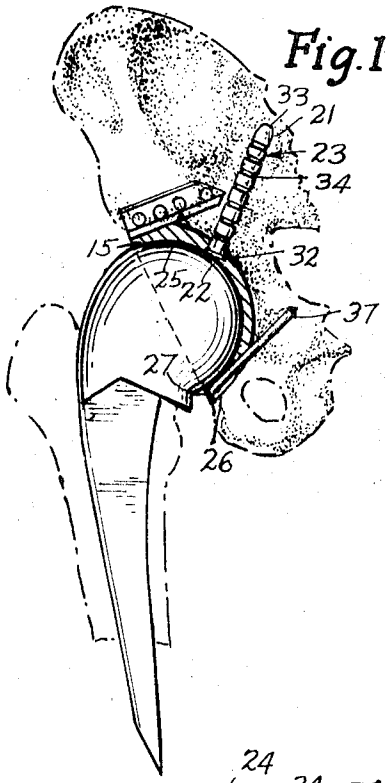


Fig. 12



Fig. 13

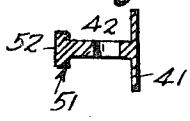


Fig. 6

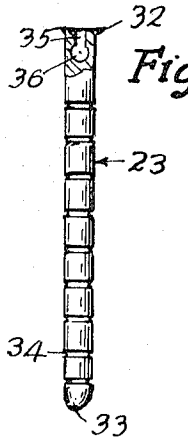


Fig. 7

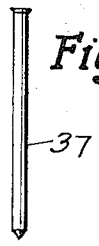


Fig. 8

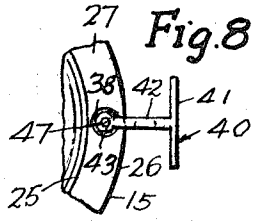


Fig. 9

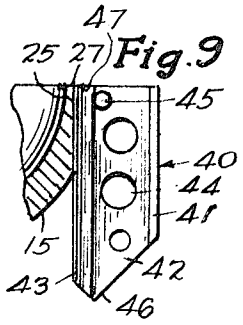


Fig. 2

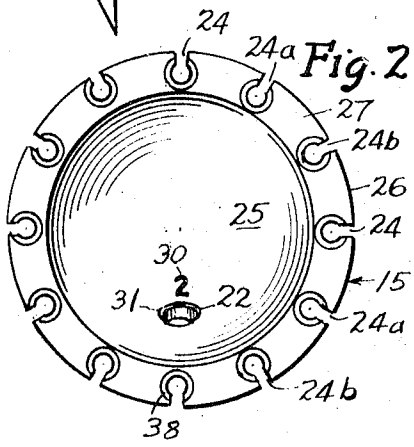


Fig. 3

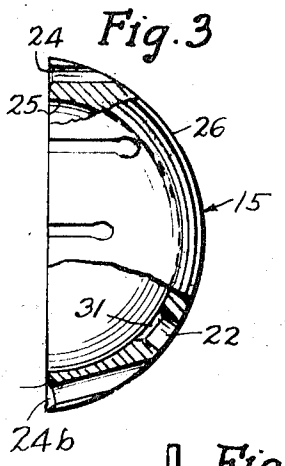


Fig. 10

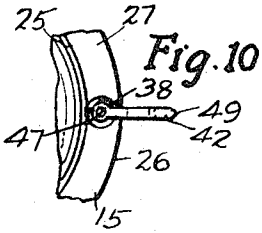


Fig. 11

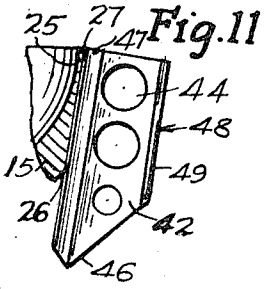


Fig. 4

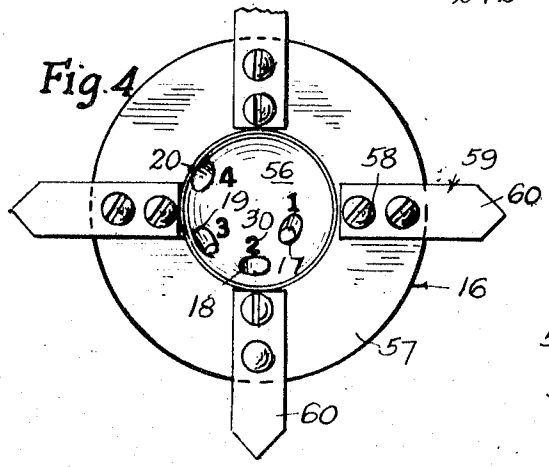
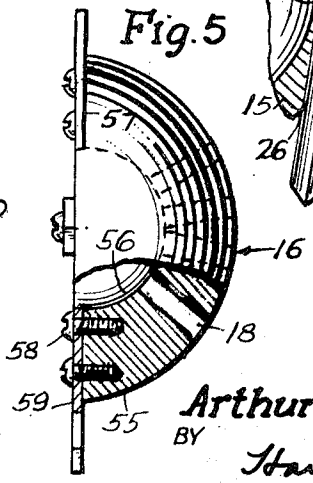


Fig. 5



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ACETABULAR REPLACEMENT PROSTHESIS AND METHOD OF ASSEMBLING

The invention relates to total hip replacement prosthesis but more so to the acetabular socket as well as to the combination of an acetabular cup prosthesis with a biomechanical femoral head replacement prosthesis (Michele U.S. Pat. No. 3,228,393) constituting a total hip replacement including the femoral head.

Prior acetabular sockets or cups have not generally been firmly and permanently anchored. The anchoring screws employed to fasten certain sockets tend ultimately to loosen under the severe forces acting on the joint. Those cups with integral and hence necessarily parallel spikes cannot be adequately anchored to suit the particular individual. For many patients the spikes may extend in the wrong direction or may be of the wrong length or shape or at the wrong location. The spikes cannot be adjusted or changed in any attempt to prevent loosening of the cup and consequent deterioration of the bony structure under the resulting excessive stresses. The spikes, instead of the convex surface of the cup, receive and transmit the pressure exerted upon the concave surface of the cup by the femoral head or the ball head of a hip prosthesis and resist the transmission of sufficient pressure upon the acetabulum socket to result in the filling of voids which might be present between the cup and said socket. Such pressure is necessary to induce or encourage the growth of filling fibros-osseous tissue which ultimately becomes hard bone in contact with a smooth outer convex surface of the cup. A maximum entry into cortical or medullary bone is needed for permanent anchorage and cannot be adequately provided by prior screws or spikes.

Prior hip joint replacement prostheses, further, do not permit the surgeon enough leeway or choice to conform the anchorage to the normal and expected natural variations in the bones of different patients, nor have such prostheses been adapted to attain the proper rotational angle to withstand effectively the eccentric weight loads to which they are subjected when in use, except for a femoral head replacement prosthesis such as is disclosed in U.S. Pat. No. 3,228,393 to which reference is hereby made and which is incorporated herein.

This invention is therefore directed to the provision of a hip joint (acetabular) cup prosthesis which when once implanted, is held securely and permanently in place, being effectively resistant to movement relative to the bone in any direction; which has a smooth convex outer surface unconstrained by fastening means from exerting pressure upon the concave surface of the socket in order to cause the formation of filling fibros-osseous tissue and thereby resulting in a firm concentric placement and secure foundation for the cup; which is adapted for standardization in few sizes without significant variation in shape but entirely capable of being fitted to individuals whose bones differ substantially in shape, dimensions, density and adaptive changes; which is anchored in two or more places by fasteners of the same or of different cross-sectional shapes, lengths, inclinations and sites and which are chosen from a variety of fasteners each designed to enter deeply into the strongest part of the pelvis whether it be cortical or medullary bone; which can be used with several types of femoral ball shaped head prostheses for total hip joint replacement; which when used with the "MICHELE" head replacement is adequate to withstand vibrational, eccentric, compressive, tensile and other otherwise destructive stresses as well as all normal stresses and to impart the proper rotational axis to the joint; which is adapted for implantation in its miniature size in the young, without the need for substitution of a larger size for relatively long periods; which is adapted for implantation in an unusually large acetabulum socket by the mere use of a standard-type cup of larger thickness than the usual cup and of standard inner diameter; which can be withdrawn in emergencies by the deliberate retraction of the fasteners; which can be readily secured in place by a simple technique and which remedies the defects of the prior orthodox prostheses above mentioned.

The above and other objects of the invention will be clear from the description which follows and from the drawings in which

FIG. 1 is a front elevational view of the implanted total hip replacement prosthesis, showing outlines of the main parts of the receiving bones in dash-dot lines and showing the cup in cross section.

FIG. 2 is a side elevational view of a typical one of the cups of a set of such cups, showing typical pin receiving holes and drift-receiving slots.

FIG. 3 is a front elevational view of FIG. 2 partly in section to expose some of the slots for the drifts.

FIG. 4 is a side elevational view of the jig or tool employed for drilling the hole in the bone at the proper angle and position for the reception of the main pin.

FIG. 5 is a front elevational view of FIG. 4 partly in section.

FIG. 6 is an elevational view, partly in section, of a typical main pin fastener.

FIG. 7 is a similar view of one of the various types of drift fasteners.

FIG. 8 is a fragmentary side elevation view of the cup and of a modified form of drift fastener inserted into one of the rim slots of the cup.

FIG. 9 is a horizontal sectional view of FIG. 8.

FIG. 10 is a view similar to FIG. 8 of a modified form of drift fastener.

FIG. 11 is a horizontal sectional view of FIG. 10.

FIGS. 12 and 13 are cross-sectional views respectively of other forms of drift fasteners.

Briefly, in practice a set of about four or more standard cups 15 (FIGS. 1–3) all of the same size, are provided. A smaller set seldom needed and a third thicker set take care respectively of youngsters and of patients having unusually large acetabulum sockets. In each cup of a set, a main pin receiving hole is positioned at an inclination and location differing from those of the holes in the other cups. Should it be found that the main pin for the cup is advisable, then after the usual surgical preparation, the jig or tool 16 of FIGS. 4 and 5 is employed to determine where and at what inclination the hole for the main pin is to be drilled in the bone to attain the maximum degree of fixation of the cup as by the greatest penetration into the pelvis. The jig is rotated in the joint socket until one of the guide holes, 17, 18, 19 or 20 is directed toward a suitable deep and strong part of the bone, whereafter the hole 21 in the bone is drilled through said guide hole. The proper cup of the set of otherwise identical cups except for the cup hole and with a corresponding hole 22 then replaces the jig and the main pin 23 is driven into the holes 21 and 22. One or more drifts or auxiliary pins (FIGS. 7–13) of the proper shape and length are driven through the proper rim slot as 24, 24*a* or 24*b* in the cup and into the bone. The natural femoral head or its equivalent prosthesis as shown in FIG. 1 is finally inserted into the cup and surgery completed. When advisable, the main pin and the drilled hole in the bone may be omitted and reliance had upon suitable drifts to secure the cup in place.

In detail and referring particularly to FIGS. 2 and 3, the generally spherical hollow cup is of nonuniform thickness, having two surfaces 25 and 26 nonconcentric with each other to provide the greatest thickness at the planar surface 27 constituting the rim of the cup. The diameter of the smooth outer convex surface 26 is approximately that of the socket most likely to be encountered in hip socket replacements. The diameter of the smooth inner concave surface 25 is precisely that of the femoral head or prosthesis coacting with the cup. For unusually large acetabulum sockets, a set of cups is provided otherwise standard but employing for each cup a greater outer cup diameter than standard. Should the socket be too small in diameter, it may usually be reamed out to fit the cup. For the young, a third set of cups is provided and if necessary, a femoral head prosthesis of less than standard size.

The slots 24, 24*a* and 24*b* for the drifts in the planar cup rim 27 pass through the cup's outer surface 26 and the rim surface 27 only and do not penetrate the cup's inner surface 25, said inner surface remaining unmutilated by the slots and preserv-

ing its full bearing area except for any cup hole optionally made through both inner and outer surfaces. Said slots extend longitudinally in the general direction of, but are respectively at different angles to the central axis of the cup to permit a choice of sites for the drifts and to insure that the drifts are not parallel when in place, better to resist unwanted relative movement of the cup and bone. Each cup **15** of the set has its own main hole **22** in radial spaced relation to the cup axis and at a different angle to said axis, than the spacing and angle of the holes of the remaining otherwise identical cups of the set. In the example shown in FIGS. **2** and **3**, the hole **22** corresponds to the hole **18** in the jig and is marked similarly to the jig hole **18**, with the identifying numeral " **2**." (See reference numeral **30**). The other holes in the jig are marked "**1**," "**3**" and "**4**," there being four standard cups in the set, each having one hole corresponding to a hole in the jig. Should it be found that a main pin is not required in any particular case, there should be a fifth cup in the set devoid of a main pin hole.

The cup hole **22** is shallowly countersunk as at **31** to receive the short conical head **32** of the main pin **23**, said head limiting the entrance of the pin into the bone and determining the fully driven position of the pin. At its leading end **33**, the otherwise corrugated pin is preferably rounded. Parallel annular grooves **34**, for the reception of cancellous bone or for receiving growing bone and for easy reading of its length on X-ray pictures in which the length may appear foreshortened, are made along the shank of the pin. Since the pin is driven deeply into well-defined medullary or cortical bone, it is relatively long.

For ease in withdrawing the pin if and when required, the recess **35** in the trailing end of the pin is provided. The reduced entrance to the enlarged bulbous part **36** of the recess is preferably substantially cylindrical. A suitable collapsible tool similar to an inside ball hole gage is used to exert a pull on the spherical wall of the recess to extract the pin, if necessary. In addition to, or in place of the main pin, one or more drifts are used for anchoring the cup. The inner marginal portions of the drifts of FIGS. **7–11** are generally cylindrical and are adapted to enter and to fit the corresponding cylindrical inner portions of the key slots **24**, **24***a* and **24***b*. Like any other kind of nail-type fastener, there should be a considerable range of cross-sectional shapes, proportions, dimensions and other characteristics in a supply of drifts to meet the varied conditions presented in different individuals.

In the form shown in FIG. **7** the drift **37** is of the cylindrical nail type, headed at its trailing end and pointed at its leading end. To permit said nail drift to be driven to a point in which its conical head is slightly below the surface **25**, the rim slots of the cup are countersunk somewhat as at **38**, the head limiting the extent to which the drift may be driven. The remaining drifts illustrated are preferably unheaded for reasons of economy, but are driven by a suitable impact tool, not shown, engaging the rim surface **27** of the cup to halt further drive when the drift is fully driven.

Referring to FIGS. **8** and **9**, the drift **40** has a relatively thin outer flange **41**, a web **42** and a cylindrical inner marginal part **43** keyed with part of the web width projecting transversely beyond the cup, into a selected rim slot of the cup. The projecting part of the web **42** together with the flange **41** are driven into the bone of the recipient. Suitable closely spaced fenestras **44** are formed in the web. A withdrawal hole **45** is positioned in the web close to the tailing end of the drift for the reception of a pulling tool if withdrawal of the drift should be required. The leading edge **46** of the drift, is sharpened for easy driving into the bone. A quite shallow countersink **47** in the trailing end of the marginal portion **43** is adapted to receive the end of a driving tool. The drift **48** of FIGS. **10** and **11** is similar to the drift **40** excepting for the omission of the flange **41** and the substitution therefor of the sharp side edge **49**.

It will be understood that the cross-sectional shapes of the drifts may be many and varied. Obviously, for example, by combining parts of the drifts **40** and **48** and changing the shape of the corresponding inner part of the key slots in the rim of the cup, drifts of a number of different cross-sectional forms would result. By varying the length of the drifts and the disposition of the fenestras therein, a still greater variety is obtained. In the examples illustrated herein, the respective drifts **50** and **51** of the FIGS. **12** and **13** each have an inner marginal portion **52** of rectangular, instead of circular, cross section. Consequently, the inner parts of those key slots in the cup rim intended to receive such drifts are enlarged and obstructed by the constricted outer parts and are also made of rectangular cross section to fit the drifts, though such slots are not specifically illustrated. The relatively thin and wide web **42** of the drifts **40** and **48** is retained and is substantially the same in both drifts **50** and **51** and the sharpened outer side edge **49** is kept in the drift **50**. In the drift **51**, the flange **41** is retained as the outer side edge portion.

Because of the differences in the inclinations of many of the rim slots, which receive the fastener elements or drifts, from each other and from the main pin hole **22**, it will be noted from FIG. **1** for example, that the fastening elements are not parallel in the bone when driven, but converge or diverge. Consequently, they are dependably secured and cannot work loose though they can be individually withdrawn deliberately as herein before described. However, neither the drifts nor the main pin are fitted so tightly in the respective slots or main hole as to prevent the cup from being pressed under the required pressure against the acetabulum socket. It has also been pointed out that only one main pin hole, differing in position from the corresponding holes in the other cups of the same set, is made in each cup, and that a suitable jig is used to guide the drill boring the main pin hole **21**, in the bone, which hole may be smaller than the diameters of the pin and of the holes in the cup.

Reference is now made to FIGS. **4** and **5** showing the hollow hemispherical drilling guide jig **16** for the purpose mentioned. The outer convex surface **55** of the jig is of the diameter and shape to fit into the acetabulum socket which is suitably reamed by means of a surgical ballend reamer, while the inner surface **56** is of sufficiently large diameter to permit about four or more guide holes as **17**, **18**, **19** and **20**, marked with the identifying numerals **30**, to be made through the thickness of the jig at different inclinations to and at different distances from the axis of the jig. Said thickness is greater than that of the cup **15** and enough to guide the drill adequately. Extending outwardly from the flat rim **57** of the main body of the jig and secured thereto as by the screws **58** are the circumferentially spaced apart flat supports **59**, the extensions **60** of which are intended to be held on the rim of the acetabulum socket during the drilling operation. The drill jig is rotated until one of the holes, as **18** is opposite the strongest and longest cortical or medullary bone extending from the socket, whereupon the main pin hole is drilled and the hole identifying numeral as for Example "**2**" is noted. The jig is then replaced by that cup of the set perforated with a hole marked "**2**" and the cup is rotated to bring its hole into alignment and registration with the drilled hole, the cup being set into the socket with its rim **27** substantially flush with the planar rim of the acetabulum (FIG. **1**) or slightly below. The main pin of the proper length is driven into the aligned holes. There is a sufficient number of rim holes **24**, **24***a* and **24***b*, which alternate around the cup rim, to allow a wide choice of sites and inclinations for the drifts to be driven therethrough to the best advantage.

It is advisable that a variety of drifts as **37**, **40**, **48**, **50** and **51** and possibly others be prepared in several lengths so that few restrictions are put upon the selection of the correct number and types of drifts needed for complete dependability on the implantation of the cup in the socket.

It will now be seen that there has been provided a prosthesis and an assembling technique adapted for either total hip joint replacement or for acetabulum socket replacement and designed to meet the severe conditions involved in such replacements because of the different shapes, proportions and

dimensions of the bones of different individuals and the unpredictable effect disease may have had upon them; that the difficulties of impermanence present in most prior prostheses for the same purpose have been adequately resolved and that the various objects of the invention have been attained.

While certain specific embodiments of the invention have been herein shown and described, various obvious changes may be made therein without departing from the spirit of the invention defined by the appended claims.

I claim:

1. In a hip replacement prosthesis, a cup having continuous spherical inner and outer surfaces and an annular rim surface and having circumferentially disposed slots therein penetrating the rim surface and the outer surface and in sufficient spaced relation outwardly of the inner surface to provide a closing inner wall on each slot and to avoid penetration by said slots of said inner surface, the slots extending through the material of the cup in the general direction of the central longitudinal axis of the cup.

2. The prosthesis of claim 1, the slots being of the keyhole type, fastening elements each having a part of the length and part of the width thereof in a selected slot, the corresponding remainder of the width of each of said elements projecting tranversely beyond the slots.

3. The prosthesis of claim 1, the cup having a pin receiving hole therethrough in predetermined inward spaced relation to the rim of the cup and in predetermined angular relation to the axis of the cup, said relations being determined by the bony structure of the recipient.

4. The prosthesis of claim 3 and a corrugated main pin passing through said hole.

5. The prosthesis of claim 3, drifts retained in the slots and a main pin passing through the hole.

6. The hip replacement prosthesis of claim 1, selected slots being enlarged along the lengths thereof and the widths thereof at the inner parts of the slots to receive part of the width and a substantial part of the length of a fastening drift with the remaining part of the width of the drift projecting transversely out of the slot to enter the bone of the recipient.

7. The prosthesis of claim 6, and fastening drifts associated with selected slots for securing the cup in the acetabulum socket, the drifts being longer than the slots and projecting transversely therefrom.

8. In a hip replacement prosthesis, a cup having rim slots therethrough, selected slots being inclined to the axis of the cup and each other, the slots being of the keyhole type, each of a number of selected slots having a pair of substantially parallel outer walls extending inwardly from the outer surface of the cup and terminating in an inner cylindrical wall of greater diameter than the distance between the parallel walls and spaced outwardly of the inner surface of the cup.

9. The method of assembling a hip replacement prosthesis having a spherical cup provided with slots passing generally longitudinally through only the rim surface and the outer surface of the cup and having fastening drifts in the slots said slots having an inwardly spaced first portion connected to an outwardly spaced second portion of lesser width which intersects said outer surface to define an open side, the cup having a hole therethrough in spaced relation to the rim surface and having a pin passing through the hole, the method comprising determining the position of said hole to correspond to a pin-receiving hole in the acetabulum of the recipient, aligning the holes, driving the pin into the aligned holes, arranging the inner part of the width of a drift wider than the selected slot second portion in said selected slot in inward spaced relation to the outer surface of the cup, and driving the outer part of the drift and the leading end part thereof into the acetabulum of the recipient.

10. The method of claim 9, the step of determining the position of the hole in the cup comprising rotating a guide jig having therethrough a number of guide holes for a drill after inserting the jig into the acetabulum socket of the recipient, the jig being rotated to carry a selected guide hole into alignment with a selected part of the bone of the recipient, drilling the hole in the bone guided by the selected hole and replacing the jig in the socket by a cup having a hole arranged correspondingly to the selected guide hole and rotating the cup to align the cuphole with the drilled hole.

11. The assembling method of claim 9, the slots in the cup being inclined to the axis of the cup and to each other, the hole in the cup being angularly related to said axis, the pin being corrugated, the drift having the same cross-sectional shape at the inner part thereof as said selected slot, the pin and the drift being nonparallel, the position of a hole in the acetabulum being determined by rotating a guide jig having a number of drill guide holes therethrough after inserting the jig in the acetabulum socket, the guide holes being at different distances from the axis of the jig, rotation of the jig through the proper angle carrying a selected hole thereof into alignment with the deepest and strongest cortical or medullary bone, drilling a hole in said bone guided by the selected hole, then replacing the jig in the socket by a cup having a hole corresponding to the selected hole of the jig, and aligning the cup hole with the drilled hole before driving the main pin into the cup and the drilled hole.

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