(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 October 2010 (28.10.2010)

PCT

(10) International Publication Number
WO 2010/124164 A1

(51) International Patent Classification:
A61B 17/58 (2006.01)

(21) International Application Number:
PCT/US2010/032173

(22) International Filing Date:
23 April 2010 (23.04.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12/429,167 23 April 2009 (23.04.2009) US
12/698,443 2 February 2010 (02.02.2010) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: A DEVICE AND METHOD FOR ACHIEVING ACCURATE POSITIONING OF ACETABULAR CUP DURING TOTAL HIP REPLACEMENT

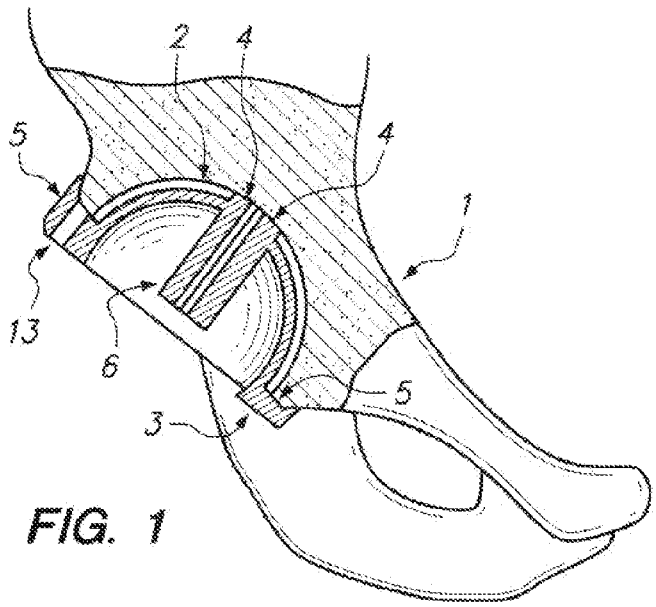

FIG. 1

(57) Abstract: A method and apparatus are provided for positioning an acetabular cup in a desired alignment in relation to a patient's hemipelvis. Using a patient-specific jig as a guide, bone is removed or displaced from the patient's hemipelvis to form a hole corresponding to a desired axis of alignment, and the acetabular cup is positioned in the desired alignment with the aid of a pin or post inserted into the hole. The hole may be located within the patient's acetabulum, and the pin or post may be affixed to the acetabular cup. To allow for positioning of the acetabular cup, the patient's acetabulum may be reamed, again with the aid of a pin or post inserted into the hole. The pin or post may be affixed to a reaming tool used for this purpose.

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A DEVICE AND METHOD FOR ACHIEVING ACCURATE POSITIONING OF ACETABULAR CUP DURING TOTAL HIP REPLACEMENT

FIELD OF THE INVENTION

The present invention relates to joint implants, particularly hip joint implants.

BACKGROUND OF THE INVENTION

Accurate acetabular cup position within the bony acetabulum is critical for successful function of a total hip prosthesis. Malposition of the cup can cause instability of the total hip implant, resulting in dislocation of the femoral head from within the cup. Malposition of the cup is also responsible for premature wear of the bearing surfaces. Both these events are a common cause for repeat surgery requiring revision of one or all of the components of a total hip replacement.

Ideal cup position is described by an inclination angle and an anteversion angle. Both are important in achieving ideal cup position. Prior art efforts for accurate acetabular cup positioning have included an alignment post on the device used to insert the acetabular cup. The alignment post typically is oriented at a 45 degree angle to the cup. Orientation of the alignment post vertically, in theory, would result in the cup being inserted into the acetabulum at a 45 degree inclination angle. However, multiple variables, such as patient position on the operating table, pelvic tilt, or poor estimation of whether the alignment post is truly vertical, can compromise accurate cup position.

Anteversion angle is typically achieved by a longitudinal rod attached to the cup insertion device. Anteversion is achieved by rotating the longitudinal rod about the transverse axis. Visual estimation of the cup position relative to the position of the acetabulum is also used as a guide. Such visual estimation is difficult due to multiple variables.

Computer assisted navigation has been utilized in an effort to achieve more accurate cup position. Such technology typically utilizes a computer, a tracking system to monitor position and points of the acetabulum and pelvis, and computer software which determines implant orientation relative to the tracking points of the acetabulum and pelvis. Its accuracy is limited due to multiple factors.

OVERVIEW

A method and apparatus are provided for positioning an acetabular cup in a desired alignment in relation to a patient's hemipelvis. Using a patient-specific jig as a guide, bone is removed or displaced from the patient's hemipelvis to form a hole corresponding to a desired axis of alignment, and the acetabular cup is positioned in the desired alignment with the aid of a pin or post inserted into the hole. The hole may be located within the patient's acetabulum, and the pin or post may be affixed to the acetabular cup. To allow for positioning of the acetabular cup, the patient's acetabulum may be reamed, again with the aid of a pin or post inserted into the hole. The pin or post may be affixed to a reaming tool used for this purpose.

Alternatively, the pin or post may be located in a region outside the patient's acetabulum. The acetabular cup is impacted into the patient's acetabulum using an impactor rod having a laser attached thereto, and during impacting, the impactor rod may be manually guided so as to target the pin or post with a laser beam produced by the laser. The laser beam points along an axis that is parallel to and offset from an axis of force of the impactor rod. In other embodiments, both a primary (central) axis guide pin or post and a secondary (non-central) axis guide pin or post are used to achieved the desired alignment.

Additional features and benefits of the present invention will become apparent from the detailed description, figures and claims set forth below.

BRIEF DESCRIPTION OF THE DRAWING

The present invention will be understood more fully from the detailed description given below, and from the accompanying drawings of various embodiments of the invention, which, however, should not be taken to limit the invention to the specific embodiments, but are for explanation and understanding only.

Figure 1 is a perspective view of a hemipelvis and acetabulum, as well as a drill guide for establishing the axis of the acetabular implant.

Figure 2 is a top perspective view of the acetabulum and drill guide of Figure 1.

Figure 3A is a diagram illustrating one possible method of producing the drill guide.

Figure 3B is a perspective view of a hemipelvis and acetabulum showing placement of primary and secondary guide pins.

Figure 4 is a perspective view of a hemipelvis and acetabulum showing cup placement using an impactor rod having a laser attached thereto.

Figure 5 is a perspective view of an acetabular cup and an acetabular fixation screw.

Figure 6 is a bottom perspective view of the acetabular fixation screw.

Figure 7 is a cross-sectional view illustrating an implant including central fixation means.

DETAILED DESCRIPTION

Those of ordinary skill in the art will realize that the following detailed description of the present invention is illustrative only, and is not intended to be in any way limiting. Other embodiments of the present invention will readily suggest themselves to such skilled persons having the benefit of this disclosure. It will be apparent to one skilled in the art that these specific details may not be required to practice present invention. In other instances, well-known devices are shown in block or schematic form to avoid obscuring the present invention. In the following description of the embodiments, substantially the same parts are denoted by the same reference numerals.

A device and method are provided whereby accurate cup position within the acetabulum, including both inclination and anteversion, may be achieved by means of computerized tomography scans (CT scans), magnetic resonance imaging (MRI), or other scans of the acetabulum obtained preoperatively, which may then be used to create an alignment jig placed within the acetabulum at the time of surgery.

Referring now to Fig. 1 and Fig. 2, a perspective view is shown of a hemipelvis 1 and acetabulum 2, as well as a drill guide 3 for establishing a desired axis of the acetabular implant. A base 4 of a drill bit sleeve 6 and outer contact points 5 of the drill guide 3 may rest on the acetabulum or pelvis. A secondary drill bit sleeve 13 may also be provided.

The drill bit sleeve 6 of the drill guide orients a drill bit so as to achieve optimal orientation of a drill hole, thus establishing the desired acetabular axis for the acetabular implant. The orientation of the drill bit sleeve 6 of the drill guide will have been determined from preoperative CT, MRI or other scans of the patient's pelvis with respect to anteversion and inclination and allow determination of a desired acetabular axis in order to establish a desired position of the face of the acetabular cup relative to the acetabular axis.

The acetabular cup may be of a generally hemispherical design, and may have a protrusion, post or spike which may then be guided into the hole drilled into the acetabulum utilizing the drill guide 3.

The alignment jig is patient specific, and may be created prior to surgery based on preoperative CT, MRI or other scans and resulting data describing measurements and points of the patient's acetabulum and pelvis. The CT, MRI or other scans can accurately determine the diameter of the acetabulum and points on the acetabulum and pelvis for reference in order to create a patient specific jig. Referring to Figure 3A, medical imaging data 301 obtained from a medical imaging apparatus 303 (e.g., CT, MRI, etc.) is inputted into 3D computer assisted design software installed on a computer or workstation 305. The computer or workstation 305 produces CAD data 307 for the patient-specific jig, which is used to control computer-guided machinery such as a computer guided laser etcher, computer-controlled stereolithography machine (illustrated in the present example), or computer guided lathe 309 to create a disposable jig 311 by means of existing CAD technologies. Further details may be found, for example, in Roose, U.S. Patent Application 2005/0148843 entitled SYSTEM AND METHOD OF DESIGNING AND MANUFACTURING CUSTOMIZED INSTRUMENTATION FOR ACCURATE IMPLANTATION OF PROSTHESIS BY UTILIZING COMPUTED TOMOGRAPHY DATA, published July 7, 2005, incorporated herein by reference.

The patient specific jig, placed within the acetabulum, has multiple contact points, for example contact points 5, on the margin and body of the jig, which rest on the acetabulum or pelvis so as to achieve a predetermined position on the acetabulum of the jig with respect to an X, Y and Z axis, and three planes in space relative to the axes. Such planes are typically referred to as sagittal, axial, and coronal planes.

The patient specific jig has a site for placing a drill hole within the dome of the patient's acetabulum. The orientation of the hole may be determined from the preoperative CT, MRI or other scans, which provide images of the acetabulum in axial, coronal and sagittal planes. Utilizing patient specific data from CT, MRI or other images, the orientation of

the drill hole of the jig placed within the acetabulum may be made so as to create an axis of rotation for placement of the acetabular cup, as determined by the drill hole. Hence, the drill hole establishes the acetabular axis, and the acetabular axis serves to orient the implant cup. In one embodiment, the axis passes through the center of the implant socket and is perpendicular to the plane of the face of the acetabular cup.

A central axis guide pin 12, which may be of the same diameter as the acetabular axis drill hole, may then be placed within the hole as shown in Fig. 3B. The central axis guide pin 12 thus establishes the predetermined desired acetabular axis, established by preoperative CT, MRI or other scans and by the patient-matched jig 3 created from the scans.

A parallel pin guide, of a type commonly used in orthopedic surgery, may also be used to place a secondary axis guide pin 7, parallel to the central axis guide pin 12, into the bony pelvis. The secondary axis guide pin 12 may be placed into the pelvis just outside of the acetabulum, to serve as a second reference point in addition to the central axis guide pin 12.

Alternatively, the secondary axis guide pin 12 may be placed by means of a drill bit sleeve 13 in the patient specific jig 3, on a location of the jig outside of the acetabulum, oriented parallel to the drill bit sleeve 6.

The central axis guide pin 12, placed in the acetabulum by means of the patient-specific jig 3, may at this point be removed, or may serve as an axis post for reaming of the acetabulum, by means of acetabular reamers which have a cannulated center axis post, which passes over the axis pin. If the acetabular axis pin is removed, an acetabular reamer may itself be provided with a guide pin that may be inserted into the central axis hole.

Following acetabular reaming, the acetabular cup may be placed by any of various options.

Referring to Fig. 4, in one option the cup 10 may be created so as to have a central hole, the hole being perpendicular to the face of the cup. The central hole may be threaded, so as to accept an impaction rod 9, which may be threaded into the cup to be implanted. The impaction rod may be created so as to be cannulated with a cannula 14 having a diameter slightly larger than the central axis guide pin 12, thus allowing it to be passed over the central axis guide pin 12 in the desired acetabular axis, and perpendicular to the face of the cup. The acetabular cup may then be impacted into the prepared acetabular bone bed by means of the impaction post or rod 9.

Referring to Figure 4, alternatively, or additionally, the cup 10 may be oriented by means of a laser pointer targeting device 8, attached to and parallel with the impaction rod 9 of the acetabular cup 10, which then targets the center of the secondary axis guide pin 7 placed outside of the acetabulum parallel to the central axis guide pin 12.

In accordance with this option, instead of referencing off the initial central axis guide pin 12, that pin is removed, and a secondary axis guide pin 7 is placed outside of the acetabulum and used as a reference. Removal of the central axis guide pin 12 initially placed within the acetabulum may at times be necessary due to inadequate bone to safely use the pin as a reference during cup impaction, or due to use of a solid metal cup which has no central axis hole option, such as a type used in metal-on-metal bearing total hip technology or metal-on-metal hip resurfacings.

Following removal of the central axis guide pin 12, the secondary axis guide pin 7, placed outside of the acetabulum, may be referenced by means of a compact laser target pointer 8, which may be attached to the acetabular cup impaction rod 9 and situated parallel to a central axis of the impaction rod 9 at a distance equal to a distance between the initial central axis guide pin 12 and the secondary axis guide pin 7. The laser pointer 8 may then be oriented so as to target the center of the flat end of the secondary axis guide pin 7. At such time as the impactor rod 9 is oriented so that the laser pointer 8 is centered on a head of the secondary axis guide pin 7, proper acetabular cup orientation

has been achieved. The acetabular cup 10 may then be impacted into the acetabulum while maintaining the laser pointer 8 centered on the head of the secondary axis guide pin 7.

If, after having achieved satisfactory impaction and fixation of the acetabular cup, the laser pointer 8 is still centered on the center of the secondary axis guide pin 7, the proper acetabular cup axis will have been achieved, as determined by preoperative CT, MRI or other scans and by the 3D computer-modeled reference jig.

Another cup design that may be used with the present alignment techniques is described in U.S. Patent Application 12/429,167 of the present inventor titled ACETABULAR CUP WITH SUPPLEMENTAL SCREW FIXATION USING CONICAL INTERFERENCE FIT BETWEEN SCREW AND CUP, filed November 14, 2008, incorporated herein by reference. This cup is designed to take full advantage of the acetabular axis drill hole and achieve precise orientation of the acetabular cup relative to the sagittal, axial and coronal planes of the patient's pelvis.

Referring more particularly to Fig. 5 and Fig. 6, perspective views are shown of an acetabular cup 51 and an acetabular fixation screw 53. The acetabular cup 51 is generally hemispherical and has a hollow center as indicated by the dashed line. The acetabular cup 51 is provided at a dome region thereof with a taper 52. In the illustrated embodiment, the cup portion and the taper 52 of acetabular cup 51 are integrally formed from a suitable material such as a bio-compatible metal (e.g., cobalt-chromium, titanium or other suitable metal, ceramic or other material).

The acetabular fixation screw 53 is an elongated body having, for example, threads extending therefrom. Any of various other fixation devices may used provided instead of or in addition to threads, such as "fish hooks," a rough-textured porous coating, etc. A

tapered recess 54 (indicated in hidden lines) is formed within the elongated body. At the bottom of the tapered recess 54, an engagement feature is provided for engaging a tool used to turn the elongated body. A forward end of the acetabular fixation screw 53 may have a non-threaded guide portion of a suitable length.

The taper 52 and the tapered recess 54 have surface properties that promote adhesion between their respective surfaces. For example, in instances where the acetabular cup 51 and acetabular fixation screw 53 are formed of metal, the surfaces of the taper 52 and the tapered recess 54 may be highly polished to promote adhesion (e.g., cold welding or bonding) of the surfaces to one another. The friction across the entire surface area of the interface provides a controllable amount of resistance to torque transmission, which prevents rotation of the cup or "spin out," an unfortunate occurrence with currently available cups.

The strength of the resulting adhesion may be suitably engineered as desired. It may be desired, for example, for the adhesion to be less than maximum to allow for possible rework. In some instances, the strength of adhesion may be manually adjustable at the time of implant. For example, normally, the acetabular fixation screw would be screwed into a hole in the acetabulum so as to be even with the surface of the acetabulum, which will typically have been reamed to receive the acetabular cup. By screwing the acetabular screw into the acetabulum slightly further (e.g., a fraction of a millimeter further), the adhesion strength may be downwardly adjusted.

Still another cup design that may be used with the present alignment techniques is described in U.S. Patent Application 11/772,698 titled PRECISION ACETABULAR MACHINING SYSTEM AND RESURFACING ACETABULAR IMPLANT, filed July 2, 2007, incorporated herein by reference. Referring to Figure 7, showing an acetabular socket 712 having a guide hole 736 formed therein, a cup 760 provided with an integral pin 762 is placed with the pin 762 inserted into the guide hole 736. Appendages 764 may optionally be provided. The cup design is such that the pin 762 is solid, not having any through-hole. Such a design is believed to better achieve proper joint lubrication.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that, based on the teachings herein, changes and modifications may be made without departing from this invention and its broader aspects. Therefore, the appended claims are intended to encompass within their scope all such changes and modifications as are within the true spirit and scope of this invention.

ASPECTS OF THE INVENTION

Various aspects of the invention include the aspects set forth below, which may be in addition to the aspects of the invention claimed in the claims, presented following the aspects set forth below.

A1. A method of securing a solid metal acetabular cup, of metal on metal bearing technology, comprising achieving fixation by means of a taper coupling between said cup and a supplemental screw placed within the bone of the acetabulum with a corresponding tapered hole in its center.

A2. Aspect A1, comprising inserting the supplemental screw with a tapered hole into a dome portion of a patient's acetabulum.

A3. Aspect A2, comprising achieving an interference fit between an acetabular cup with a tapered post located at a dome region of the acetabular cup and a coupling screw (3) with hole of a corresponding taper, achieving immediate frictional fixation;

wherein friction across the entire surface area of the interface provides a controllable amount of resistance to torque transmission, which prevents rotation of the cup.

A4. A method of securing an acetabular cup having a tapered projection, comprising:

anchoring within a bone structure a receiving member having a tapered recess; and

fitting the tapered projection of the acetabular cup within the tapered recess to achieve fixation.

A5. An acetabular cup comprising:

a cup portion; and

a tapered projection extending from a region of the cup portion, a surface of the tapered projection having surface properties that promote adhesion between the surface of the tapered projection and a surface of a tapered recess of a receiving member.

A6. Aspect A5, wherein the cup portion and the tapered projection are integrally formed.

A7. Aspect A5, wherein the tapered projection is formed of metal.

A8. Aspect A7, wherein the cup portion is formed of metal.

A9. A receiving member for securing an acetabular cup, comprising:

an elongated body; and

a tapered recess formed within the elongated body, a surface of the tapered recess having surface properties that promote adhesion between the surface of the tapered recess and a surface of a tapered projection of the acetabular cup.

A10. Aspect A9, comprising an engagement feature within the tapered recess for engaging a tool used to insert the elongated body into a bone structure.

A11. Aspect A9, wherein the elongated body comprises a non-threaded guide portion at a leading end thereof.

A12. The Aspect A9, wherein the receiving member is formed of metal.

A13. Aspect A5, wherein the tapered projection extends from a dome region of the cup portion

A14. Aspect A9, wherein the elongated member has threads extending therefrom.

B1. A method of controlling orientation of an acetabular implant by means of a patient-specific acetabular alignment jig, which allows for creation of a drill hole in the acetabulum, thereby establishing an acetabular axis.

B2. Aspect B1, comprising:

obtaining a medical imaging scan of a patient's pelvis;

mapping computer data from the medical imaging scan with respect to at least one of acetabular depth, diameter, outer wall morphology, inclination, anteversion, and desired acetabular axis; and

supplying the computer data to three-dimensional computer software.

B3. Aspect B2, comprising utilizing the computer data to create said patient-specific acetabular alignment jig using computer-guided machinery.

B4. Aspect B2, comprising mapping computer data from the medical imaging scan with respect to at least two of acetabular depth, diameter, outer wall morphology, inclination, anteversion, and desired acetabular axis.

B5. Aspect B2, comprising mapping computer data from the medical imaging scan with respect to at least three of acetabular depth, diameter, outer wall morphology, inclination, anteversion, and desired acetabular axis.

B6. A method comprising:

affixing a patient-specific jig to an outer wall of a patient's acetabulum; and

drilling an acetabular axis hole in a base of the acetabulum so as to create a desired acetabular axis, in order to achieve accurate inclination and anteversion.

B7. Aspect B6, comprising placing an acetabular cup having a face and a projection substantially perpendicular to the face by inserting the projection into the acetabular axis hole, so as to achieve desired orientation of the face of the acetabular cup.

B8. A patient-specific acetabular alignment jig produced by a method comprising:

obtaining a medical imaging scan of a patient's pelvis;

mapping computer data from the medical imaging scan with respect to at least one of acetabular depth, diameter, outer wall morphology, inclination, anteversion, and desired acetabular axis;

supplying the computer data to three-dimensional computer software; and

utilizing the computer data to create a patient-specific alignment jig using computer-guided machinery.

B9. Aspect B8, the method comprising mapping computer data from the medical imaging scan with respect to at least two of acetabular depth, diameter, outer wall morphology, inclination, anteversion, and desired acetabular axis.

B9. Aspect B8, the method comprising mapping computer data from the medical imaging scan with respect to at least three of acetabular depth, diameter, outer wall morphology, inclination, anteversion, and desired acetabular axis.

C1. A method of positioning an acetabular cup in a desired alignment in relation to a patient's hemipelvis, comprising:

using a patient-specific jig as a guide, removing or displacing bone from the patient's hemipelvis to form a hole corresponding to a desired axis of alignment; and

positioning the acetabular cup in the desired alignment with the aid of a pin or post inserted into the hole.

C2. Aspect C1, wherein the pin or post is affixed to the acetabular cup.

C3. Aspect C1, further comprising, to allow for positioning of the acetabular cup, reaming the patient's acetabulum with the aid of a pin or post inserted into the hole.

C4. Aspect C3, wherein the pin or post is affixed to a reaming tool.

C5. Aspect C1, wherein the pin or post is located in a region outside the patient's acetabulum.

C6. Aspect C5, further comprising:

impacting the acetabular cup into the patient's acetabulum using an impactor rod having a laser attached thereto; and

during said impacting, manually guiding the impactor rod so as to target the pin or post with a laser beam produced by the laser.

C7. Aspect C6, wherein the laser beam points along an axis that is parallel to and offset from an axis of force transmission of the impactor rod.

C8. A method of placing an acetabular cup having a projecting member, comprising:

establishing an acetabular axis hole using a patient-specific jig; and

inserting the projecting member into the acetabular axis hole so as to achieve a desired orientation of a face of the acetabular cup.

C9. Aspect C8, wherein the projecting member is one of a pin, a post, a spike and a screw.

C10. Aspect C8, wherein the desired orientation is perpendicular to the projecting member.

C11. A method of achieving correct orientation of an acetabular cup, comprising:

forming an acetabular axis drill hole within a patient's acetabulum and hemipelvis;

placing a central axis guide post within the acetabular axis drill hole;

placing an acetabular cup with the aid of the central axis guide post;

attaching to the acetabular cup an impactor rod; and

impacting the acetabular cup by advancing the impactor rod in line with a central axis of the central axis guide post.

C12. Aspect C11, further comprising:

placing a secondary axis guide post in bone surrounding the acetabulum, parallel to the central axis guide post; and

using the secondary axis guide post to guide placement of the acetabular cup.

C13. A method of achieving correct orientation of an acetabular cup, comprising:

placing a central axis guide post within an area of a patient's acetabulum, thereby establishing a central axis;

placing a secondary axis guide post in bone surrounding the acetabulum, parallel to the central axis guide post, thereby establishing a secondary axis; and

using the secondary axis guide post to guide placement of the acetabular cup.

C14. Aspect C13, comprising:

attaching to the acetabular cup an impactor rod; and

impacting the acetabular cup by advancing the impactor rod in line with the central axis.

C15. Aspect C13, comprising:

providing a laser pointer attached to the impactor rod pointing parallel to an axis of the impactor rod;

wherein a distance between an axis of the laser pointer and the axis of the impactor rod is equal to a distance between the central axis and the secondary axis.

C16. A method of achieving correct orientation of an acetabular cup, comprising:

establishing a central alignment axis;

placing an alignment target, thereby establishing a secondary alignment axis;

providing a laser pointer attached to an impactor rod pointing parallel to an axis of the impactor rod, wherein a distance between an axis of the laser pointer and the axis of the impactor rod is equal to a distance between the central alignment axis and the secondary alignment axis;

impacting the acetabular cup using the impactor rod while manually maintaining alignment of the laser pointer and the secondary alignment axis by viewing incidence of a laser beam upon the alignment target.

C17. Aspect C16, wherein the alignment target is a pin or post.

C18. Aspect C16, comprising:

placing a central axis guide post within an area of a patient's acetabulum, thereby establishing the central axis;

placing a secondary axis guide post in bone surrounding the acetabulum, parallel to the central axis guide post, thereby establishing the secondary axis.

C19. Aspect C16, comprising impacting the acetabular cup by advancing the impactor rod in line with the central axis.

C20. An apparatus for impacting an acetabular cup, comprising:

an impactor rod; and

attached to the impactor rod, a laser, the laser producing a laser beam, the laser beam pointing along an axis that is parallel to and offset from an axis of force transmission of the impactor rod.

C21. A method of acetabular reaming using a cannulated reamer having a cannula that fits over a pin or post, comprising;

establishing with respect to a patient's acetabulum a desired acetabular axis;

inserting into the patient's acetabulum a pin or post aligned with the desired acetabular axis;

fitting the cannula of the cannulated reamer over the pin or post; and

reaming the patient's acetabulum using the pin or post as a centering guide.

C22. A cannulated reamer for acetabular reaming, comprising:

a hemispherical reaming member having a reaming surface on an outside diameter thereof; and

coupled to the hemispherical reaming member, a cannulated axial member having a cannula that fits over a pin or post to provide a centering action during reaming of a patient's acetabulum.

CLAIMS

What is claimed is:

1. A method of positioning an acetabular cup in a desired alignment in relation to a patient's hemipelvis, comprising:

using a patient-specific jig as a guide, removing or displacing bone from the patient's hemipelvis to form a hole corresponding to a desired axis of alignment; and

positioning the acetabular cup in the desired alignment with the aid of a pin or post inserted into the hole.

2. The method of claim 1, wherein the pin or post is affixed to the acetabular cup.

3. The method of claim 1, further comprising, to allow for positioning of the acetabular cup, reaming the patient's acetabulum with the aid of a pin or post inserted into the hole.

4. The method of claim 3, wherein the pin or post is affixed to a reaming tool.

5. The method of claim 1, wherein the pin or post is located in a region outside the patient's acetabulum.

6. The method of claim 5, further comprising:

impacting the acetabular cup into the patient's acetabulum using an impactor rod having a laser attached thereto; and

during said impacting, manually guiding the impactor rod so as to target the pin or post with a laser beam produced by the laser.

7. The method of claim 6, wherein the laser beam points along an axis that is parallel to and offset from an axis of force transmission of the impactor rod.

8. The method of claim 1, comprising:

with the aid of said pin or post inserted into the hole, inserting in the patient's hemipelvis a secondary pin or post in a region outside the patient's acetabulum; and

removing the pin or post inserted into the hole.

9. A patient-specific acetabular alignment jig produced by a method comprising:

obtaining a medical imaging scan of a patient's pelvis;

mapping computer data from the medical imaging scan with respect to at least one of acetabular depth, diameter, outer wall morphology, inclination, anteversion, and desired acetabular axis;

supplying the computer data to three-dimensional computer software; and

utilizing the computer data to create a patient-specific alignment jig using computer-guided machinery.

10. The patient-specific alignment jig of claim 9, the method comprising mapping computer data from the medical imaging scan with respect to at least two of acetabular depth, diameter, outer wall morphology, inclination, anteversion, and desired acetabular axis.

11. The patient-specific alignment jig of claim 9, the method comprising mapping computer data from the medical imaging scan with respect to at least three of acetabular depth, diameter, outer wall morphology, inclination, anteversion, and desired acetabular axis.

12. The patient-specific alignment jig of claim 9, the method comprising mapping computer data from the medical imaging scan with respect to desired acetabular axis.

13. The patient-specific alignment jig of claim 9, comprising a drill guide sleeve corresponding to the desired acetabular axis.

14. The patient-specific alignment jig of claim 13, comprising a further drill guide sleeve.

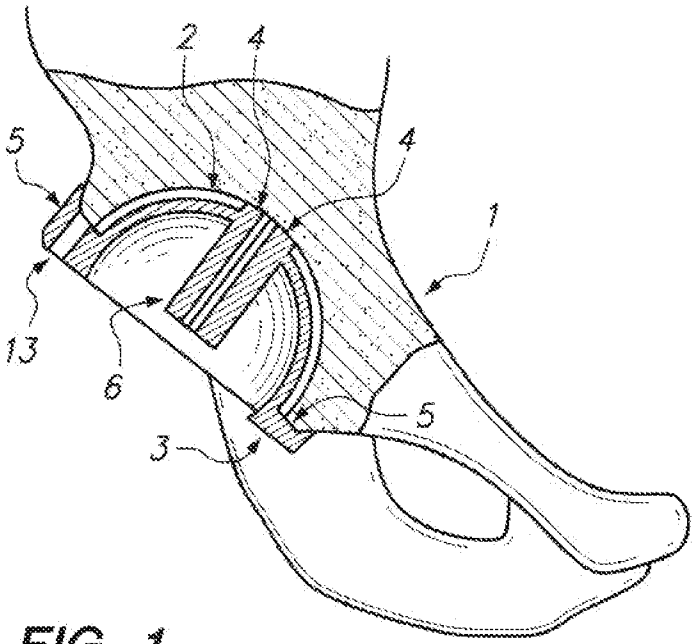

FIG. 1

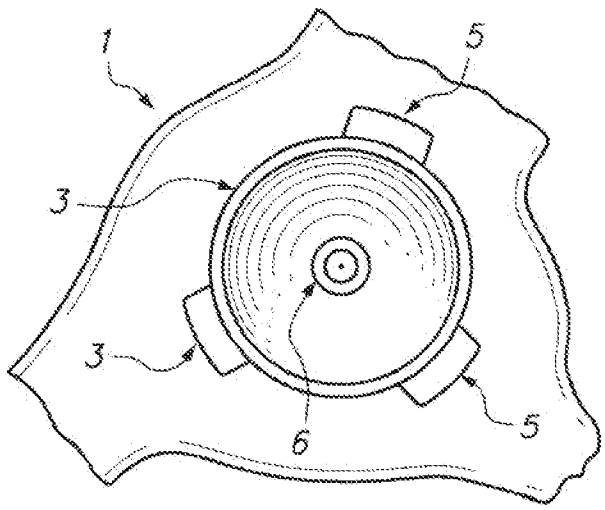

FIG. 2

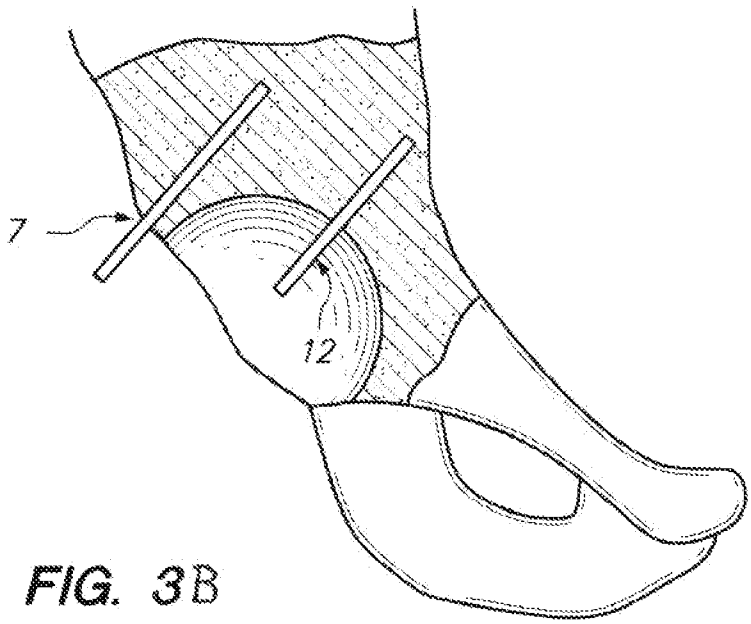

FIG. 3B

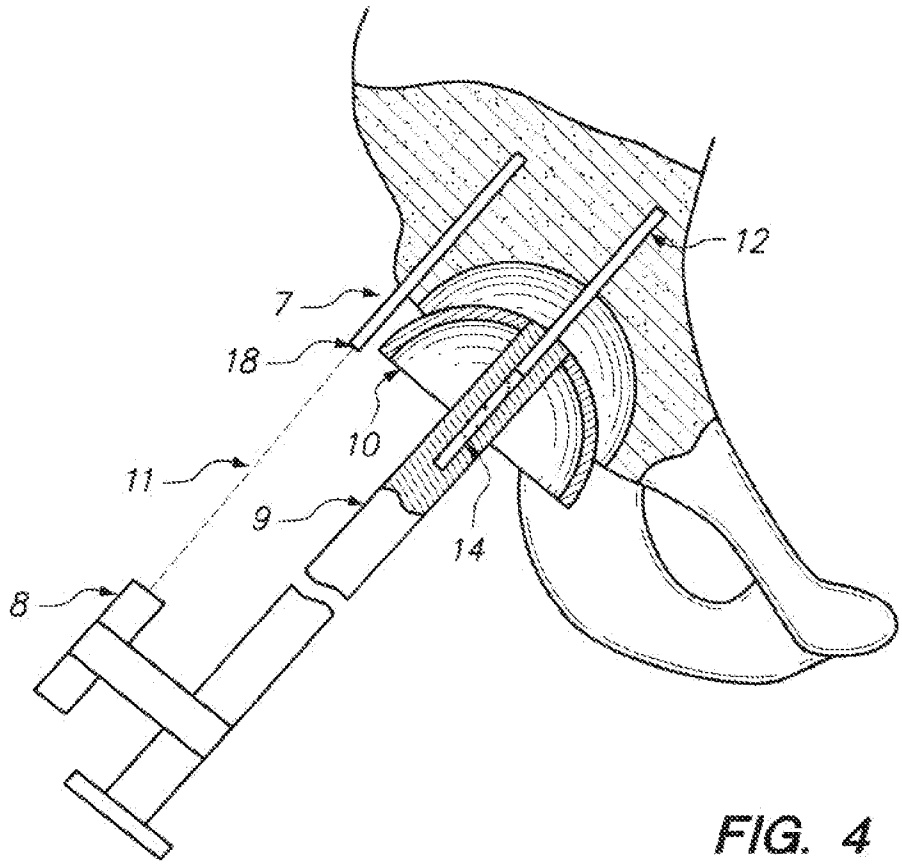

FIG. 4

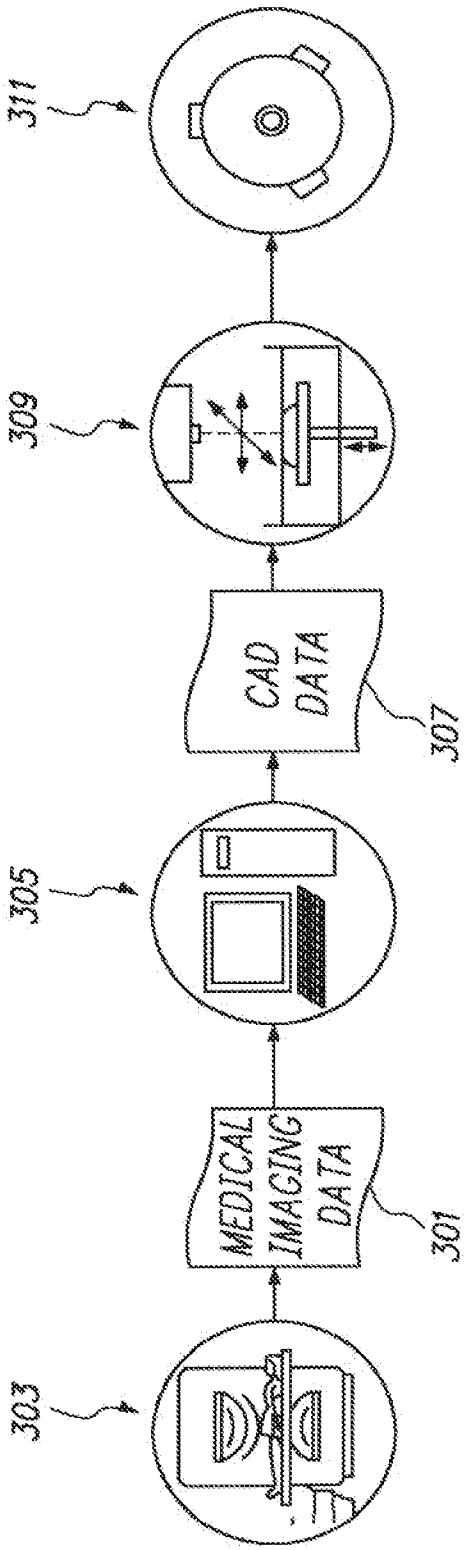

FIG. 3A

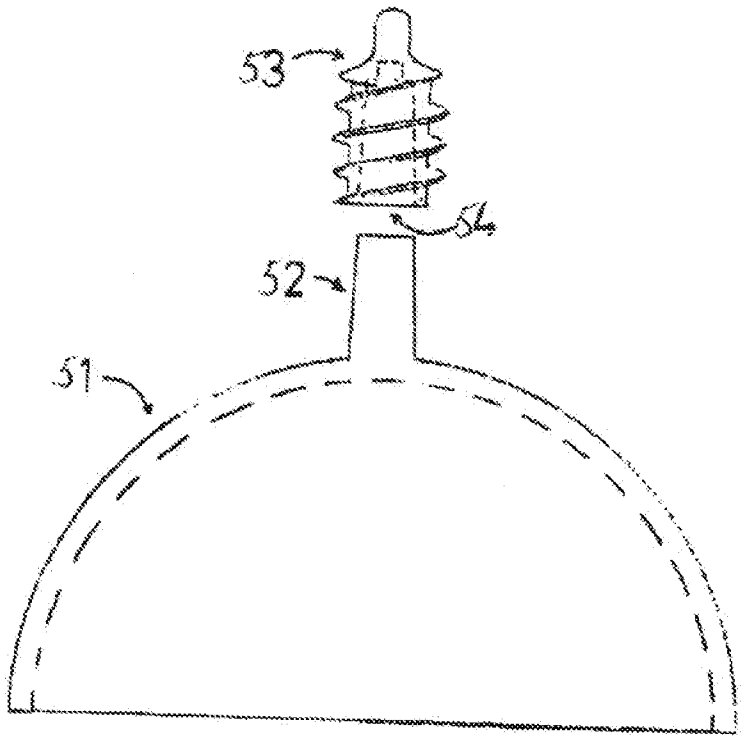

Fig. 5

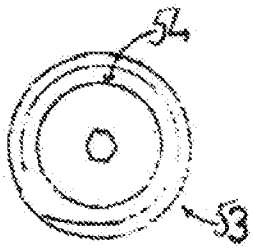

Fig. 6

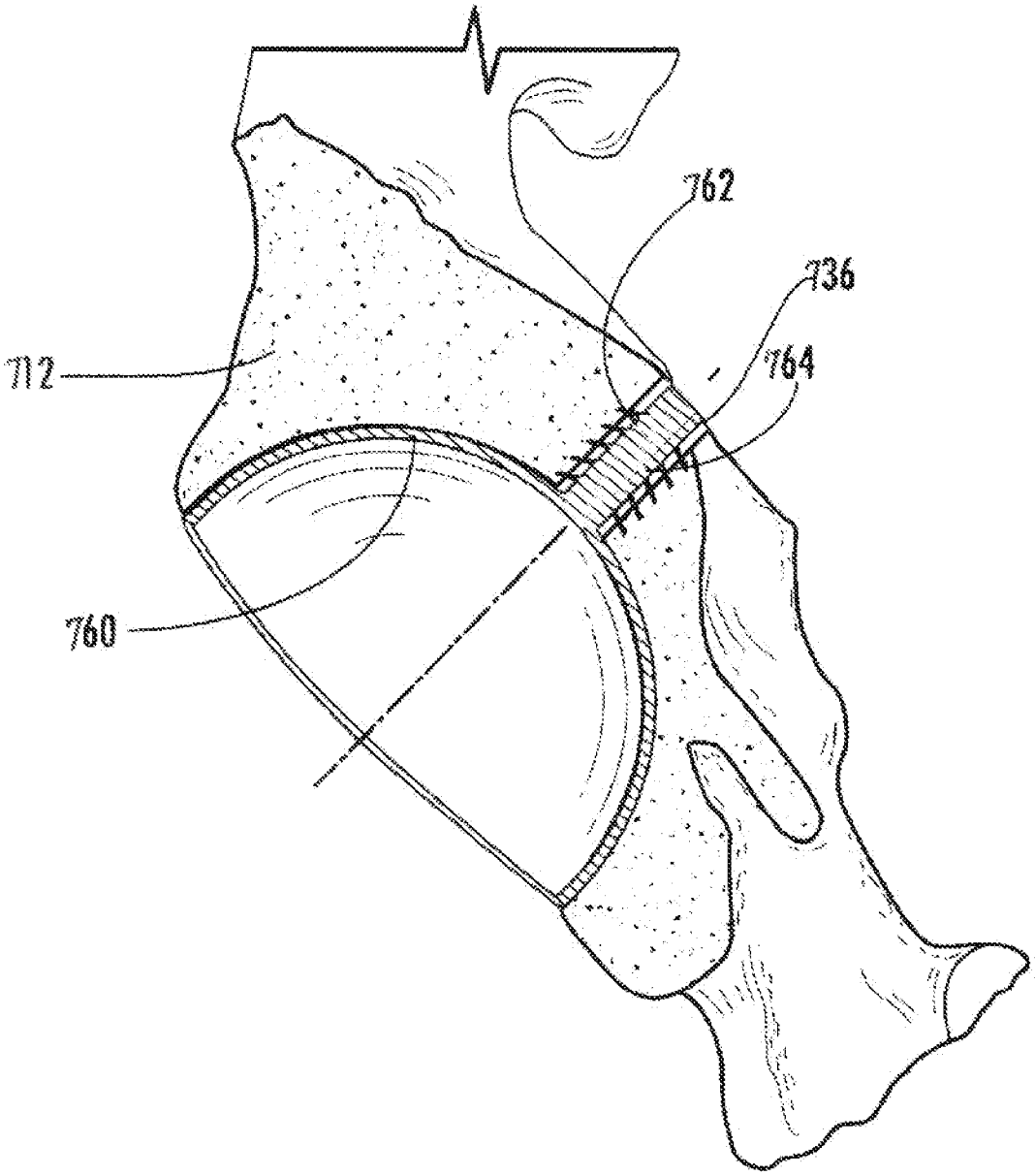

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/032173

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61B 17/58 (2010.01)
USPC - 606/91
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - A61B 17/58 (2010.01)
USPC - 606/91, 102

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent, Google Patents, USPTO Web

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 6,395,005 B1 (LOVELL) 28 May 2002 (28.05.2002) entire document	1-5, 8 ---------- 6, 7
Y	US 6,743,235 B2 (SUBBA RAO) 01 June 2004 (01.06.2004) entire document	6, 7
A	US 4,716,894 A (LAZZERI et al) 05 January 1988 (05.01.1988) entire document	1-8
A	US 5,284,483 A (JOHNSON et al) 08 February 1994 (08.02.1994) entire document	1-8

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 July 2010	18 AUG 2010
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/032173

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-8

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2010/032173

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I, claims 1-8 are drawn to positioning an acetabular cup.
Group II, claims 9-14 are drawn to a method of computer modeling.

The inventions listed in Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1, because under PCT Rule 13.2 they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I, a method for positioning an acetabular cup using a patient-specific instrument, are not present in Group II; and the special technical features of Group II, a method for designing an alignment jig by obtaining scanned images for use in three dimensional computer software modeling, are not present in Group I.

Since none of the special technical features of the Group I and II inventions are found in more than one of the inventions, unity is lacking.