Title: PATIENT-SPECIFIC MILL GUIDE

FIG. 1

[Continued on next page]
Abstract: A patient-specific surgical system, such as a patient-specific milling guide, is provided for preparing a bone to receive an orthopedic prosthesis.
This application claims priority from U.S. Provisional Patent Application Serial No. 61/256,067, entitled "PATIENT-SPECIFIC MILL GUIDE," filed October 29, 2009, the disclosure of which is hereby expressly incorporated by reference herein in its entirety.

BACKGROUND

1. Field of the Invention.

The present invention relates to surgical systems and orthopedic prostheses. More particularly, the present invention relates to patient-specific surgical systems and orthopedic prostheses.

2. Description of the Related Art.

A joint arthroplasty procedure may be performed to repair a damaged bone of a joint. In operation, a surgeon may use a milling system to prepare the damaged bone for receiving an orthopedic prosthesis. For example, during a total or partial knee arthroplasty procedure, the surgeon may mill the distal femur to provide an attachment surface for receiving a distal femoral prosthesis. The distal femoral prosthesis includes a bone-engaging surface configured to rest against the prepared attachment surface of the distal femur and an articulating surface that may be designed to articulate with the proximal tibia or the patella, for example. The distal femoral prosthesis may be a unicompartamental implant, a bicompartamental implant, or a total femoral implant, for example.
SUMMARY

[0004] The present invention provides a patient-specific surgical system, such as a patient-specific milling guide, for preparing a bone to receive an orthopedic prosthesis.

[0005] According to an embodiment of the present invention, an orthopedic guide is provided for preparing a particular patient's bone to receive a prosthesis using a milling tool with a rotating burr. The orthopedic guide includes a platform and a plurality of legs coupled to the platform. The platform has a top surface and a bottom surface that faces the patient's bone, the platform defining an elongate milling track that extends through the platform from the top surface to the bottom surface of the platform, the milling track being sized and shaped to guide the milling tool across the patient's bone with the burr of the milling tool rotating beneath the bottom surface of the platform to remove a first bone portion from the patient's bone. Each of the plurality of legs includes a referencing end that is contoured to abut the patient's bone, the referencing ends of the plurality of legs cooperating to locate the orthopedic guide at a predetermined location of the patient's bone.

[0006] According to another embodiment of the present invention, a method is provided for preparing a particular patient's bone to receive a prosthesis having an articulating surface and a bone-engaging surface. The method includes the steps of: providing a digital model of the bone; identifying a portion of the bone to be removed to receive the prosthesis; providing a patient-specific guide; using the patient-specific guide to remove the identified portion of the bone, thereby forming a prepared surface of the bone; and inlaying the prosthesis into the bone by positioning the bone-engaging surface of the prosthesis against the prepared surface of the bone, the articulating surface of the prosthesis transitioning smoothly into a remaining surface of the bone located adjacent to the prepared surface of the bone.

[0007] According to yet another embodiment of the present invention, a method is provided for preparing a particular patient's bone to receive a prosthesis. The method includes the steps of: providing a digital model of the bone; providing a digital model of
the prosthesis, the digital model of the prosthesis having a bone-contacting surface with a predetermined shape; identifying a portion of the bone to be removed to receive the bone-contacting surface of the prosthesis; providing a patient-specific guide to remove the identified portion of the bone; and manufacturing the prosthesis to fill at least the removed portion of the bone.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

[0009] Figure 1 is a lateral perspective view of an exemplary patient-specific guide of the present invention positioned against a distal femur;

[0010] Figure 2 is a medial perspective view of the patient-specific guide of Figure 1 positioned against the distal femur;

[0011] Figure 3 is an anterior elevational view of the patient-specific guide of Figure 1 positioned against the distal femur;

[0012] Figure 4 is a proximal plan view of the patient-specific guide of Figure 1 positioned against the distal femur;

[0013] Figure 5 is a distal plan view of the patient-specific guide of Figure 1 positioned against the distal femur;

[0014] Figure 6 is a posterior perspective of the patient-specific guide of Figure 1 positioned against the distal femur;

[0015] Figure 7A is a perspective view of an exemplary milling tool of the present invention;
Figure 7B is a perspective view of an exemplary cutting tool of the present invention;

Figure 8 is a flow chart of an exemplary method of the present invention;

Figure 9 is a medial perspective view of a prepared distal femur;

Figure 10 is a lateral perspective view of an exemplary distal femoral prosthesis of the present invention;

Figure 11 is a cross-sectional view of the distal femoral prosthesis of Figure 10, also showing in phantom a standard component from which the distal femoral prosthesis is formed;

Figure 12 is a lateral perspective view of the distal femoral prosthesis of Figure 10 implanted onto the prepared distal femur;

Figure 13 is a view similar to Figure 12 with the prepared distal femur shown in phantom;

Figure 14 is a medial perspective view of another exemplary patient-specific guide of the present invention, the patient-specific guide having a modular platform, which may be used for intraoperative customization; and

Figure 15 is a medial perspective view of yet another exemplary patient-specific guide of the present invention, the patient-specific guide having a removable bottom plate, which may be used for intraoperative customization.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate exemplary embodiments of the invention and such exemplifications are not to be construed as limiting the scope of the invention in any manner.
DETAILED DESCRIPTION

[0026] Orthopedic system 10 is provided for preparing femur 100 to receive a distal femoral prosthesis 50 (Figure 10). An exemplary orthopedic system 10 includes a patient-specific guide 12 (Figures 1-6), a milling tool 14 (Figure 7A), and optionally a cutting tool 16 (Figure 7B). Although orthopedic system 10 is described and depicted herein as being used to prepare femur 100, orthopedic system 10 may be used to prepare other anatomical structures, such as the tibia, radius, ulna, and other bones, to receive corresponding orthopedic prostheses.

[0027] As shown in Figure 1, distal end 102 of femur 100 includes anterior surface 104, distal surface 106, and posterior surface 108. Also, distal end 102 of femur 100 includes medial condyle 110, lateral condyle 112, and intercondylar notch 114 located between medial condyle 110 and lateral condyle 112. During flexion and extension of the knee, medial condyle 110 and lateral condyle 112 of femur 100 articulate against the proximal end of a tibia (not shown), and a patella (not shown) glides across anterior surface 104 of femur 100.

[0028] Referring to Figures 1-6, an exemplary guide 12 of orthopedic system 10 includes anterior platform 20, intermediate platform 22 that extends obtusely from anterior platform 20, and distal platform 24 that extends obtusely from intermediate platform 22. Distal platform 24 may be transverse or substantially perpendicular to anterior platform 20. Guide 12 also includes top surface 26 and an opposing bottom surface 28 that span platforms 20, 22, 24.

[0029] Guide 12 further includes milling tracks 20a, 22a, 24a, that are defined by platforms 20, 22, 24, respectively, for guiding milling tool 14 (Figure 7A) across distal end 102 of femur 100. Each milling track 20a, 22a, 24a, of guide 12 extends entirely through its respective platform 20, 22, 24, from top surface 26 to bottom surface 28. The number, size, and arrangement of milling tracks 20a, 22a, 24a, may vary depending on the particular instrument being used and the desired resection of femur 100, for example. Each milling track 20a, 22a, 24a, of guide 12 includes an opening 20b, 22b, 24b, that is
larger in size than the respective milling track 20a, 22a, 24a, to receive milling tool 14 therein, as described further below. Aside from openings 20b, 22b, 24b, milling tracks 20a, 22a, 24a, are narrow in width to capture milling tool 14 therein. As shown in Figures 3 and 5, each milling track 20a, 22a, 24a, includes a plurality of substantially parallel segments 20c, 22c, 24c, and a transverse, interconnecting segment 20d, 22d, 24d.

[0030] Guide 12 further includes legs 30, 32, 34, that extend from bottom surface 28 of guide 12, as shown in Figure 1. More particularly, legs 30 extend from bottom surface 28 of anterior platform 20, legs 32 extend from bottom surface 28 of intermediate platform 22, and legs 34 extend from bottom surface 28 of distal platform 34. Each leg 30, 32, 34, includes a corresponding referencing end 30a, 32a, 34a. Each referencing end 30a, 32a, 34a, may have a partially rounded shape and/or smooth edges such that referencing ends 30a, 32a, 34a, can be rested against cartilage or soft tissue without puncturing the cartilage.

[0031] In addition to having milling tracks 20a, 22a, 24a, guide 12 may further include at least one cut referencing surface 38 for guiding cutting tool 16 (Figure 7B) across distal end 102 of femur 100. As shown in Figures 5 and 6, cut referencing surface 38 of guide 12 is a planar surface defined by distal platform 24 and leg 34 of guide 12. In the illustrated embodiment, cut referencing surface 38 of guide 12 extends in a direction substantially perpendicular to distal platform 24 of guide 12. Although cut referencing surface 24 is illustrated as a single, planar surface, it is also within the scope of the present invention that guide 12 may include an elongate slot for guiding cutting tool 16 across distal end 102 of femur 100 in a captured manner.

[0032] Referring next to Figures 7A and 7B, exemplary surgical tools of orthopedic system 10 are illustrated. As shown in Figure 7A, an exemplary milling tool 14 of orthopedic system 10 includes handpiece 80, rotating shaft 82 that extends through handpiece 80, and burr 84. Handpiece 80 of milling tool 14 includes top abutment surface 86 and burr 84 of milling tool 14 includes bottom abutment surface 88 that is spaced apart from top abutment surface 86 and faces top abutment surface 86. Burr 84 is coupled to rotating shaft 82 for rotation therewith. Burr 84 is configured to cut bone
when it is placed against bone and rotated via rotating shaft 82. For example, burr 84 may include teeth 84a that are configured to cut bone. As shown in Figure 7B, an exemplary cutting tool 16 of orthopedic system 10 includes handpiece 90 and an oscillating blade 92 that moves relative to handpiece 90 to cut bone.

[0033] Referring next to Figure 8, an exemplary method 200 is provided for using a patient-specific guide 12 to prepare distal end 102 of femur 100.

[0034] First, in step 202 of method 200, the surgeon obtains image data of a patient's knee joint, including distal end 102 of femur 100, using a suitable imaging modality, such as magnetic resonance imaging (MRI), computed tomography (CT), ultrasound, or any another suitable imaging technique by which a volumetric, three dimensional image data set of the patient's joint may be obtained.

[0035] Optionally, the patient's knee joint may be placed in extension and tension while obtaining the imaging data. In patients who have arthritis or another disease or condition that affects the knee joint, for example, it may be helpful for the surgeon to assess the joint space between distal end 102 of femur 100 and the proximal end of the tibia (not shown) in tension to properly size the orthopedic prosthesis and to optimally reconstruct the knee joint. A suitable brace (not shown) may be applied about the knee joint or may be used to pull on the ankle, for example, in order to place the knee joint in tension when the patient's leg is extended. In this manner, when the imaging data is obtained, femur 100, the tibia (not shown), and the surrounding soft tissue are all visible about the joint space such that the surgeon may evaluate soft tissue laxity to properly determine the size and position of the orthopedic prosthesis, as discussed further below.

[0036] In addition to obtaining three dimensional imaging data of the knee joint when the knee is in extension, further imaging data may also be obtained of the knee joint in flexion, such as in mid flexion, in 90° flexion, or in full flexion. In one embodiment, additional three dimensional volumetric scans may be obtained in each of the foregoing positions. Alternatively, a two-dimensional imaging modality, such as an X-ray or fluoroscopy, may be used to obtain additional images in one or more positions in which
the knee joint is in flexion, and a tension brace of the type described above may be used to assess laxity in the joint space. As described below, this additional imaging data may be used to construct a computer model of the knee joint and/or aid in the determination of the size and positioning of the orthopedic prosthesis.

Next, in step 204 of method 200, the imaging data of femur 100 obtained during step 202 may be processed by a computer planning system which includes suitable computer software to generate a three-dimensional computer model of femur 100. For example, the computer planning system may include image processing software that is able to segment, or differentiate, the desired anatomic structure (e.g., bone tissue) from undesired structures (e.g., the surrounding soft tissue in the joint). Then, the image processing software generates a computer model of the desired structure. One suitable method for generating a computer model of a desired anatomic structure involves assigning a grey value to each pixel of the imaging data, setting a threshold grey value, and segmenting desired pixels from undesired pixels based on the threshold grey value, as discussed in U.S. Patent No. 5,768,134 to Swaelens et al., the disclosure of which is expressly incorporated herein by reference.

Using the computer model from step 204, the surgeon then selects a model of a desired prosthesis. According to an exemplary embodiment of the present invention, the computer planning system displays the computer model to the surgeon so that the surgeon can evaluate the anatomy of the joint to determine the implant solution that is optimized for the anatomical needs of the patient. Selecting the model of the desired prosthesis may involve designing a custom, patient-specific prosthesis in step 205a of method 200 or choosing a standard prosthesis from a set of known orthopedic prostheses in step 205b of method 200. For example, in step 205a, the surgeon or computer planning system may design a model of a patient-specific implant that best matches the anatomical needs of the patient. Alternatively, in step 205b, the surgeon or computer planning system may access a digital database or library of known orthopedic prostheses and select a model of a desired prosthesis from the database.
Then, in step 206 of method 200, the surgeon uses the computer model of femur 100 to position and orient the desired orthopedic prosthesis from step 205 relative to the bone. It is within the scope of the present invention that the orienting and positioning step 206 may occur after or simultaneously with the selecting step 205. According to an exemplary embodiment of the present invention, the surgeon overlays a digital representation or image of the desired prosthesis onto the computer model of the bone to ensure the proper size of the desired prosthesis and the proper orientation of the desired prosthesis relative to the bone.

In certain embodiments, the surgeon or computer planning system may evaluate soft tissue laxity to properly size multiple prostheses simultaneously. For example, the computer planning system may evaluate soft tissue laxity in the knee joint to simultaneously size a distal femoral prosthesis 50 (Figure 10) and a proximal tibial prosthesis (not shown). Also, if multiple data sets of the knee joint in various positions of extension and flexion have been obtained, the same may be used for modeling a dynamic representation of the joint in which the surgeon may assess the joint in multiple positions of extension and flexion.

After the surgeon plans the size and location of the desired prosthesis using the computer model during step 206, the computer planning system determines at step 208 of method 200 which portions of the bone must be removed from the computer model to receive the desired prosthesis. In one embodiment, the computer planning system may identify for removal areas of overlap between the computer model of the bone and the digital model of the desired prosthesis. For example, using the computer model of the bone and the digital model of the desired prosthesis, the computer planning system may determine that a cavity must be formed in anterior surface 104 and distal surface 106 of femur 100, that posterior surface 108 of femur 100 must be cut along medial condyle 110 and/or lateral condyle 112, and that anchor holes must be drilled into femur 100 so that femur 100 may receive the desired distal femoral prostheses 50 (Figure 10).

Next, in step 210 of method 200, the computer planning system designs a custom, patient-specific guide 12 based on the calculations from step 208. For example,
the computer planning system may determine the shape and size of platforms 20, 22, 24, milling tracks 20a, 22a, 24a, and legs 30, 32, 34, of the patient-specific guide 12. The patient-specific guide 12 may be an entirely custom product that is manufactured using a casting/molding process or a rapid prototyping process, such as 3-D printing, stereolithography, selective laser sintering, fused deposition modeling, laminated object manufacturing, or electron beam melting, for example. Alternatively, the patient-specific guide 12 may be manufactured by removing material from a standard guide (e.g. from legs 30, 32, 34, of a standard guide).

[0043] Guide 12 may be constructed of a material that is able to withstand contact from milling tool 14 (Figure 7A) and/or cutting tool 16 (Figure 7B). In certain embodiments, guide 12 may be constructed entirely of a suitable plastic or metal. In other embodiments, guide 12 may be constructed of more than one material. For example, platforms 20, 22, 24, and milling tracks 20a, 22a, 24a, of guide 12 may be constructed of metal to withstand contact from milling tool 14 (Figure 7A), while legs 30, 32, 34, of guide 12 may be constructed of plastic. In this example, the metallic platforms 20, 22, 24, may be standard, ready-made components that are snapped into the custom-made, plastic legs 30, 32, 34, as shown in Figure 14. In another example, the majority of guide 12 may be constructed of plastic except for a metallic shield or plate 29 attached to bottom surface 28 of guide 12 to withstand contact from milling tool 14 (Figure 7A), as shown in Figure 15.

[0044] The modular guides 12 of Figures 14 and 15 may permit intraoperative customization. For example, a set of modular metallic platforms 20, 22, 24, may be provided, and the surgeon may choose, intraoperatively, desired platforms 20, 22, 24, from the set.

[0045] Then, in step 212 of method 200, the surgeon accesses distal end 102 of femur 100, such as using a minimally invasive surgical procedure, and, if necessary, the surgeon moves the patella (not shown) away from femur 100.

[0046] After distal end 102 of femur 100 is exposed in step 212, the surgeon continues to step 214 of method 200 and places the patient-specific guide 12 against
femur 100. First, the surgeon orients the patient-specific guide 12 with bottom surface 28 of guide 12 facing toward femur 100 and top surface 26 of guide 12 facing away from femur 100, as shown in Figure 1. The surgeon then places legs 30, 32, 34, of guide 12 against femur 100. Because legs 30, 32, 34, project beyond bottom surface 28 of guide 12, platforms 20, 22, 24, of guide 12 hover above femur 100 when legs 30, 32, 34, contact femur 100, as shown in Figure 1.

[0047] According to an exemplary embodiment of the present invention, the patient-specific guide 12 conforms to femur 100 at a single predetermined location. For example, referencing ends 30a, 32a, 34a, of legs 30, 32, 34, may be shaped to match the contour of femur 100 at a single predetermined location. In the illustrated embodiment, referencing end 30a of leg 30 is shaped to match the contour of anterior surface 104 of femur 100 beneath anterior platform 20 of guide 12 (Figure 2), referencing end 32a of leg 32 is shaped to match the contour of anterior surface 104 of femur 100 beneath intermediate platform 22 of guide 12 (Figure 2), and referencing end 34a of leg 34 is shaped to match the contour of distal surface 106 of femur 100 beneath distal platform 24 of guide 12 (Figure 6). In this exemplary embodiment, the surgeon is able to ensure that guide 12 is properly aligned by visualizing all of the legs 30, 32, 34, resting flush against femur 100 and/or by receiving tactile feedback of the fit between guide 12 and femur 100. If one leg 30, for example, is hovering away from femur 100, the surgeon will know to reposition guide 12 relative to femur 100 because the surgeon may visualize a gap between leg 30 and femur 100 and/or because the surgeon may feel that guide 12 is unbalanced on femur 100.

[0048] Once guide 12 is properly aligned with femur 100, the surgeon may temporarily secure guide 12 to femur 100 in step 216 of method 200. As shown in Figure 3, the surgeon may temporarily secure guide 12 to femur 100 by inserting screws, nails, or other suitable anchors (not shown) through apertures 36 in guide 12 and into the bone of femur 100. Any suitable number and arrangement of apertures 36 may be provided in guide 12. For example, although apertures 36 are shown as being located in intermediate
platform 22 of guide 12, apertures 36 may be located in anterior platform 20 and/or distal platform 24 of guide 12.

[0049] Next, in step 218 of method 200, the surgeon uses the patient-specific guide 12 to shape distal end 102 of femur 100. In operation, guide 12 (Figures 1-6) controls the position of milling tool 14 (Figure 7A) relative to femur 100 so that milling tool 14 removes a desired portion of bone from femur 100. With guide 12 secured to femur 100, as shown in Figure 1, the surgeon first inserts milling tool 14 into opening 20b, 22b, 24b, of a desired milling track 20a, 22a, 24a. Then, milling tool 14 is moved into the desired milling track 20a, 22a, 24a, with top abutment surface 86 of milling tool 14 abutting top surface 26 of guide 12 to prevent milling tool 14 from being pushed too far beneath guide 12 toward femur 100. Thus, the depth of insertion of burr 84 into femur 100 is governed by the distance between top surface 26 of guide 12 and femur 100, which distance may be varied by altering the length of legs 30, 32, 34, for example. Also, bottom abutment surface 88 of milling tool 14 may abut bottom surface 28 of guide 12 to prevent milling tool 14 from being pulled away from guide 12 and femur 100. As the surgeon moves milling tool 14 through milling tracks 20a, 22a, 24a, burr 84 rotates beneath platforms 20, 22, 24, of guide 12 to remove a desired portion of bone from femur 100. For example, as shown in Figure 9, guide 12 and milling tool 14 may be used to mill cavity 120 into femur 100 that spans anterior surface 104 and distal surface 106 of femur 100.

[0050] It is within the scope of the present invention that platforms 20, 22, 24, of guide 12 may be non-planar, such that the depth of insertion of burr 84 into femur 100 varies across the surface of femur 100. An exemplary guide 12 and an exemplary milling tool 14 are described in U.S. Patent Application Serial No. 11/687,161, entitled "SINGLE PLANE ANATOMIC REFERENCING TISSUE PREPARATION," the entire disclosure of which is expressly incorporated herein by reference.

[0051] In addition to milling femur 100 using guide 12 and milling tool 14, the surgeon may use guide 12 and cutting tool 16 (Figure 7B) to cut portions of femur 100. For example, the surgeon may drag the oscillating blade 92 of cutting tool 16 along
referencing surface 38 of guide 12 and posterior surface 108 of femur 100 (Figures 5 and 6) to resect medial condyle 110 and/or lateral condyle 112 along cut line 122 (Figures 12 and 13). It is also within the scope of the present invention that guide 12 may be provided with other cut referencing surfaces or cut slots so that the surgeon is able to cut other surfaces of femur 100, including anterior surface 104 and/or distal surface 106 of femur 100.

Guide 12 may include other features for preparing femur 100 to receive distal femoral prostheses 50 (Figure 10). For example, it is within the scope of the present invention that guide 12 may include holes (not shown) for drilling anchor holes 124 (Figure 9) into femur 100. These holes in guide 12 may be similar to apertures 36 in guide 12, which are described above for attaching guide 12 to femur 100.

According to an exemplary embodiment of the present invention, the bone actually removed from femur 100 using the patient-specific guide 12 during step 218 corresponds to the resection planned using the computer model of femur 100 during step 208. As discussed above in the description of step 208, the computer planning system may determine, for example, that a cavity must be formed in anterior surface 104 and distal surface 106 of femur 100, that medial condyle 110 and/or lateral condyle 112 must be cut along posterior surface 108 of femur 100, and that anchor holes must be drilled into femur 100. Then, in step 210, the computer planning system designs a patient-specific guide 12 that will guide resection of femur 100 as planned. For example, the computer planning system may vary the size and shape of platforms 20, 22, 24, milling tracks 20a, 22a, 24a, and legs 30, 32, 34, to design a patient-specific guide 12 that will guide resection of femur 100 as planned. Returning to the previous example, the surgeon may then use the patient-specific guide 12 to: (1) form cavity 120 in anterior surface 104 and distal surface 106 of femur 100 (Figure 9) that corresponds to the planned cavity, (2) cut medial condyle 110 and/or lateral condyle 112 of femur 100 along cut line 122 (Figure 12) that corresponds to the planned cut line, and/or (3) form anchor holes 124 in femur 100 (Figure 9) that correspond to the planned anchor holes.
After preparing femur 100 in step 218, the desired distal femoral prosthesis 50 is provided to the surgeon. Providing the desired prosthesis may involve manufacturing a custom, patient-specific prosthesis in step 219a of method 200 based on the patient-specific prosthesis designed during step 205a. Alternatively, providing the desired prosthesis may involve choosing a standard prosthesis from a set of known orthopedic prostheses in step 219b of method 200 based on the model selected during step 205b.

According to an exemplary embodiment of the present invention, a patient-specific distal femoral prosthesis 50 may be provided in step 219a that is sized and shaped to replicate the portion of bone that was removed from femur 100 using guide 12. However, if the natural articulating surface of femur 100 had been damaged or had deteriorated, the patient-specific distal femoral prosthesis 50 may be sized and shaped to replicate the portion of bone that was removed from femur 100 using guide 12, as well as the portion of bone that was missing from femur 100 due to disease or traumatic injury, for example. In this embodiment, articulating surface 52 of distal femoral prosthesis 50 may be sized and shaped to replicate the natural articulating surface of femur 100.

According to another exemplary embodiment of the present invention, the same computer planning system that plans the desired resection may be used to design and/or manufacture a patient-specific distal femoral prosthesis 50. In certain embodiments, the patient-specific distal femoral prosthesis 50 may be an entirely custom product that is manufactured using a casting/molding process or a rapid prototyping process, such as 3-D printing, stereolithography, selective laser sintering, fused deposition modeling, laminated object manufacturing, or electron beam melting, for example. In other embodiments, and as shown in Figure 11, the patient-specific distal femoral prosthesis 50 be manufactured by providing a bulk construct or block 60 having top surface 62 and a standard bottom surface 64 and then machining top surface 62 of block 60 to form the patient-specific distal femoral prosthesis 50, 50', 50", having articulating surface 52, 52', 52", that match each patient's particular anatomy and the same bone-engaging surfaces 54, 54', 54". Advantageously, providing block 60 having a
standard bottom surface 64 will standardize some features of the patient-specific guide 12.

[0057] Finally, in step 220 of method 200, the surgeon implants the desired distal femoral prosthesis 50 in distal end 102 of femur 100. Distal femoral prosthesis 50 may be a unicompartmental implant, a bicompartamental implant, or a total femoral implant, for example. An exemplary distal femoral prosthesis 50 is illustrated in Figure 10 and includes a top articulating surface 52 and a bottom bone-engaging surface 54. Distal femoral prosthesis 50 may also include one or more anchors or pegs 56 that project from bone-engaging surface 54 of distal femoral prosthesis 50, as shown in Figure 10.

[0058] In operation, the surgeon secures distal femoral prosthesis 50 to femur 100 with bone-engaging surface 54 of distal femoral prosthesis 50 abutting the prepared distal end 102 of femur 100, as shown in Figures 12 and 13. Distal femoral prosthesis 50 may be secured to femur 100 using a suitable adhesive such as bone cement or mechanical fasteners, for example. The attachment between distal femoral prosthesis 50 and femur 100 may be enhanced by inserting pegs 56 of distal femoral prosthesis 50 into anchor holes 124 of femur 100.

[0059] According to an exemplary embodiment of the present invention, distal femoral prosthesis 50 may be at least partially inlayed into the prepared distal end 102 of femur 100. For example, as shown in Figures 12 and 13, proximal end 58 of distal femoral prosthesis 50 fits within cavity 120 and is inlayed in femur 100. An inlayed prosthesis provides a smooth transition between the prosthesis and surrounding cartilage and/or bone, which may facilitate a smooth articulation with adjacent anatomical structures. In the illustrated embodiment, distal femoral prosthesis 50 is inlayed to provide a smooth transition region 126 between prosthesis 50 and anterior surface 104 of femur 100. For example, articulating surface 52 of distal femoral prosthesis 50 and anterior surface 104 of femur 100 may rest in substantially the same plane, such that articulation across surfaces 52, 104, is substantially continuous. Other portions of distal femoral prosthesis 50 may rest atop a prepared surface of femur 100. For example, as
shown in 12, distal end 59 of distal femoral prosthesis 50 rests atop femur 100 along cut line 122.

While this invention has been described as having exemplary designs, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.
WHAT IS CLAIMED IS:

1. An orthopedic guide for preparing a particular patient's bone to receive a prosthesis using a milling tool with a rotating burr, the orthopedic guide comprising:
   a platform having a top surface and a bottom surface that faces the patient's bone, the platform defining an elongate milling track that extends through the platform from the top surface to the bottom surface of the platform, the milling track being sized and shaped to guide the milling tool across the patient's bone with the burr of the milling tool rotating beneath the bottom surface of the platform to remove a first bone portion from the patient's bone; and
   a plurality of legs coupled to the platform, each of the plurality of legs comprising a referencing end that is contoured to abut the patient's bone, the referencing ends of the plurality of legs cooperating to locate the orthopedic guide at a predetermined location of the patient's bone.

2. The orthopedic guide of claim 1, wherein the plurality of legs project beneath the bottom surface of the platform such that the bottom surface of the platform hovers above the patient's bone when the referencing ends of the plurality of legs abut the patient's bone.

3. The orthopedic guide of claim 1, wherein the plurality of legs are spaced apart about a periphery of the platform.

4. The orthopedic guide of claim 1, wherein the platform includes an anterior portion, an intermediate portion that extends obtusely from the anterior portion of the platform, and a distal portion that extends obtusely from the intermediate portion of the platform, the orthopedic guide configured for use with the patient's femur such that the anterior portion of the platform rests above an anterior surface of the patient's femur and the distal portion of the platform rests above a distal surface of the patient's femur.
5. The orthopedic guide of claim 4, wherein the milling track spans the anterior portion, the intermediate portion, and the distal portion of the platform.

6. The orthopedic guide of claim 1, wherein the platform includes an anterior portion and a distal portion that extends substantially perpendicular to the anterior portion of the platform, the orthopedic guide configured for use with the patient's femur such that the anterior portion of the platform rests above an anterior surface of the patient's femur and the distal portion of the platform rests above a distal surface of the patient's femur.

7. The orthopedic guide of claim 1, wherein the milling track includes an enlarged opening for receiving the burr of the milling tool, the milling track narrowing in width apart from the enlarged opening to retain the burr of the milling tool beneath the platform.

8. The orthopedic guide of claim 1, wherein the milling track includes a plurality of substantially parallel segments and a transverse interconnecting segment that joins together the plurality of substantially parallel segments.

9. The orthopedic guide of claim 1, wherein the platform further defines a substantially planar cut referencing surface that is configured to guide a cutting tool across the patient's bone to remove a second bone portion from the patient's bone.

10. The orthopedic guide of claim 9, wherein the cut referencing surface is located on an exterior surface of the platform.

11. A method for preparing a particular patient's bone to receive a prosthesis having an articulating surface and a bone-engaging surface, the method comprising the steps of:
    providing a digital model of the bone;
    identifying a portion of the bone to be removed to receive the prosthesis;
    providing a patient-specific guide;
using the patient-specific guide to remove the identified portion of the bone, thereby forming a prepared surface of the bone; and
inlaying the prosthesis into the bone by positioning the bone-engaging surface of the prosthesis against the prepared surface of the bone, the articulating surface of the prosthesis transitioning smoothly into a remaining surface of the bone located adjacent to the prepared surface of the bone.

12. The method of claim 11, further comprising the step of providing a digital model of the prosthesis.

13. The method of claim 12, wherein the identifying step comprises overlaying the digital model of the prosthesis onto the digital model of the bone.

14. The method of claim 11, wherein the using step comprises at least one of milling and cutting the bone.

15. The method of claim 11, wherein the inlaying step comprises aligning the articulating surface of the prosthesis and the remaining surface of the bone in substantially the same plane.

16. A method for preparing a particular patient's bone to receive a prosthesis, the method comprising the steps of:
   providing a digital model of the bone;
   providing a digital model of the prosthesis, the digital model of the prosthesis having a bone-contacting surface with a predetermined shape;
   identifying a portion of the bone to be removed to receive the bone-contacting surface of the prosthesis;
   providing a patient-specific guide to remove the identified portion of the bone;
   and
   manufacturing the prosthesis to fill at least the removed portion of the bone.
17. The method of claim 16, wherein the removed portion of the bone has a three-dimensional geometry, the manufacturing step comprising manufacturing the prosthesis to replicate the three-dimensional geometry of the removed portion of the bone.

18. The method of claim 16, wherein the manufacturing step comprises at least one of a rapid prototyping process and a casting process.

19. The method of claim 16, wherein the manufacturing step comprises removing material from a bulk construct to form an articulating surface of the prosthesis while retaining a bone-engaging surface of the bulk construct.

20. The method of claim 16, wherein the patient-specific guide is contoured to rest against a predetermined location of the bone.
202 Obtain image data of bone

204 Generate three-dimensional model of bone

205a Design model of patient-specific prosthesis

205b Select model of prosthesis from set

206 Position and orient desired orthopedic prosthesis

208 Plan resection

210 Design patient-specific guide

212 Access bone

214 Place patient-specific guide against bone

216 Secure patient-specific guide to bone

218 Shape bone using patient-specific guide

219a Manufacture patient-specific prosthesis

219b Select prosthesis from set

220 Implant desired orthopedic prosthesis

FIG. 8
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/15 A61B17/17
ADD.

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)
A61B

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 practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

* 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 document 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

"A" document member of the same patent family

Date of the actual completion of the international search
25 February 2011

Date of mailing of the international search report
22/03/2011

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax. (+31-70) 340-3016

Authorized officer
Fernandez Ari llo, J
INTERNATIONAL SEARCH REPORT

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.: 11-20
   because they relate to subject matter not required to be searched by this Authority, namely:
   Pursuant to Rule 39.1(iv) PCT, the subject-matter of claims 11-20 has not been searched, since it is directed to a method for treatment of the human body by surgery (preparing a bone to receive a prosthesis).

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).

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

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 an 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.:

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.
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