United States Patent Application Publication	20250255728
Kind Code	A1
Publication Date	August 14, 2025
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Femoral Component For Bone Conservation

Abstract

A femoral prosthetic component includes a patellar guide portion, a pair of condyles projecting from the guide portion and forming an intercondylar notch therebetween, a bearing surface, and an interface surface configured to face a resected surface of a femur. The interface surface comprises an anterior face and a posterior face, and is substantially contoured between the anterior and posterior face to match a contoured surface of the femur. The substantially contoured interface surface may include at least one planar surface portion to about a flat cut portion in the surface of the femur. This planar surface portion may be a distal flat at a distal face of the interface surface. The contoured interface surface may alternatively include a plurality of planar surface portions. The femoral prosthetic component is configured such that preparation of the bone to match the interface surface results in minimal resection of the distal femur.

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Family ID: **1000008574928**

Appl. No.: **19/196152**

Filed: **May 01, 2025**

Related U.S. Application Data

parent US continuation 18370945 20230921 parent-grant-document US 12310856 child US 19196152
parent US continuation 17360095 20210628 parent-grant-document US 11793649 child US 18370945
parent US continuation 16249462 20190116 ABANDONED child US 17360095
parent US continuation 14578007 20141219 parent-grant-document US 10219908 child US

16249462
us-provisional-application US 61921964 20131230

Publication Classification

Int. Cl.: **A61F2/38** (20060101); **A61B17/16** (20060101); **A61B34/30** (20160101); **A61B34/37** (20160101); **A61F2/30** (20060101)

U.S. Cl.:

CPC **A61F2/3859** (20130101); **A61B17/1675** (20130101); **A61B34/30** (20160201); **A61B34/37** (20160201); A61F2002/30878 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. application Ser. No. 18/370,945, filed Sep. 21, 2023, which is a continuation of U.S. application Ser. No. 17/360,095, filed Jun. 28, 2021, now U.S. Pat. No. 11,793,649, which is a continuation of U.S. application Ser. No. 16/249,462, filed on Jan. 16, 2019, which is a continuation of U.S. application Ser. No. 14/578,007, filed on Dec. 19, 2014, now U.S. Pat. No. 10,219,908, which claims the benefit of and priority to U.S. Provisional Patent Application Ser. No. 61/921,964, filed Dec. 30, 2013, the disclosures of which are hereby incorporated herein by reference in their entirety.

BACKGROUND
[0002] The present invention relates generally to orthopedic prosthesis systems used in knee joint replacement surgeries and, more particularly, to a femoral implant for use in knee arthroplasty procedures.
[0003] The knee joint comprises the interface between the distal end of the femur and the proximal end of the tibia. In a properly-functioning knee joint, medial and lateral condyles of the femur pivot smoothly along menisci attached to respective medial and lateral condyles of the tibia. When the knee joint is damaged, the natural bones and cartilage that form the joint may be unable to properly articulate, which can lead to joint pain and, in some cases, interfere with normal use of the joint.
[0004] In some situations, surgery is required to restore normal use of the joint and reduce pain. Depending upon the severity of the damage, the surgery may involve partially or completely replacing the joint with prosthetic components. During such knee replacement procedures, a surgeon resects damaged portions of the bone and cartilage, while attempting to leave healthy tissue intact. The surgeon then fits the healthy tissue with artificial prosthetic components designed to replicate the resected tissue and restore proper knee joint operation.
[0005] One knee replacement procedure—total knee arthroplasty (“TKA”)—involves the resection of some or all of each of the medial and lateral condyles of both the femur and tibia and the removal of the fibro-cartilage menisci located at the femorotibial interface. A prosthetic femoral component, typically made of titanium or other strong, surgical-grade metal, is fitted and secured to the distal end of the femur to replace the resected portion of the femur. Similarly, a prosthetic tibial component, the base of which is also typically made of titanium or other suitable metal, is fitted and secured to the proximal end of the tibia to replace the resected portion of the tibia.
[0006] Femoral components commonly utilize a bone facing surface having a five-cut or five-surface baseline configuration, such as that depicted in FIGS. **1**A-**1**C. These designs are typically not directed to patient-specific anatomy and use relatively basic lines and arcs for reduced cost

manufacture. Designs of this type can be generally used on many patients having unique knee joint anatomies, and scaled only in size to accommodate the particular patient. Though advantageous for manufacture, the five basic cut design may require a high amount of bone volume to be removed in preparation to receive the implant thereon, thereby significantly reducing the strength of the bone.

SUMMARY

[0007] A femoral prosthetic component includes a patellar guide portion, a pair of condyles projecting from the guide portion and forming an intercondylar notch therebetween, a bearing surface, and an interface surface configured to face a resected surface of a femur. The interface surface comprises an anterior face and a posterior face, and is substantially contoured between the anterior and posterior face to match a contoured surface of the femur. The substantially contoured interface surface may include at least one planar surface portion to abut a flat cut portion in the surface of the femur. This planar surface portion may be a distal flat at a distal face of the interface surface. The contoured interface surface may alternatively include a plurality of planar surface portions. The femoral prosthetic component may be configured such that preparation of the bone to match the interface surface results in minimal resection of the distal femur.

[0008] Another embodiment of the invention relates to a prosthetic component includes a prosthetic body portion, the body portion having a bearing surface and an interface surface configured to face a resected surface of a bone prepared to receive the prosthetic component. The interface surface is substantially contoured to match a contoured surface of the prepared bone and the contoured interface surface is configured such that preparation of the bone to receive the prosthetic component results in minimal bone resection.

[0009] Yet another embodiment of the invention relates to a method for implanting a prosthetic implant including selecting a prosthetic component, wherein the prosthetic component comprises a prosthetic body portion, the body portion having a bearing surface and an interface surface configured to face a resected surface of a bone prepared to receive the prosthetic component. The method further includes removing, using a first cutting tool, a first portion of the bone to form a resected surface of the bone configured to match a counterpart portion of the interface surface of the prosthetic component. The interface surface of the prosthetic component is substantially contoured and is configured to match the resected surface of the bone that is substantially contoured.

[0010] The invention is capable of other embodiments and of being practiced or being carried out in various ways. Alternative exemplary embodiments relate to other features and combinations of features as may be generally recited in the claims.

Description

BRIEF DESCRIPTION OF THE FIGURES

[0011] The invention will become more fully understood from the following detailed description, taken in conjunction with the accompanying drawings, wherein like reference numerals refer to like elements, in which:

[0012] FIG. **1** illustrates a perspective view of a post-operative prosthetic knee joint fitted with a prosthetic system, consistent with an exemplary embodiment.

[0013] FIG. **2**A illustrates a top view of a first exemplary embodiment of a prosthetic component.

[0014] FIG. **2**B illustrates a side view of the first exemplary embodiment of a prosthetic component.

[0015] FIG. **2**C illustrates a posterior perspective view of the first exemplary embodiment of a prosthetic component.

[0016] FIG. **3**A illustrates a top view of a second exemplary embodiment of a prosthetic component.

[0017] FIG. **3**B illustrates a side view of the second exemplary embodiment of a prosthetic component.
[0018] FIG. **3**C illustrates a posterior perspective view of the second exemplary embodiment of a prosthetic component.
[0019] FIG. **4**A illustrates a top view of a third exemplary embodiment of a prosthetic component.
[0020] FIG. **4**B illustrates a side view of the third exemplary embodiment of a prosthetic component.
[0021] FIG. **4**C illustrates a posterior perspective view of the third exemplary embodiment of a prosthetic component.
[0022] FIG. **5**A illustrates a top view of a fourth exemplary embodiment of a prosthetic component.
[0023] FIG. **5**B illustrates a side view of the fourth exemplary embodiment of a prosthetic component.
[0024] FIG. **5**C illustrates a posterior perspective view of the fourth exemplary embodiment of a prosthetic component.
[0025] FIG. **6** illustrates a side view of a fifth exemplary embodiment of a prosthetic component.
[0026] FIG. **7** illustrates a side view of a sixth exemplary embodiment of a prosthetic component.
[0027] FIG. **8** illustrates a side perspective view of a seventh exemplary embodiment of a prosthetic component.
[0028] FIG. **9**A illustrates a perspective view of an eighth exemplary embodiment of a prosthetic component.
[0029] FIG. **9**B illustrates a top view of the eighth exemplary embodiment of a prosthetic component.
[0030] FIG. **10**A illustrates a perspective view of a ninth exemplary embodiment of a prosthetic component.
[0031] FIG. **10**B illustrates a top view of the ninth exemplary embodiment of a prosthetic component.
[0032] FIG. **11**A illustrates a perspective view of a tenth exemplary embodiment of a prosthetic component.
[0033] FIG. **11**B illustrates a top view of the tenth exemplary embodiment of a prosthetic component.
[0034] FIG. **12**A illustrates a front perspective view of an eleventh exemplary embodiment of a prosthetic component.
[0035] FIG. **12**B illustrates a rear perspective view of the eleventh exemplary embodiment of a prosthetic component.
[0036] FIG. **13**A illustrates a front perspective view of a twelfth exemplary embodiment of a prosthetic component.
[0037] FIG. **13**B illustrates a rear perspective view of the twelfth exemplary embodiment of a prosthetic component.
[0038] FIG. **14**A illustrates a front perspective view of a thirteenth exemplary embodiment of a prosthetic component.
[0039] FIG. **14**B illustrates a rear perspective view of the thirteenth exemplary embodiment of a prosthetic component.
[0040] FIG. **15** illustrates a rear view of a fourteenth exemplary embodiment of a prosthetic component.
[0041] FIG. **16** illustrates a side view of a prosthetic component according to an exemplary embodiment having a first embodiment of an elongated projection.
[0042] FIG. **17** illustrates a side view of a prosthetic component according to an exemplary embodiment having a second embodiment of an elongated projection.
[0043] FIG. **18** illustrates a side view of a prosthetic component according to an exemplary embodiment having a third embodiment of an elongated projection.

[0044] FIG. **19**A illustrates a side view of a first embodiment of a trial projection.
[0045] FIG. **19**B illustrates a top view of the first embodiment of a trial projection.
[0046] FIG. **20**A illustrates a side view of a second embodiment of a trial projection.
[0047] FIG. **20**B illustrates a top view of the second embodiment of a trial projection.
[0048] FIG. **21**A illustrates a side view of a third embodiment of a trial projection.
[0049] FIG. **21**B illustrates a top view of the third embodiment of a trial projection.
[0050] FIG. **22**A illustrates a side view of a fourth embodiment of a trial projection.
[0051] FIG. **22**B illustrates a top view of the fourth embodiment of a trial projection.
[0052] FIG. **23**A illustrates a side view of a fifth embodiment of a trial projection.
[0053] FIG. **23**B illustrates a top view of the fifth embodiment of a trial projection.
[0054] FIG. **24**A illustrates a side view of a sixth embodiment of a trial projection.
[0055] FIG. **24**B illustrates a top view of the sixth embodiment of a trial projection.
[0056] FIG. **25**A illustrates a rear view of a fifteenth exemplary embodiment of a prosthetic component.
[0057] FIG. **25**B illustrates a front perspective view of the fifteenth exemplary embodiment of a prosthetic component.
[0058] FIG. **25**C illustrates a top view of the fifteenth exemplary embodiment of a prosthetic component.
[0059] FIG. **26**A illustrates a front perspective view of a sixteenth exemplary embodiment of a prosthetic component.
[0060] FIG. **26**B illustrates a top view of the sixteenth exemplary embodiment of a prosthetic component.
[0061] FIG. **27**A illustrates a perspective view of a distal femur prepared to receive a femoral component according to an exemplary embodiment.
[0062] FIG. **27**B illustrates a perspective view of a distal femur having an exemplary femoral component attached thereto.
[0063] FIG. **28** illustrates a perspective view of an embodiment of a surgical system according to an exemplary embodiment.
[0064] FIG. **29** illustrates a block diagram of a model surgical system according to an exemplary embodiment.

DETAILED DESCRIPTION

[0065] Before turning to the figures, which illustrate the exemplary embodiments in detail, it should be understood that the application is not limited to the details or methodology set forth in the description or illustrated in the figures. It should also be understood that the terminology is for the purpose of description only and should not be regarded as limiting.
[0066] FIG. **1** illustrates a prosthetic implant system **110** implanted on a patient's knee. The prosthetic implant system **110** shown comprises a plurality of components, each of which is configured to replace a respective resected portion of the native knee joint. According to one embodiment, prosthetic implant system **110** may include a tibial implant system **120** and a femoral component **130**. After installation during knee replacement surgery, tibial implant system **120** and femoral component **130** cooperate to replicate the form and function of a native knee joint.
[0067] Femoral component **130** may be secured to the distal end of femur **102** and configured to replace the structure and function of the native femoral portion of the knee joint **100**. As such, femoral component **130** may be manufactured from surgical-grade metal or metal alloy material (such as surgical-grade steel, titanium, cobalt-chrome, etc.) that is substantially rigid for providing sufficient strength to support the forces required of the knee joint. According to one embodiment, femoral component **130** may embody a single component having a plurality of different structural features, each configured to perform a particular function associated with the knee joint. For example, femoral component **130** may comprise a pair of condyles **132**, each of which is coupled to a patellar guide portion **133**. The pair of condyles **132** may be separated from one another by an

intercondylar notch **138**, which provides a channel through which one or more cruciate ligaments **103**, such as anterior cruciate ligament (ACL) **103***a* and/or posterior cruciate ligament (PCL) **103***b*, may pass.

[0068] Femoral component **130** may be configured to engage and articulate with portions of tibial implant system **120**, as shown in FIG. **1**. During use, the femur is rotated relative to the tibia during flexion and extension, which causes femoral component **130** depicted in FIG. **1** to rotate relative to a base portion **121** across the top surface of insert portions **123**.

[0069] Referring particularly to FIGS. **2**A-**2**C (and similarly shown in the embodiments of FIGS. **3**A-**26**), the body portion of femoral component **230** comprises a patellar guide portion **233** and a pair of condyles **232**, including a medial condyle **232***a* and lateral condyle **232***b*. Patellar guide portion **233** of femoral component **230** may extend from the front of the distal end of the femur and curve downward toward the intercondylar fossa of the femur, which is exposed by intercondylar notch **238**. Medial and lateral condyles **232***a*, **232***b* project from the bottom of patellar guide portion **233** and extend on either side of intercondylar notch **238**, around the underside of the femur and continuing toward the posterior of the femur.

[0070] The body portion of femoral component **230** also includes a bearing surface **235***a* and an interface surface **235***b*. Bearing surface **235***a* comprises a curved, outward-facing (inferior) surface formed by patellar guide portion **233** and condyles **232**. Accordingly, bearing surface **235***a* is configured to articulate with one or more features of the knee joint, such as the patella (not shown). Interface surface **235***b* comprises the inner (superior) surface of femoral component **230** and is configured to engage with and attach to the resected surface of femur **102**. The above-noted characteristics of femoral component **230** may be included, alone or in combination, as part of each of the exemplary embodiments discussed herein, though specific reference to these features in each embodiment may not be made.

[0071] According to the embodiment of FIGS. **2**A-**2**C, interface surface **235***b* may include a plurality of planar surfaces, each of which corresponds to a resected plane of the femur that has been prepared using a cutting tool having a planar cutting blade. The planar surfaces of the interface surface **235***b* of femoral component **230** are configured to match with an anterior cut, an anterior chamfer cut, a distal cut, a posterior chamfer cut, and a posterior cut. Although illustrated as having five planar surfaces in the baseline embodiment of FIGS. **2**A-**2**C, it is contemplated that interface surface **235***b* may be configured as having any shape suitable for engagement with a resected surface of the femur.

[0072] Indeed, with increasing use and capabilities of computer-assisted surgery (CAS) systems (such as that depicted in FIG. **28** and discussed below), a user may have the freedom to perform a greater variety of cuts, using a variety of tools to prepare the resected surface of the bone. Advantageously, with the ability to make these cuts more efficiently and with greater ease, prosthetic components, and interface surfaces in particular, may be configured in such a way that minimizes the amount of bone that must be resected to prepare the bone, such as the distal end of the femur, to receive the prosthetic component. Other advantages of enhanced interface surface designs include better fixation of the implant on the bone, thinner implants, shorter operating room time, and minimizing stresses and strains on the bone, implant, and fixation cement. Finally, enhanced component designs (made possible by the advances in CAS technology and systems) may allow for tailoring the component to patient-specific anatomy, which can similarly provide the advantages noted above and can result in greater longevity of the component. FIGS. **3**A-**12** show various exemplary embodiments exhibiting the component variations to minimize resected bone and provide at least the advantages described above.

[0073] Referring to FIGS. **3**A-**3**C, femoral component **330** has a multi-planar interface surface **335***b*. In the embodiment shown, the interface surface **335***b* has eight planar surfaces, though any number of planar surfaces may be used. The planar faces include, at least, an anterior face **341**, distal face **343**, and posterior face **345**. Distal face **343** includes distal face portion **343***a* at least

partially on medial condyle **332***a* and distal face portion **343***b* at least partially on lateral condyle **332***b*. Similarly, posterior face **345** includes posterior face portion **345***a* at least partially on medial condyle **332***a* and posterior face portion **345***b* at least partially on lateral condyle **332***b*. As the number of planar surfaces of the interface surface **335***b* increases, the more closely the interface surface **335***b* resembles a fully contoured surface between anterior face **341** and posterior face **345**. Preparing a bone to receive a prosthetic component having a contoured interface surface **335***b* allows for the greatest amount of bone to be conserved. Conversely, larger straight cuts require a greater amount of bone to be resected. The embodiment of FIGS. **3**A-**3**C, having several planar surfaces on its interface surface **335***b*, requires less bone removal than, for example, the embodiment shown in FIGS. **2**A-**2**C. While nearly resembling a contoured interface surface **335***b* and thus providing improved bone conservation, the multi-planar configuration also allows for use of a single tool throughout the preparation process (such as a tool having a planar blade, i.e. straight cut sagittal saw), and is intended to reduce operating room time over configurations that may require changing between tools (for example, to a rotary cutting tool) during the procedure.

[0074] FIGS. **4**A-**4**C depict an embodiment of a femoral component **430** having a fully contoured interface surface **435***b* between anterior face **441** and posterior face **445**. A fully contoured configuration is a preferred configuration for maximum bone conservation. A prepared contoured surface of the distal femur **102**, made possible by using a rotary cutting tool, such as a burr, rather than a sagittal saw for at least some cuts, requires the removal of less bone from the femur **102**. A fully contoured interface surface **435***b* can also advantageously produce a relatively thin implant compared with the profile of the embodiments of FIGS. **2**A-**2**C and **3**A-**3**C.

[0075] FIGS. **5**A-**5**C depict a femoral component **530** having an interface surface **535***b* with a hybrid configuration. Femoral component **530** has an anterior face **541** and posterior face **545** separated by a contoured surface with a distal flat portion **543**, having a first distal flat **543***a* and a second distal flat **543***b*. The configuration of the interface surface **535***b* is a preferred embodiment for its bone conservation advantages (by way of the substantially curved surface between anterior face **541** and posterior face **545**), but as an advantage over the fully contoured configuration of FIGS. **4**A-**4**C, the hybrid configuration of femoral component **530** may also be preferred by surgeons accustomed to flat planar surfaces to aide in positioning and orientation with confidence. Bone preparation to receive femoral component **530** utilizes both a rotary cutter and a straight cut sagittal saw to shape the bone to match interface surface **535***b*. Other features of the embodiment of FIGS. **5**A-**5**C, such as the median groove **533***a*, canopy **550**, and elongated projections **534** will be discussed in greater detail below.

[0076] Other exemplary femoral components are shown in FIGS. **6**-**8**. These exemplary embodiments depict various ways in which femoral components, particularly the interface surface of femoral components, can be modified in order for bone conservation, better patient-specific fit, thinner implant profile, and other component enhancements. As shown in FIG. **6**, femoral component **630** has an anterior face **641**, distal face **643**, and posterior face **645**. In the embodiment shown, distal face is angled distally from anterior face **641** towards posterior face **645**. Femoral component **730** shown in FIG. **7** also includes an anterior face **741**, distal face **743**, and posterior face **745**. In this embodiment, between each of the planar cut segments at the faces **741**, **743**, and **745** is a non-planar surface segment such as cylindrical chamfer cuts **742** and **744**. Cylindrical chamfer cuts **742**, **744** provide a smooth, curved transition between the faces **741**, **743**, **745** of interface surface **735***b*, which as noted above, lessens the amount of bone that must be removed to prepare the bone to receive the implant. Any combination of planar segments and non-planar surface segments may be used in an embodiment similar to provide a substantially contoured interface surface between anterior face **741** and posterior face **745**. In the exemplary embodiment of FIG. **8**, femoral component **830** also comprises an anterior face **841**, distal face **843**, and posterior face **845**. In this embodiment, posterior face **845** is pitched. This pitched surface more closely matches the anatomic configuration of the femur **102**, therefore requiring less bone removal

while still maintaining a substantially uniform thickness of the component **830** from the bone.
[0077] Other embodiments for conserving bone during resection and preparation to receive a femoral component include pitched planar surfaces on the interface surfaces. The embodiments of FIGS. **9**-**11** depict variations of the five-cut femoral component **230** of FIGS. **2**A-**2**C. FIGS. **9**A-**9**B show femoral component **930** having a pitched distal surface **943**. As shown, two pitched planes **943***a* and **943***b* converge towards the center axis (extending substantially along intercondylar notch **938** and between condyles **932**) of femoral component **930** to create the pitched distal surface **943**. The embodiment of FIGS. **10**A-**10**B depicts femoral component **1030** having a pitched distal surface **1043**, as well as a pitched anterior chamfer **1042** and posterior chamfer **1044**. Femoral component **1130**, shown in FIGS. **11**A-**11**B, includes all five pitched surfaces on interface surface **1135***b*, including pitched anterior face **1141**, anterior chamfer **1142**, distal face **1143**, posterior chamfer **1144**, and posterior face **1145**.
[0078] The patellar guide portion of femoral components, such as patellar guide portions **1233**, **1333** and **1433** of FIGS. **12**-**14**, may be configured to emulate the structure and function of the native patellar surface, which is located on the front of the distal end of femur **102**. For example, as shown in FIG. **12**A, patellar guide portion **1233** includes a median groove **1233***a* that is located toward the center of patellar guide portion **1233**. Located on either side of median groove **1233***a* and directly above respective condyles **1232***a*, **1232***b* are a plurality of raised surfaces **1233***b*, **1233***c*. Median groove **1233***a* provides the surface that articulates with the patella (or "kneecap," not shown), while raised surfaces **1233***b*, **1233***c* prevent the patella from sliding outside of median groove **1233***a*. Similarly, FIGS. **13**A and **14**A portray median groove **1333***a* and **1433***a*, respectively.
[0079] In accordance with the present embodiments, one feature of enhanced femoral component structures may be femoral components having a thinner profile, to improve bone conservation, overall effectiveness, and patient satisfaction in the implanted component. In order to accommodate both the thinner profile and a deep median groove (**1233***a*, **1333***a*, or **1433***a*, for example) to emulate the structure and function of the native patellar surface, the interface surface of the femoral component may include a raised canopy portion, such as canopy **1250**, **1350**, **1450**. The raised canopy provides for the median groove on the bearing surface (such as bearing surfaces **1235***a*, **1335***a*, and **1435***a*) without requiring the patellar guide portion and portions of the medial and lateral condyles to take on a thickness that accommodates the depth of the groove.
[0080] The raised canopy can take on a variety of shapes and configurations. As shown in FIG. **12**B, canopy **1250** has a boxed configuration. In the embodiment of FIG. **13**B, canopy **1350** takes on a v-shaped configuration. And in the embodiment shown in FIG. **14**B, canopy **1450** has an arched configuration. The various configurations of the canopies may utilize various bone preparation methods and tools. The bone preparation for the boxed configuration of FIG. **12**B may include a straight saw cut and two reciprocal cuts. The bone preparation for the v-shaped configuration of FIG. **13**B may include two saw cuts in a "v" formation. The bone preparation for the arched configuration of FIG. **14**B may include a cut or cuts using a reamer. The surgical system depicted in FIGS. **28**-**29** may be used to plan bone preparation and to perform the bone preparation cuts.
[0081] As discussed above with reference to FIGS. **1**-**2**, and now particularly referring to FIG. **15**, condyles **1532** may comprise medial condyle **1532***a* and lateral condyle **1532***b*. Condyles **1532** are configured to replace the structure and function of the corresponding native condyles of the femur. As such, condyles **1532** project from the lower portion of patellar guide portion **1533** on the anterior side of femur **102**, curve around the underside of femur **102**, and extend to the posterior side of femur **102**. Condyles **1532** are configured to provide the primary structural and articular support for the femoral component of the knee joint. In an exemplary embodiment depicted in FIG. **15**, the posterior portion of condyles **1532** are curved inwardly towards a center axis of the component **1530** (extending substantially along intercondylar notch **1538** and between condyles

1532) to more closely match the anatomic shape of the posterior region of the femur **102**. Condyles **1532** having a curved posterior shape may allow for a more natural feel for the patient during the range of motion from flexion to extension. The configuration may also provide better contact with the tibia or a tibial component.

[0082] As shown in FIGS. **16-18**, femoral component **530** may include one or more elongated projections **134** that protrude from the interface surface **535***b*. Though the elongated projections **134** are depicted on femoral component **530**, the elongated projections **134** discussed in this section may be used in combination with any of the femoral components discussed above. In preferred embodiments, elongated projections **134** are centered between the medial and lateral edges of each condyle **532***a* and **532***b*. Elongated projections **134** are also preferably centered anterior-posteriorly on the distal face **543**.

[0083] Elongated projections **134** may be inserted into corresponding holes that have been surgically formed within femur **102** during a TKA procedure. The elongated projections **134** may be secured within the holes and configured to limit movement between femoral component **530** and femur **102**. In an exemplary embodiment, elongated projections **134** are configured to be press fit into holes in the femur **102**. Bone cement may be used to further secure the elongated projections **134** in the holes in the femur **102**. The elongated projections **134** provide increased cement bonding surface area, and also provide stability while bonding cement is curing between other surfaces of the femur **102** and the femoral component.

[0084] FIGS. **16-18** depict various design combinations for the elongated projections **134**. Elongated projections **134** may take on various forms, including by way of example, a cylinder (as in elongated projections **1634**, **1734**), a tapered cone (as in elongated projection **1834**), a cruciform, or a dog bone configuration. The elongated projections **134** may have a smooth (as in elongated projection **1634**) or textured finish (as in elongated projections **1734**, **1834**), such as blasted or fluted finish. Thin edges, such as those shown in FIGS. **17** and **18** may bite into the bone more readily than dull edges or more rounded configurations, and therefore can provide greater stability in a press fit engagement with the bone. At the same time, edges are preferably designed so as to not create micro-fractures in the bone as it is advanced into the hole formed in the bone. Finally, the elongated projections **134** may have varying tip designs, including by way of example a flat tip (as in elongated projection **1834**), a tapered tip, or a round tip (as in elongated projections **1634**, **1734**). Though exemplary embodiments are shown in FIGS. **16-18**, any combination of various forms, finishes, and tips may be used. It is contemplated that the embodiments and features of elongated projections **134** may also apply to projections for stabilizing other types of prosthetic components to bone, such as for stabilizing tibial components to the proximal tibia.

[0085] FIGS. **19-24** depict various embodiments of elongated projections that may be used with trial femoral components for confirming the size, geometry, position, and/or orientation of the selected femoral component. The trial projections **136** are preferably shorter than the elongated projections **134** so as not to disrupt the entire length of the holes in the bone, such that elongated projections on femoral component **530** can still achieve a press fit engagement when inserted. The trial projections **136** may have the same or different cross-sectional shape as the intended elongated projections **134**. FIGS. **19-20** depict embodiments wherein the trial projection **136** has the same cross-sectional configuration as the elongated projection **134**. FIGS. **19**A-**19**B show an embodiment having a single slot therein, while FIGS. **20**A-**20**B depict an embodiment that is t-slotted. The slots in the trial projections **136** allow for flexing of the projections as passed into the hole in the bone. FIGS. **21-22** depict embodiments having the same cross-sectional configuration as the elongated projection **134**, but are intended to be shifted in orientation. In this way, small amounts of bone are engaged by the trial projections **136**, but not at the same location as the intended elongated projection **134**, thereby allowing the elongated projection **134** to also engage the bone. FIGS. **22**A-**22**B depict an embodiment that is slotted. FIGS. **23-24** depict embodiments having a different cross-sectional shape as the intended elongated projections **134**. In these figures,

trial projections **136** have a triangle shape. In the embodiments shown, the edges of the triangle are configured to match up with the edges of elongated projections **134**. As shown in the embodiments of FIGS. **19**-**24**, the tip of the trial projections **136** may also vary, and may include flat, rounded, or tapered tip configurations.

[0086] In some embodiments, the femoral components may utilize alternative mechanisms to assist with fixation of the component to the bone. One such embodiment, such as femoral component **2530** shown in FIGS. **25**A-**25**C, does not utilize elongated projections, but rather includes one or more half peg extensions **2560**. Half pegs **2560** may be formed in the interface surface **2535***b* and are configured to fit into similarly shaped recesses in the prepared femur. In the embodiment shown, half pegs **2560** extend longitudinally along the anterior face **2541** and the posterior face **2445** on each of the condyles **2532**. It is contemplated that half pegs **2560** may extend laterally along the anterior face **2541** and the posterior face **2545** on each of the condyles **2532**, or may also be positioned on any portion of the interface surface **2535***b* between the anterior face **2541** and the posterior face **2545**.

[0087] FIGS. **26**A-**26**B depict a femoral component **2630** utilizing both elongated projections **2634** and reinforcing keels **2670** formed in the interface surface **2635***b* to assist with fixation of the femoral component **2630** to the bone. In the embodiment shown, reinforcing keels **2670***a* and **2670***b* on the posterior face **2645** on each of the condyles **2632** extend from the posterior face **2645** towards the distal face **2643**. Reinforcing keels **2670***a* and **2670***b* are substantially centered between the medial and lateral sides of the condyles **2632**, but in alternative embodiments may be positioned in other positions or orientations. Reinforcing keel **2670***c* on the anterior face **2641** extends from the anterior face **2641** towards the distal face **2643**. In the embodiment shown, reinforcing keel **2670***c* is substantially centered between the medial and lateral sides of the anterior face **2641**, but in alternative embodiments may be positioned in other positions or orientations.

[0088] Femur **102** may be resected to receive femoral component **2630** as shown in FIG. **27**A. As shown, femur **102** has been prepared using one or more bone tools to match the configuration of interface surface **2635***b* of femoral component **2630**. FIG. **27**B shows femoral component **2630** positioned on femur **102**.

[0089] As shown in the figures, femoral components according to the present invention can include various combinations of the features and configurations as disclosed above. Though certain combinations are shown in the exemplary embodiments provided, it should be understood that any of the disclosed femoral components, interface surfaces, elongated projections, trial projections, half pegs, and/or reinforcing keels may be used in combination with one another, and such combinations are contemplated in the present disclosure.

[0090] A method of implanting a femoral component according to the exemplary embodiments may include selecting a prosthetic component having a prosthetic body portion including a bearing surface and an interface surface. The interface surface, as discussed above, is configured to face a resected surface of a bone prepared to receive the prosthetic component. Then, using cutting tools, portions of the bones may be removed to form the resected surface of the bone, which is configured to match a counterpart portion of the interface surface of the prosthetic component.

[0091] The preparation of the bone, including removal of the bone, such as the distal femur, to receive the femoral components as described herein may be implemented using a robotic surgical system such as the RIOR Robotic Arm Interactive Orthopedic System available from MAKO Surgical Corp., Ft. Lauderdale, Florida. FIG. **28** shows an embodiment of an exemplary surgical system **2800** in which and for which the techniques described above can be implemented. The surgical system **2800** includes a computing system **2852**, a feedback mechanism such as haptic device **2854** which may carry the surgical tool, such as a cutting tool, and a tracking system **2856**. In operation, the surgical system **2800** enables comprehensive, intraoperative surgical planning including planning bone preparation procedures and performing bone preparation. The surgical system **2800** may also provide haptic guidance to a user (e.g., a surgeon) and/or limits the user's

manipulation of the haptic device **2854** as the user performs a surgical procedure. The computing system **2852** may be programmed to determine control parameters based on data representative of a patient's anatomy (e.g., preoperative CT image data, ultrasound data); a virtual (or haptic) object associated with (or registered to) the anatomy; a parameter relative to the anatomy (e.g., a depth defined with respect to a portion of the anatomy); and/or the anatomy. The computing system **2852** can control the feedback mechanism, such as haptic device **2854** to generate a force, a torque, and/or vibration based on the position of the tool relative to the virtual object, the parameter, and/or the anatomy. In this way, surgical system **2800** can aid a user to plan or perform bone preparation to receive a prosthetic component according to one or more of the exemplary embodiments.

[0092] Embodiments of the subject matter, the methods, and the operations described in this specification can be implemented in digital electronic circuitry, or in computer software embodied on a tangible medium, firmware, or hardware, including the structures disclosed in this specification and their structural equivalents, or in combinations of one or more of them. In the embodiment of FIG. **28**, the computing system **2852** may include hardware and software for operation and control of the surgical system **2800**. Such hardware and/or software is configured to enable the system **2800** to perform the techniques described herein. The computing system **2852** includes a surgical controller **2862**, a display device **2864**, and an input device **2866**.

[0093] The surgical controller **2862** may be any known computing system but is preferably a programmable, processor-based system. For example, the surgical controller **2862** may include a microprocessor, a hard drive, random access memory (RAM), read only memory (ROM), input/output (I/O) circuitry, and any other known computer component. The surgical controller **2862** is preferably adapted for use with various types of storage devices (persistent and removable), such as, for example, a portable drive, magnetic storage, solid state storage (e.g., a flash memory card), optical storage, and/or network/Internet storage. The surgical controller **2862** may comprise one or more computers, including, for example, a personal computer or a workstation operating under a suitable operating system and preferably includes a graphical user interface (GUI).

[0094] Referring to FIG. **29**, in an exemplary embodiment, the surgical controller **2862** includes a processing circuit **2870** having a processor **2872** and memory **2874**. Processor **2872** can be implemented as a general purpose processor executing one or more computer programs to perform actions by operating on input data and generating output. The processes and logic flows can also be performed by, and apparatus can also be implemented as, special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application specific integrated circuit), a group of processing components, or other suitable electronic processing components. Generally, a processor will receive instructions and data from a read only memory or a random access memory or both. Memory **2874** (e.g., memory, memory unit, storage device, etc.) comprises one or more devices (e.g., RAM, ROM, Flash-memory, hard disk storage, etc.) for storing data and/or computer code for completing or facilitating the various processes described in the present application. Memory **2874** may be or include volatile memory or non-volatile memory. Memory **2874** may include database components, object code components, script components, or any other type of information structure for supporting the various activities described in the present application. According to an exemplary embodiment, memory **2874** is communicably connected to processor **2872** and includes computer code for executing one or more processes described herein. The memory **2874** may contain a variety of modules, each capable of storing data and/or computer code related to specific types of functions. In one embodiment, memory **2874** contains several modules related to surgical procedures, such as a planning module **2874***a*, a navigation module **2874***b*, a registration module **2874***c*, and a robotic control module **2874***d*.

[0095] Alternatively or in addition, the program instructions can be encoded on an artificially generated propagated signal, e.g., a machine-generated electrical, optical, or electromagnetic signal, that is generated to encode information for transmission to suitable receiver apparatus for execution by a data processing apparatus. A computer storage medium can be, or be included in, a

computer-readable storage device, a computer-readable storage substrate, a random or serial access memory array or device, or a combination of one or more of them. Moreover, while a computer storage medium is not a propagated signal, a computer storage medium can be a source or destination of computer program instructions encoded in an artificially generated propagated signal. The computer storage medium can also be, or be included in, one or more separate components or media (e.g., multiple CDs, disks, or other storage devices). Accordingly, the computer storage medium may be tangible and non-transitory.

[0096] A computer program (also known as a program, software, software application, script, or code) can be written in any form of programming language, including compiled or interpreted languages, declarative or procedural languages, and it can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, object, or other unit suitable for use in a computing environment. A computer program may, but need not, correspond to a file in a file system. A program can be stored in a portion of a file that holds other programs or data (e.g., one or more scripts stored in a markup language document), in a single file dedicated to the program in question, or in multiple coordinated files (e.g., files that store one or more modules, sub programs, or portions of code). A computer program can be deployed to be executed on one computer or on multiple computers that are located at one site or distributed across multiple sites and interconnected by a communication network.

[0097] Generally, a computer will also include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto optical disks, or optical disks. However, a computer need not have such devices. Moreover, a computer can be embedded in another device, e.g., a mobile telephone, a personal digital assistant (PDA), a mobile audio or video player, a game console, a Global Positioning System (GPS) receiver, or a portable storage device (e.g., a universal serial bus (USB) flash drive), to name just a few. Devices suitable for storing computer program instructions and data include all forms of non-volatile memory, media and memory devices, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto optical disks; and CD ROM and DVD-ROM disks. The processor and the memory can be supplemented by, or incorporated in, special purpose logic circuitry.

[0098] Embodiments of the subject matter described in this specification can be implemented in a computing system that includes a back end component, e.g., as a data server, or that includes a middleware component, e.g., an application server, or that includes a front end component, e.g., a client computer having a graphical user interface or a Web browser through which a user can interact with an embodiment of the subject matter described in this specification, or any combination of one or more such back end, middleware, or front end components. The components of the system can be interconnected by any form or medium of digital data communication, e.g., a communication network. Examples of communication networks include a local area network ("LAN") and a wide area network ("WAN"), an inter-network (e.g., the Internet), and peer-to-peer networks (e.g., ad hoc peer-to-peer networks).

[0099] Referring to the embodiment of surgical controller **2862** depicted in FIG. **29**, the surgical controller **2862** further includes a communication interface **2876**. The communication interface **2876** of the computing system **2852** is coupled to a computing device (not shown) of the haptic device **2854** via an interface, to the tracking system **2856** via an interface, and to the display **2864** through an interface. Through the communication interface **2876**, pre-operative image data **2880** may also be received from an imaging system. The interfaces can include a physical interface and a software interface. The physical interface of the communication interface **2876** can be or include wired or wireless interfaces (e.g., jacks, antennas, transmitters, receivers, transceivers, wire terminals, etc.) for conducting data communications with external sources via a direct connection or a network connection (e.g., an Internet connection, a LAN, WAN, or WLAN connection, etc.).

The software interface may be resident on the surgical controller **2862**, the computing device (not shown) of the haptic device **2854**, and/or the tracking system **2856**. In some embodiments, the surgical controller **2862** and the computing device (not shown) are the same computing device. The software may also operate on a remote server, housed in the same building as the surgical system **2800**, or at an external server site.

[0100] Computer system **2852** also includes display device **2864**. The display device **2864** is a visual interface between the computing system **2852** and the user. The display device **2864** is connected to the surgical controller **2862** and may be any device suitable for displaying text, images, graphics, and/or other visual output. For example, the display device **2864** may include a standard display screen (e.g., LCD, CRT, OLED, TFT, plasma, etc.), a touch screen, a wearable display (e.g., eyewear such as glasses or goggles), a projection display, a head-mounted display, a holographic display, and/or any other visual output device. The display device **2864** may be disposed on or near the surgical controller **2862** (e.g., on the cart as shown in FIG. **28**) or may be remote from the surgical controller **2862** (e.g., mounted on a stand with the tracking system **2856**). The display device **2864** is preferably adjustable so that the user can position/reposition the display device **2864** as needed during a surgical procedure. For example, the display device **2864** may be disposed on an adjustable arm (not shown) or to any other location well-suited for ease of viewing by the user. As shown in FIG. **28** there may be more than one display device **2864** in the surgical system **2800**.

[0101] The display device **2864** may be used to display any information useful for a medical procedure, such as, for example, images of anatomy generated from an image data set obtained using conventional imaging techniques, graphical models (e.g., CAD models of implants, instruments, anatomy, etc.), graphical representations of a tracked object (e.g., anatomy, tools, implants, etc.), constraint data (e.g., axes, articular surfaces, etc.), representations of implant components, digital or video images, registration information, calibration information, patient data, user data, measurement data, software menus, selection buttons, status information, and the like.

[0102] In addition to the display device **2864**, the computing system **2852** may include an acoustic device (not shown) for providing audible feedback to the user. The acoustic device is connected to the surgical controller **2862** and may be any known device for producing sound. For example, the acoustic device may comprise speakers and a sound card, a motherboard with integrated audio support, and/or an external sound controller. In operation, the acoustic device may be adapted to convey information to the user. For example, the surgical controller **2862** may be programmed to signal the acoustic device to produce a sound, such as a voice synthesized verbal indication "DONE," to indicate that a step of a surgical procedure is complete. Similarly, the acoustic device may be used to alert the user to a sensitive condition, such as producing a tone to indicate that a surgical cutting tool is nearing a critical portion of soft tissue.

[0103] To provide for other interaction with a user, embodiments of the subject matter described in this specification can be implemented on a computer having input device **2866** that enables the user to communicate with the surgical system **2800**. The input device **2866** is connected to the surgical controller **2862** and may include any device enabling a user to provide input to a computer. For example, the input device **2866** can be a known input device, such as a keyboard, a mouse, a trackball, a touch screen, a touch pad, voice recognition hardware, dials, switches, buttons, a trackable probe, a foot pedal, a remote control device, a scanner, a camera, a microphone, and/or a joystick. For example, input device **2866** can allow the user to provide input to adjust the surgical plan. Other kinds of devices can be used to provide for interaction with a user as well; for example, feedback provided to the user can be any form of sensory feedback, e.g., visual feedback, auditory feedback, or tactile feedback; and input from the user can be received in any form, including acoustic, speech, or tactile input. In addition, a computer can interact with a user by sending documents to and receiving documents from a device that is used by the user; for example, by sending web pages to a web browser on a user's client device in response to requests received from

the web browser.
[0104] The system **2800** also includes a tracking (or localizing) system **2856** that is configured to determine a pose (i.e., position and orientation) of one or more objects during a surgical procedure to detect movement of the object(s). For example, the tracking system **2856** may include a detection device that obtains a pose of an object with respect to a coordinate frame of reference of the detection device. As the object moves in the coordinate frame of reference, the detection device tracks the pose of the object to detect (or enable the surgical system **2800** to determine) movement of the object. As a result, the computing system **2852** can capture data in response to movement of the tracked object or objects. Tracked objects may include, for example, tools/instruments, patient anatomy, implants/prosthetic devices, and components of the surgical system **2800**. Using pose data from the tracking system **2856**, the surgical system **2800** is also able to register (or map or associate) coordinates in one space to those in another to achieve spatial alignment or correspondence (e.g., using a coordinate transformation process as is well known). Objects in physical space may be registered to any suitable coordinate system, such as a coordinate system being used by a process running on the surgical controller **2862** and/or the computer device of the haptic device **2854**. For example, utilizing pose data from the tracking system **2856**, the surgical system **2800** is able to associate the physical anatomy, such as the patient's femur, with a representation of the anatomy (such as an image displayed on the display device **2864**). Based on tracked object and registration data, the surgical system **2800** may determine, for example, a spatial relationship between the image of the anatomy and the relevant anatomy.
[0105] Registration may include any known registration technique, such as, for example, image-to-image registration (e.g., monomodal registration where images of the same type or modality, such as fluoroscopic images or MR images, are registered and/or multimodal registration where images of different types or modalities, such as MRI and CT, are registered); image-to-physical space registration (e.g., image-to-patient registration where a digital data set of a patient's anatomy obtained by conventional imaging techniques is registered with the patient's actual anatomy); and/or combined image-to-image and image-to-physical-space registration (e.g., registration of preoperative CT and MRI images to an intraoperative scene). The computing system **2852** may also include a coordinate transform process for mapping (or transforming) coordinates in one space to those in another to achieve spatial alignment or correspondence. For example, the surgical system **2800** may use the coordinate transform process to map positions of tracked objects (e.g., patient anatomy, etc.) into a coordinate system used by a process running on the computer of the haptic device **2854** and/or the surgical controller **2862**. As is well known, the coordinate transform process may include any suitable transformation technique, such as, for example, rigid-body transformation, non-rigid transformation, affine transformation, and the like.
[0106] The tracking system **2856** may be any tracking system that enables the surgical system **2800** to continually determine (or track) a pose of the relevant anatomy of the patient. For example, the tracking system **2856** may include a non-mechanical tracking system, a mechanical tracking system, or any combination of non-mechanical and mechanical tracking systems suitable for use in a surgical environment. The non-mechanical tracking system may include an optical (or visual), magnetic, radio, or acoustic tracking system. Such systems typically include a detection device adapted to locate in predefined coordinate space specially recognizable trackable elements (or trackers) that are detectable by the detection device and that are either configured to be attached to the object to be tracked or are an inherent part of the object to be tracked. For example, a trackable element may include an array of markers having a unique geometric arrangement and a known geometric relationship to the tracked object when the trackable element is attached to the tracked object. The known geometric relationship may be, for example, a predefined geometric relationship between the trackable element and an endpoint and axis of the tracked object. Thus, the detection device can recognize a particular tracked object, at least in part, from the geometry of the markers (if unique), an orientation of the axis, and a location of the endpoint within a frame of reference

deduced from positions of the markers.
[0107] The markers may include any known marker, such as, for example, extrinsic markers (or fiducials) and/or intrinsic features of the tracked object. Extrinsic markers are artificial objects that are attached to the patient (e.g., markers affixed to skin, markers implanted in bone, stereotactic frames, etc.) and are designed to be visible to and accurately detectable by the detection device. Intrinsic features are salient and accurately locatable portions of the tracked object that are sufficiently defined and identifiable to function as recognizable markers (e.g., landmarks, outlines of anatomical structure, shapes, colors, or any other sufficiently recognizable visual indicator). The markers may be located using any suitable detection method, such as, for example, optical, electromagnetic, radio, or acoustic methods as are well known. For example, an optical tracking system having a stationary stereo camera pair sensitive to infrared radiation may be used to track markers that emit infrared radiation either actively (such as a light emitting diode or LED) or passively (such as a spherical marker with a surface that reflects infrared radiation). Similarly, a magnetic tracking system may include a stationary field generator that emits a spatially varying magnetic field sensed by small coils integrated into the tracked object.
[0108] The haptic device **2854** may be the Tactile Guidance System™ (TGS™) manufactured by MAKO Surgical Corp., and used to prepare the surface of the patient's bone for insertion of the femoral component. The haptic device **2854** provides haptic (or tactile) guidance to guide the surgeon during a surgical procedure. The haptic device is an interactive surgical device, such as a robotic arm, that holds a surgical tool (e.g., a surgical burr) and is manipulated by the surgeon to perform a procedure on the patient, such as cutting a surface of a bone in preparation for femoral component installation. As the surgeon manipulates the robotic arm to move the tool and sculpt the bone, the haptic device **2854** guides the surgeon by providing force feedback that constrains the tool from penetrating a virtual boundary.
[0109] The construction and arrangement of the systems and methods as shown in the various exemplary embodiments are illustrative only. Although only a few embodiments have been described in detail in this disclosure, many modifications are possible. Accordingly, all such modifications are intended to be included within the scope of the present disclosure. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. Other substitutions, modifications, changes, and omissions may be made in the design, operating conditions and arrangement of the exemplary embodiments without departing from the scope of the present disclosure.

Claims

1. A distal femoral implant comprising: a distal portion including a first bone facing surface and a second bone facing surface, the first bone facing surface having a first plurality of distal planar bone facing surfaces configured to engage a resected distal surface of a distal femur, the second bone facing surface being raised relative to the first bone facing surface and having a second plurality of distal planar bone facing surfaces configured to engage the resected distal surface of the distal femur; an anterior portion extending from the distal portion, the anterior portion including a bone facing surface configured to engage a resected anterior surface of the distal femur; and a pair of posterior condylar portions extending from the distal portion, each posterior condylar portion of the pair of posterior condylar portions including a bone facing surface configured to engage a resected posterior surface of the distal femur.
2. The distal femoral implant of claim 1, wherein the first plurality of distal planar bone facing surfaces includes a first subportion and a second subportion, the second plurality of distal planar bone facing surfaces being between the first and second subportions.
3. The distal femoral implant of claim 1, wherein a total quantity of the first plurality of distal planar bone facing surfaces is the same as a total quantity of the second plurality of distal planar

bone facing surfaces.
4. The distal femoral implant of claim 1, wherein each distal planar bone facing surface of the first plurality of distal planar bone facing surfaces is aligned with a respective distal planar bone facing surface of the second plurality of distal planar bone facing surfaces in a medial-lateral direction of the distal femoral implant.
5. The distal femoral implant of claim 4, wherein a first distal planar bone facing surface of the first plurality of distal planar bone facing surfaces has an antero-posterior dimension that is the same as an antero-posterior dimension of a second distal planar bone facing surface of the second plurality of distal planar bone facing surfaces, the second distal planar bone facing surface being adjacent to the first distal planar bone facing surface.
6. The distal femoral implant of claim 1, wherein a first distal planar bone facing surface of the first plurality of distal planar bone facing surfaces is parallel to a second distal planar bone facing surface of the second plurality of distal planar bone facing surfaces, the second distal planar bone facing surface being adjacent to the first distal planar bone facing surface.
7. The distal femoral implant of claim 1, wherein the second bone facing surface extends along respective inner edges of the pair of posterior condylar portions, the respective inner edges defining an opening between the pair of posterior condylar portions.
8. The distal femoral implant of claim 1, wherein the first and second plurality of distal planar bone facing surfaces each include at least six distal planar bone facing surfaces.
9. A distal femoral implant comprising: a distal portion including a bone facing surface, the bone facing surface having a plurality of faces, wherein each face of the plurality of faces has a different angulation with respect to the other faces of the plurality of faces, and wherein each face of the plurality of faces includes a raised portion and a base portion, the raised portion being raised relative to the base portion; an anterior portion extending anteriorly from the distal portion; and a posterior portion extending posteriorly from the distal portion.
10. The distal femoral implant of claim 9, wherein, for each face of the plurality of faces, the raised portion is in between a first subportion of the base portion and a second subportion of the base portion.
11. The distal femoral implant of claim 9, wherein the raised portion and the base portion of each face of the plurality of faces is aligned in a medial-lateral direction of the distal femoral implant.
12. The distal femoral implant of claim 11, wherein a first face of the plurality of faces includes a first base portion and a first raised portion, the first base portion having an antero-posterior dimension that is the same as that of the first raised portion.
13. The distal femoral implant of claim 9, wherein a first base portion of a first face of the plurality of faces is parallel to a first raised portion of the first face of the plurality of faces, the first raised portion being adjacent to the first base portion.
14. A distal femoral implant comprising: a distal portion including a bone facing surface, the bone facing surface of the distal portion including a plurality of planar surfaces and a raised surface, the raised surface being raised relative to the plurality of planar surfaces; an anterior portion extending from the distal portion; and a pair of condylar portions extending from the distal portion, the pair of condylar portions defining a notch therebetween, wherein the raised surface abuts an apex of the notch.
15. The distal femoral implant of **14**, wherein the distal portion further comprises a pair of posts, each post of the pair of posts extending from one planar surface of the plurality of planar surfaces.
16. The distal femoral implant of **14**, wherein the raised surface includes a planar surface section, the planar surface section being parallel to a planar surface of the plurality of planar surfaces.
17. The distal femoral implant of **14**, wherein the raised surface includes a plurality of planar surface sections, each planar surface section of the plurality of planar surface sections of the raised surface being aligned with a respective planar surface of the plurality of planar surfaces in a medial-lateral direction of the distal femoral implant.

18. The distal femoral implant of **14**, wherein a first planar surface of the plurality of planar surfaces is parallel to a first planar surface section of the raised surface, the first planar surface section being adjacent to the first planar surface.

19. The distal femoral implant of **14**, wherein the raised surface includes a non-planar surface section.

20. The distal femoral implant of **19**, wherein the non-planar surface section is planar in an anterior-posterior direction of the distal femoral implant and non-planar in a medial-lateral direction of the distal femoral implant.