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(54) **LIGAMENT GUIDE REGISTRATION**

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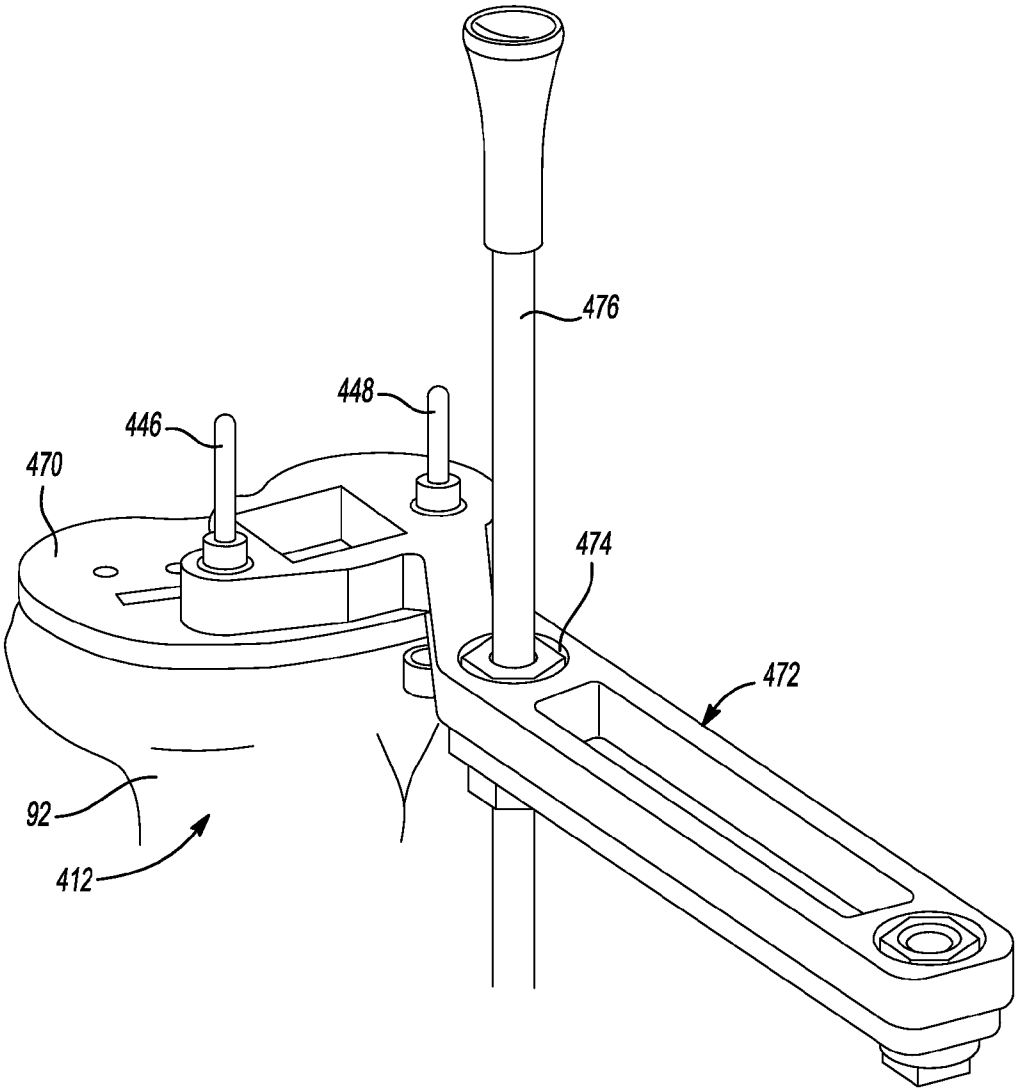
(57) **ABSTRACT**

A patient-specific guide tool for guiding an instrument toward a bone for implantation of a prosthetic device is disclosed. The guide tool includes a body portion having a guide element, and a patient-specific portion having at least one patient-specific mating feature that is configured to engage a soft tissue at or near the bone. A method of manufacturing a guide tool for guiding an instrument toward a bone is also disclosed.



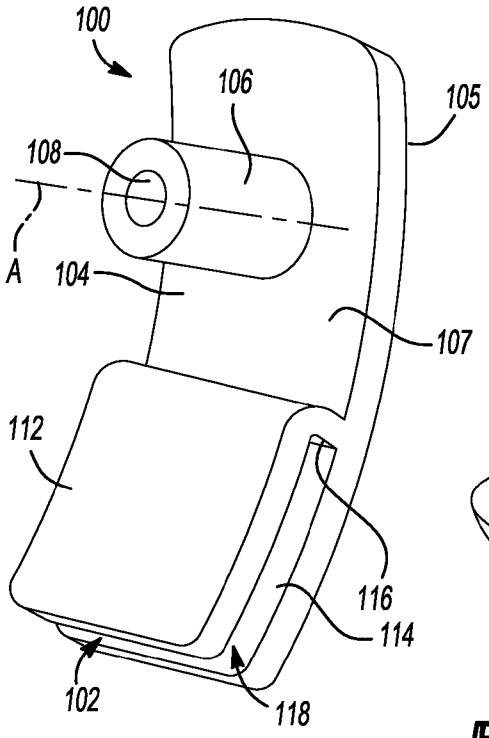


Fig-1

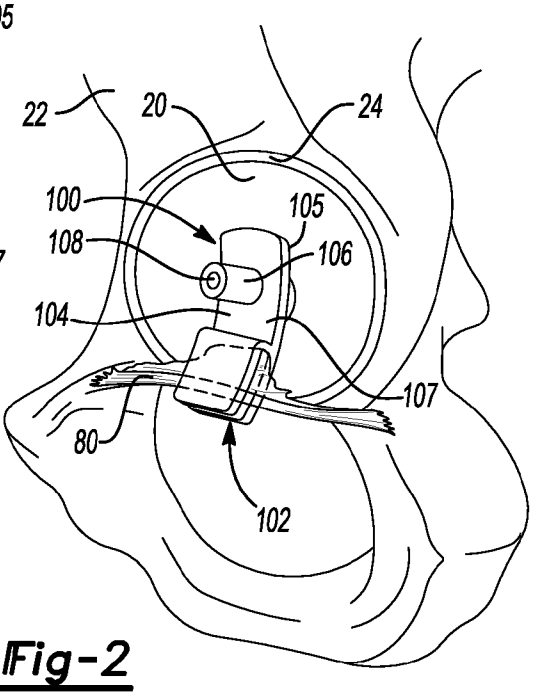


Fig-2

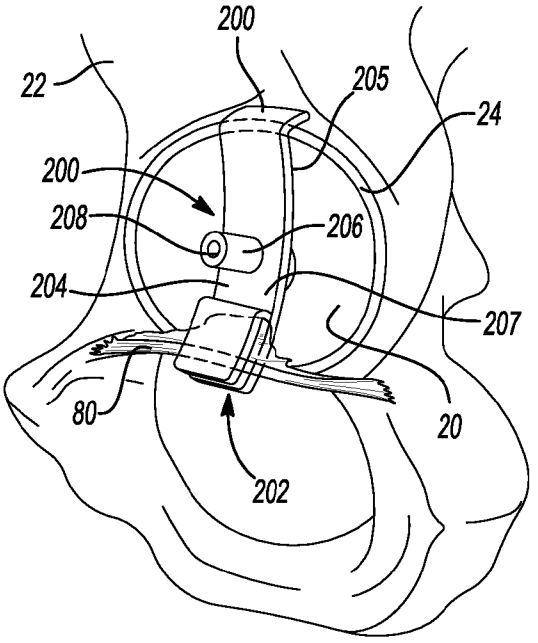


Fig-3

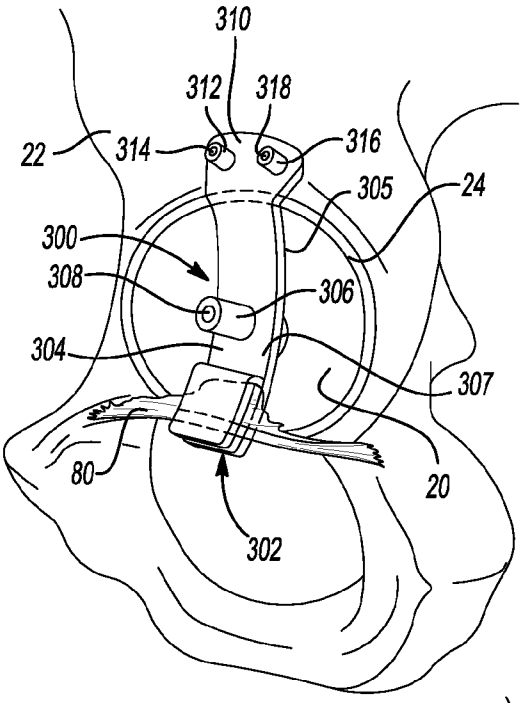

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Fig-4

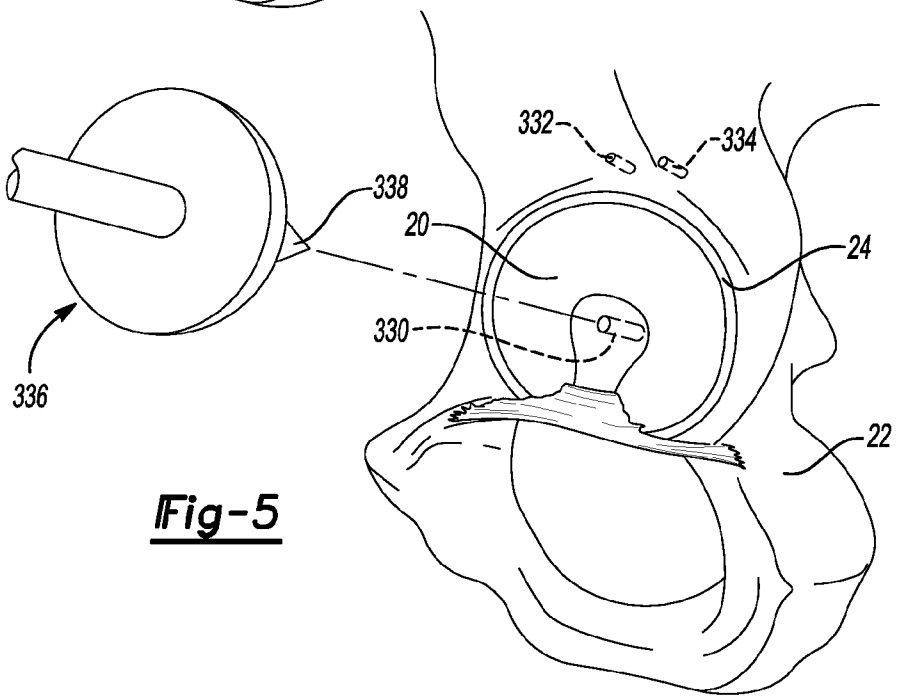
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Fig-5

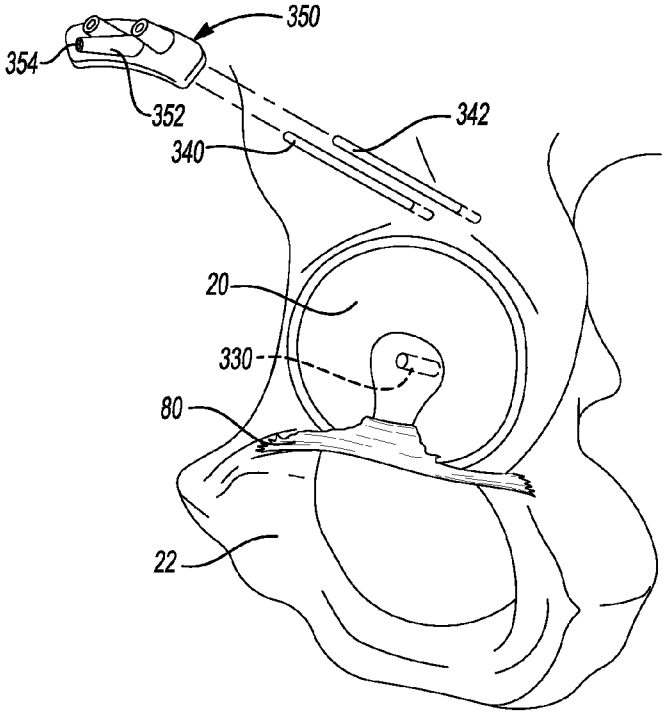
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Fig-6

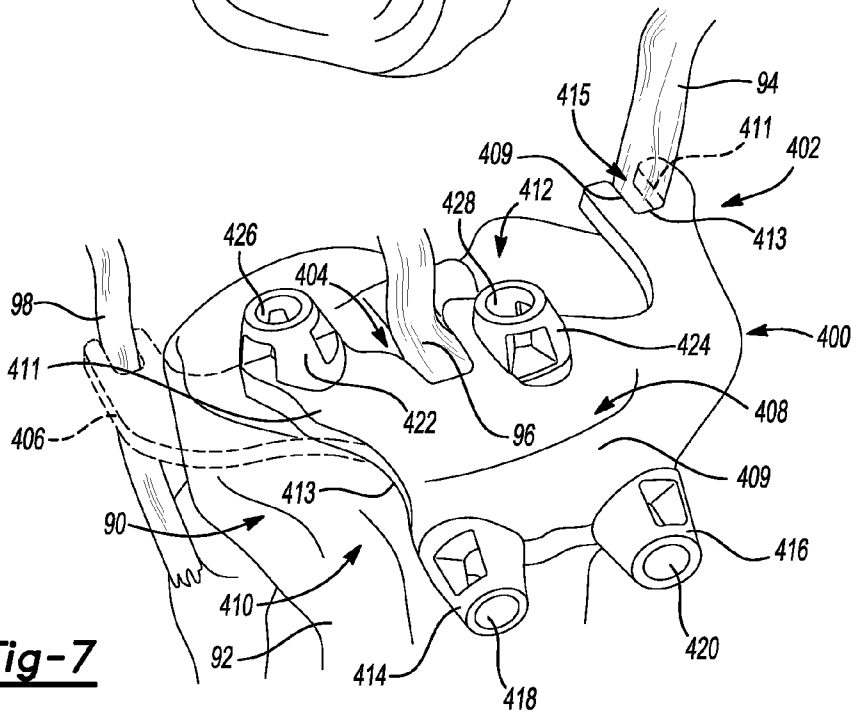
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Fig-7

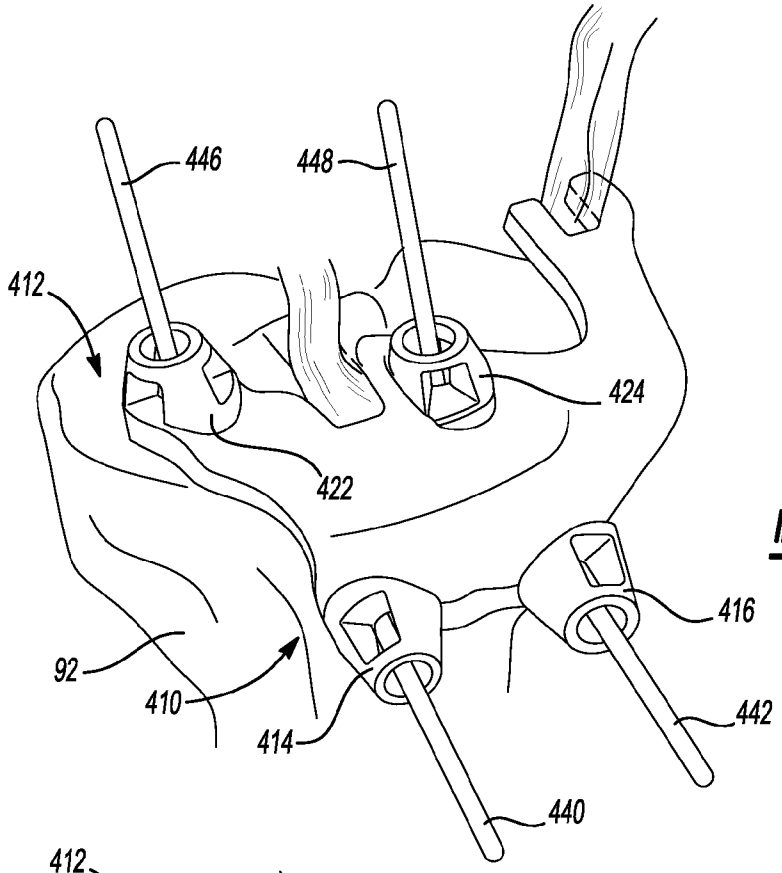
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Fig-8

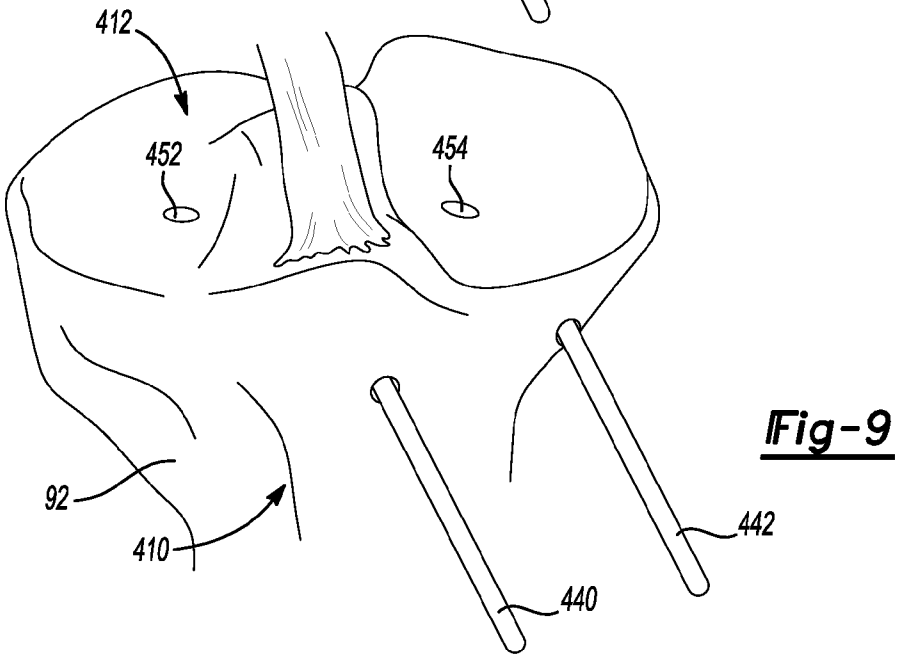
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Fig-9

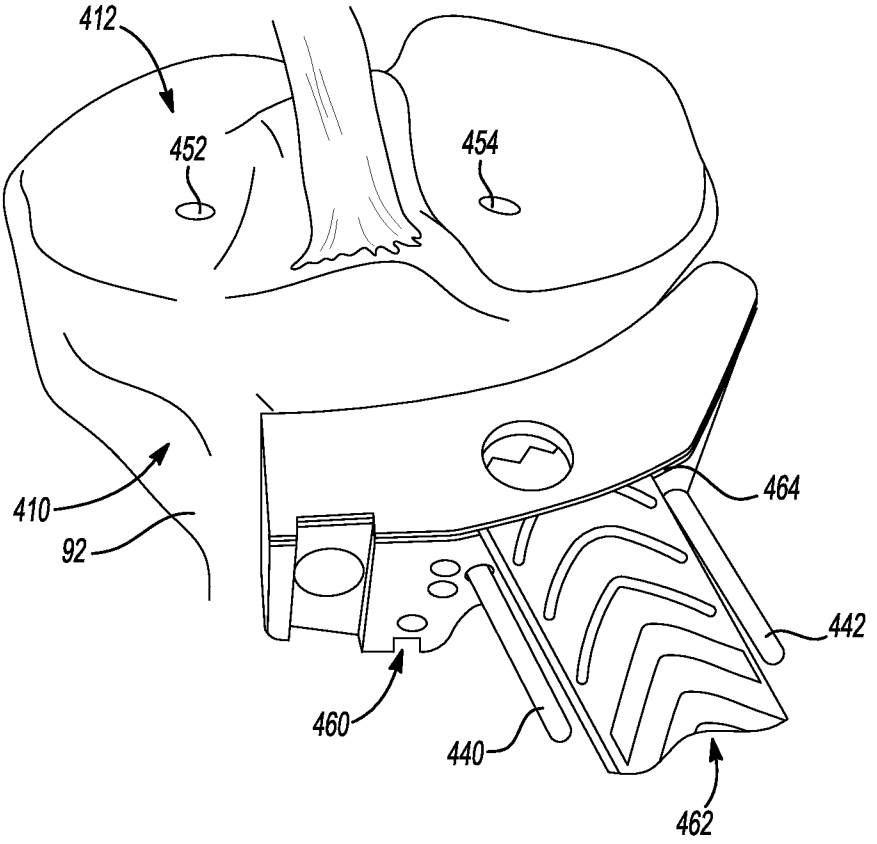

Fig-10

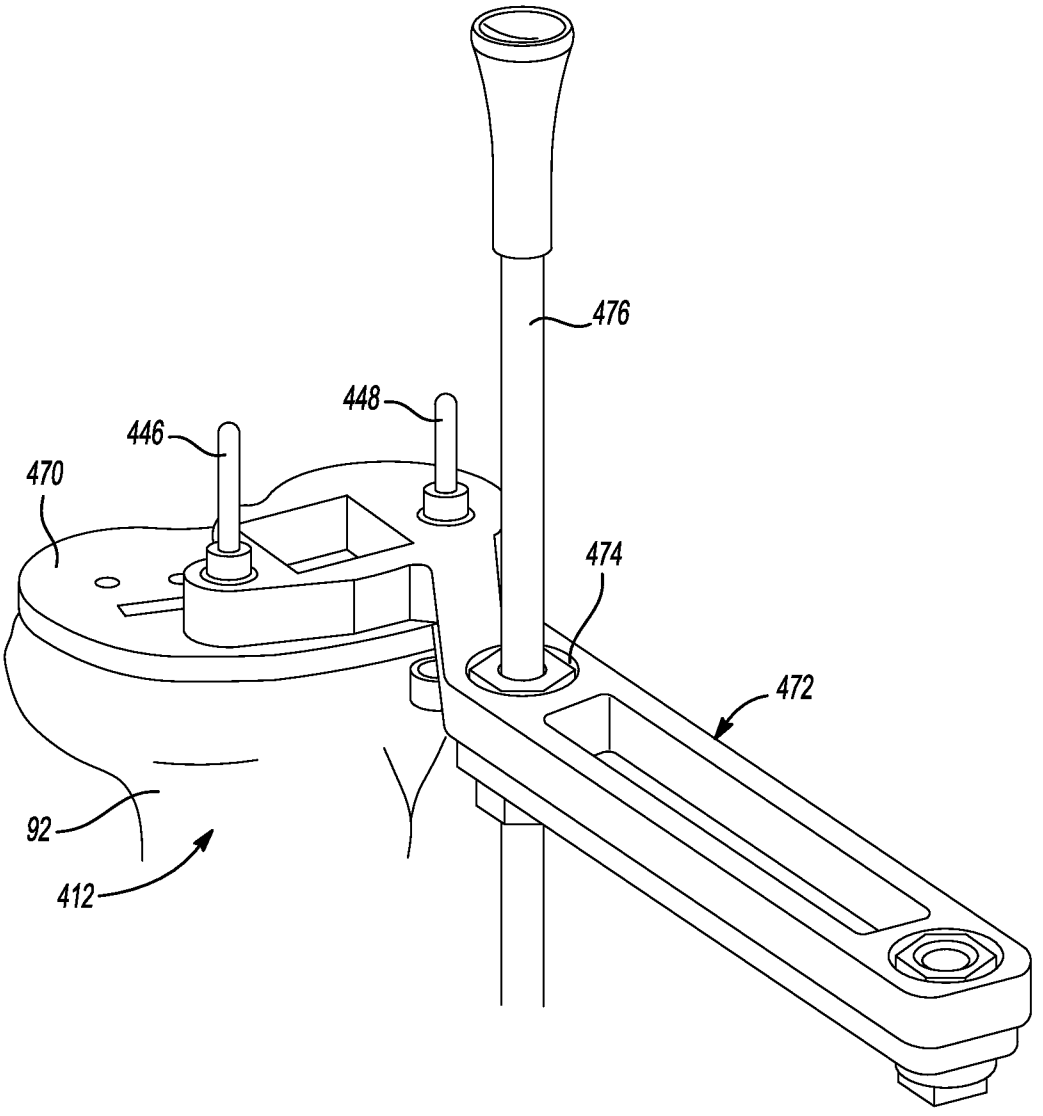

Fig-11

LIGAMENT GUIDE REGISTRATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of U.S. Provisional Patent Application No. 61/893,570 filed on Oct. 21, 2013. The entire disclosure of the above application is incorporated herein by reference.

FIELD

[0002] The subject disclosure is related to various patient-specific alignment guides for use in joint replacement, resurfacing procedures and other procedures related to the joint or the various bones of the joint, including adjacent bones. A feature on the patient-specific alignment guides conforms to or engages a soft tissue to align a guide portion of the guides to a predetermined position relative to a bone at the joint. The soft tissue can be a ligament, tendon, muscle, fibrous tissue or fat. The patient-specific alignment guides are designed and constructed preoperatively based on two- or three-dimensional images of the patient's bone and soft tissue at or near a joint.

BACKGROUND

[0003] This section provides background information related to the present disclosure which is not necessarily prior art.

[0004] Joint reconstruction surgery requires careful planning by a surgeon and specialized instrumentation. Methods used for reconstructing a joint sometimes are not sufficiently accurate to reproduce the natural movement of the joint. Planning for the surgery is often based on two-dimensional x-ray films and surgeons often resort to shaping prosthetics during surgery. During the surgery, the surgeon typically uses non-patient specific alignment guides to prepare a defect on a bone for implantation of a prosthesis.

[0005] Recently, patient-specific alignment guides have been implemented as an alternative to standard orthopedic instrumentation and planning. The manufacture of patient-specific guides can require imaging protocols from which three-dimensional and pre-operative plans are created. These pre-operative plans can be used to create the patient-specific guides, which generally "lock" or "nest" into native boney landmarks at the site of the defect. When used in surgery, the patient-specific guide sits on a bone surface in order for the surgeon to carry out the pre-operatively planned procedure.

[0006] Although current patient-specific guides are an improvement from previous instrumentation, there remains a need for patient-specific instruments that reference landmarks other than bone.

SUMMARY

[0007] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0008] A patient-specific guide tool for guiding an instrument toward a bone for implantation of a prosthetic device is disclosed. The guide tool comprises a body portion that includes an engagement surface and a guide feature. The guide feature is configured to guide movement of the instrument toward the bone. The guide tool further comprises a patient-specific portion that is coupled to the body portion. The patient-specific portion includes at least one patient-specific attachment portion including at least one patient-specific soft tissue mating feature that is configured to conform to or engage a first soft tissue at or near the bone to thereby position the engagement surface at a predetermined position relative to the bone. The mating feature can be a hook, notch, slit, slot, or tab. The soft tissue can be a ligament, tendon, muscle, fibrous tissue, or fat.

[0009] A patient-specific guide tool for guiding an instrument toward a bone for implantation of a prosthetic device is also disclosed. The guide tool comprises a body portion and a first patient-specific portion extending from the body portion. The body portion can include a guide feature having an elongated bore. The guide feature is configured to guide movement of the instrument toward the bone. The first patient-specific portion includes at least one patient-specific mating feature that is configured to engage soft tissue at or near the bone in accordance with a two-dimensional or three-dimensional model of the bone and soft tissue of a specific patient reconstructed preoperatively from at least one image scan of the patient. The guide tool further comprises a second patient-specific portion extending form the body portion. The second patient-specific portion includes a patient-specific bone engaging surface. The guide tool thereby positions the guide feature at a predetermined position relative to the bone.

[0010] A method of manufacturing a guide tool for guiding an instrument to a bone is also disclosed. The method comprises obtaining at least one image of at least a portion of the bone; determining the location of soft tissue at or near the bone; generating a two-dimensional or three-dimensional model of the bone and soft tissue; and fabricating a patient-specific guide tool having a body portion and a patient-specific portion, the body portion including a guide feature, and the patient-specific portion including at least one mating feature that is configured to engage the soft tissue according to the two-dimensional or three-dimensional model. Determining the location of soft tissue at or near the bone can comprise obtaining an MRI, CT scan or ultrasound of the portion of the bone. Alternatively, determining the location of soft tissue at or near the bone can comprise obtaining an X-ray of the bone of the specific patient and locating the position of the soft tissue at or near the bone according to known locations of the soft tissue relative to the bone.

[0011] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0012] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0013] FIG. **1** is a representation of a patient-specific acetabular guide;

[0014] FIG. **2** is a representation of a patient-specific acetabular guide on an acetabulum;

[0015] FIG. **3** is a representation of a patient-specific acetabular guide comprising a patient-specific rim portion on an acetabulum;

[0016] FIG. **4** is a a representation of a patient-specific acetabular guide comprising a patient-specific rim portion having a pair of guiding elements on an acetabulum;

[0017] FIG. **5** is a representation of a reamer aligned with a pilot hole in an acetabulum;

[0018] FIG. **6** is a representation of a pelvis having alignment pins positioned in the pelvis;

[0019] FIG. **7** is a representation of a patient-specific tibial guide positioned on a proximal end of a tibia;

[0020] FIG. **8** is a representation of a patient-specific tibial guide with alignment pins inserted through guide elements;

[0021] FIG. **9** is a representation of a proximal end of a tibia with alignment pins inserted in the anterior face of the tibia;

[0022] FIG. **10** is a representation of a tibial cut block positioned adjacent to an anterior face of a tibia; and

[0023] FIG. **11** is a representation of a trial plate positioned adjacent to a superior face of a resected tibia at a proximal end.

[0024] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

[0025] Example embodiments will now be described more fully with reference to the accompanying drawings.

[0026] The present teachings generally provide patient-specific surgical instruments that include, for example, alignment guides, drill guides, templates, cutting/resection guides for use in joint replacement, resurfacing procedures and other procedures related to the joint or the various bones of the joint, including adjacent bones. A feature on the surgical instruments can be placed in contact with soft tissue to align a guide portion of the instrument to a face of a bone at the joint. The soft tissue can be a ligament, tendon, muscle, fibrous tissue or fat.

[0027] In various embodiments, the joint is a hip. In such embodiments, the present teachings generally provide a patient-specific acetabular guide or proximal femoral guide for use in orthopedic surgery, such as in joint replacement or revision surgery, for example. The patient-specific alignment guides can be used either with conventional or patient-specific implant components prepared with computer-assisted image methods.

[0028] In other embodiments, the joint is a knee. When the joint is a knee, the patient-specific surgical instruments can be used in knee joint replacement, resurfacing procedures and other procedures related to the knee joint or the various bones of the knee joint, including the femur and the tibia. The present teaching can be applied to partial and full knee reconstructions.

[0029] In a further embodiment, the joint is a shoulder. When the joint is a shoulder, the patient-specific surgical instruments can be used in shoulder joint replacement, resurfacing procedures and other procedures related to the shoulder joint or the various bones of the shoulder joint, including the glenoid and adjacent bones. The present teachings can be applied to anatomic shoulder replacement and reverse shoulder replacement.

[0030] The patient-specific instruments can be used either with conventional implant components or with patient-specific implant components and/or bone grafts that are prepared using computer-assisted image methods according to the present teachings. Computer modeling for obtaining two or three dimensional images of the patient's anatomy using MRI or CT, X-ray, or ultrasound scans of the patient's anatomy, the patient-specific prosthesis components and the patient-specific guides, templates and other instruments, can be designed using various CAD programs and/or software available, for example, by Materialise USA, of Plymouth, Mich.

[0031] The patient-specific instruments and any associated patient-specific implants and bone grafts can be generally designed and formed using computer modeling based on two or three dimentional anatomic image(s) generated from X-rays, MRI, CT, ultrasound or other medical scans. Specifically, an anatomical feature (e.g., a scapula, knee, or pelvis with surrounding soft tissue) can be imaged to detect certain features of the anatomy (e.g., dimensions, curvature of surfaces, soft tissues, etc.). Then, patient-specific instruments can be formed according to these measurements. Various pre-operative procedures are disclosed in commonly assigned U.S. Pat. No. 8,092,465, issued on Jan. 10, 2012, U.S. patent Publication No. 2011/0184419, published on Jul. 28, 2011, and U.S. Publication No. 2012/0310399, published on Dec. 6, 2012, which are all incorporated herein by reference in their entirety.

[0032] The patient-specific instrument can have a three-dimensional engagement feature that is complementary and made to conformingly contact or engage a soft tissue. In some embodiments, the patient-specific instrument can further have a three-dimensional engagement surface that is a mirror image or negative of a boney surface or cartilage. The three-dimensional engagement surface is complementary to and made to conformingly contact, engage, or nest on a bony anatomical surface or cartilage. Thus, the patient-specific instruments can be configured to fit at only one position to the anatomical surface. The patient-specific instruments can include custom-made guiding formations, such as, for example, guiding bores or cannulated guiding posts or cannulated guiding extensions or receptacles that can be used for supporting or guiding other objects, such as instruments, drill guides, reamers, cutters, cutting guides and cutting blocks or for inserting pins or other fasteners according to a surgeon-approved pre-operative plan.

[0033] In various embodiments, the patient-specific instruments can also include one or more patient-specific alignment guides for receiving and guiding a tool, such as a drill or pin or guide wire at corresponding patient-specific orientations relative to a selected anatomic axis for the specific patient. The patient-specific instruments can include guiding or orientation formations and features for guiding the implantation of patient-specific or off-the-shelf implants associated with the surgical procedure. The geometry, shape and orientation of the various features of the patient-specific instruments, as well as various patient-specific implants and bone grafts, if used, can be determined during the pre-operative planning stage of the procedure in connection with the computer-assisted modeling of the patient's anatomy. During the pre-operative planning stage, patient-specific instruments, custom, semi-custom or non-custom implants and other non-custom tools, can be selected and the patient-specific components can be manufactured for a specific-patient with input from a surgeon or other professional associated with the surgical procedure.

[0034] In the following discussion, the terms "patient-specific", "custom-made" or "customized" are defined to apply to components, including tools, implants, portions or combinations thereof, which include certain geometric features, including surfaces, curves, or other lines, and which are made to closely conform as mirror-images or negatives or complementary surfaces of corresponding geometric features or anatomic landmarks of a patient's anatomy obtained or gathered

during a pre-operative planning stage based on two or three dimensional computer images of the corresponding anatomy reconstructed from image scans of the patient by computer imaging or X-ray methods. Further, patient-specific guiding features, such as, guiding apertures, guiding slots, guiding members or other holes, openings, or guide surfaces that are included in alignment guides, drill guides, cutting guides, rasps or other instruments or in implants are defined as features that are made to have positions, orientations, dimensions, shapes and/or define cutting planes and axes specific to the particular patient's anatomy including various anatomic or mechanical axes based on the computer-assisted pre-operative plan associated with the patient.

[0035] The prepared patient-specific alignment guides can be configured to mate in alignment with natural soft tissue landmarks by orienting and placing the corresponding alignment guide intra-operatively at or near the bone to mate with corresponding soft tissue. In some embodiments, the patient-specific alignment guides can further be configured to mate in alignment with natural boney anatomic landmarks by orienting and placing the corresponding alignment guide intra-operatively on top of the bone to mate with corresponding boney landmarks, as well as with soft tissue landmarks. The soft tissue and boney landmarks function as passive fiducial identifiers or fiducial markers for positioning of the various alignment guides, drill guides or other patient-specific instruments.

[0036] The various patient-specific alignment guides can be made of any biocompatible material, including, polymer, ceramic, metal or combinations thereof. The patient-specific alignment guides can be opaque, semi-transparent, or transparent. The patient-specific alignment guides can be disposable and can be combined or used with reusable and non patient-specific cutting and guiding components.

[0037] More specifically, the present teachings provide various embodiments of patient-specific acetabular, knee, glenoid, or other appropriate guides. The acetabular, knee, glenoid or other appropriate guides of the present teachings can have patient-specific engagement surfaces that reference various portions of the hip, knee, or shoulder joint and include drill guides, guiding bores or sleeves or other guiding formations that can accurately position a guide wire for later acetabular, knee, or glenoid preparation and implantation procedures and for alignment purposes, including implant position control, implant version control, implant inclination control.

[0038] In the following, when of portion of a patient-specific guide is described as "referencing" a portion of the anatomy, it will be understood that the referencing portion of the patient-specific guide is a patient-specific portion or surface mirroring or negative to the corresponding referenced soft tissue, cartilage surface and/or bone surface. Exemplary, non-limiting patient-specific guides are shown, but additional patient-specific guides can be configured based on the present teachings.

[0039] With reference to FIGS. **1-4**, the present teachings provide various exemplary patient-specific acetabular guides **100**, **200**, **300**. The acetabular guides **100**, **200**, **300** can be used in connection with various other instruments to facilitate guided reaming of an acetabulum **20** of a pelvis **22** of a specific patient and guided insertion and implantation of an acetabular implant or acetabular cup in the acetabulum **20**. The patient-specific acetabular guides **100**, **200**, **300** engage the acetabulum **20** of the specific patient in only one position and can provide an accurate alignment axis relative to a planned orientation of an acetabular cup. The acetabular guides **100**, **200**, **300** can also provide secure fitting and rotational stability in a design that is lightweight with minimal size and bulk.

[0040] FIG. **1** illustrates a patient-specific acetabular guide **100**, having a patient-specific soft tissue mating feature **102**, a patient-specific body **104** with a bone engaging surface **105** and an opposing surface **107**, and a guiding or pilot element **106** having an elongated bore **108** with a patient-specific alignment axis A. The soft tissue mating feature **102** can comprise two substantially parallel plates **112**, **114** coupled together at a stop **116** in a U-shape defining a slot **118**. The mating feature **102** is configured to conform, nest, receive, or engage a soft tissue. While a single soft tissue mating feature **102** is illustrated, it should be understood that multiple soft tissue mating features can be integrated into a single guide and engage multiple distinct soft tissue areas to provide added stability. In some embodiments, the bone engaging surface **105** is negative or mirror image of the surface of the acetabulum **20**. When positioned on the acetabulum **20**, the bone engaging surface **105** nests on the boney surface. In other embodiments, the bone engaging surface **105** does not mirror, or only slightly mirrors the surface of the acetabulum. In such embodiments, the acetabular guide **100** is positioned only by the soft tissue mating feature **102**.

[0041] In FIG. **2**, the patient-specific acetabular guide **100** is positioned on the acetabulum **20** of the pelvis **22** with the soft tissue mating feature **102** mating or engaging with a transverse acetabular ligament **80**. The mating feature **102** can mate or engage with the transverse acetabular ligament **80** in such a manner that the ligament **80** contacts the parallel plates **112**, **114** and the stop **116**, which define the slot **118**. The mating feature **102** is configured to conform, nest, or engage a soft tissue. The alignment axis A is configured to be central to the acetabulum **20** and perpendicular to the acetabulum's surface when the guide **100** is positioned on the acetabulum **21**. As mentioned above, the bone engaging surface **105** may or may not be a negative or mirror image of the surface of the acetabulum **20**.

[0042] The acetabular guide **100** can be provided in various fitment options depending on the planned exposure of the acetabulum **20** for the reaming procedure and implantation. Each fitment option can include a portion that mates with the transverse acetabular ligament **80**, which provides a landmark for rotational stability and unique positioning on the acetabulum **20**. To additionally improve stability, each fitment option can also include a portion that covers the acetabular fossa at the center of the acetabulum **20**. As shown in FIGS. **3** and **4**, another fitment option for the acetabular guide includes a rim portion **210**, **310** that is complementary to a portion of an acetabular rim **24**. The rim portion **210**, **310** can have a concave surface that references and mates with a convex acetabular rim **24**, thus providing additional stability to guides **200**, **300**. The rim portion **210**, **310** can be a mirror image or negative of the rim surface **24**, enabling the rim portion **210**, **310** to nest, engage, or conform to the rim **24**. Each fitment option allows the acetabular guide **100**, **200**, **300** to have a compact size, extend through the center of the acetabulum **20** for alignment, and include portions that can fit over various anatomic landmarks in a unique position for the patient. The particular fitment option can be selected for each

specific patient based on the patient's anatomy, the procedure to be performed and the surgeon's preference and/or technique.

[0043] Referring to FIGS. **1-2**, the patient-specific soft tissue mating portion **102** of the acetabular guide **100** includes a feature that is functional to reversibly mate with soft tissue, such as a ligament. The feature can be a hook, notch, slit, slot, or tab. As shown in detail in FIG. **1**, the mating feature **102** can include a slot **118** formed by two parallel plates **112**, **114** and a stop **116** in a U-shape. The mating feature **102** is designed by using a two-dimensional or three-dimensional image or model of the acetabulum **20**, surrounding soft tissue, and surrounding pelvic area of the specific patient, as described above. To avoid costly digital imaging protocols, the mating feature **102** can be designed by only an X-ray along with knowledge of the typical location of the transacetabular ligament or other soft tissue landmarks. Mating the acetabular guide **100** to the transverse acetabular ligament **80** enables the acetabular guide **100** to be oriented in a unique position within the acetabulum **20**. The acetabular guide **100** can be designed to have a generally small thickness, such that it can form a lightweight three-dimensional shell from which the guiding element **106** extends opposite to the acetabular surface. The guiding element **106** can be formed to be a monolithic or integral portion of the acetabular guide **100**. Alternatively, the guiding element **106** can be modularly and removably coupled to the acetabular guide **100**, using, for example, a threaded connection, snap-on connectors, or other removable attachments.

[0044] FIG. **3** shows a patient-specific acetabular guide **200** with an additional fitment option. The guide **200** includes a patient-specific soft tissue mating feature **202**, a patient-specific body **204** with a bone engaging surface **205** and an opposing surface **207**, and a guiding or pilot element **206** having an elongated bore **208**. As illustrated, the acetabular guide **200** is generally similar to guide **100**. Unlike acetabular guide **100**, acetabular guide **200** further comprises a patient-specific rim portion **210** that is complementary to a portion of the acetabular rim **24**. In some embodiments, a concave surface of the rim portion **210** mates with the convex rim **24**. Acetabular guide **200** has a patient-specific soft tissue mating feature **202**, patient-specific body **204**, and a patient-specific rim portion, which collectively impart greater stability to the guide **200** when it is positioned on an acetabulum **20**. In various embodiments, the bone engaging surface **205** of the body **204** is a mirror image or negative of the surface of the acetabulum **20**, which allows the guide **200** to nest on the articular surface of the acetabulum **20** to provide further stability.

[0045] FIG. **4**. shows a patient-specific acetabular guide **300**, similar to acetabular guide **200**. Acetabular guide **300** comprises a soft tissue mating feature **302**, a patient-specific body **304** with a bone engaging surface **305** and an opposing surface **307**, a guiding or pilot element **306** having an elongated bore **308**, and a patient-specific rim portion **310**. In various embodiments, the bone engaging surface **305** of the body **203** is a mirror image or negative of the surface of the acetabulum **20**, which allows the guide **300** to nest on the boney surface to provide further stability. Acetabular guide **300** further includes a second guiding or pilot element **312** having an elongated bore **314**, and a third guiding or pilot element **316** having an elongated bore **318**. The guiding elements **312**, **316** can be formed to be a monolithic or integral portion of acetabular guide **300**. Alternatively, the guiding elements **312**, **316** can be modularly and removably coupled to the acetabular guide **300**, using, for example, a threaded connection, snap-on connectors, or other removable attachments. The guiding elements **312**, **316** are located at predetermined locations relative to the acetabulum **20**. A surgeon can drill guide holes and/or insert guide pins through the guiding elements **312**, **316** and into the pelvis **22**.

[0046] FIG. **5** shows a pelvis **22** and acetabulum **20** including a pilot hole **330** in the acetabulum **20**, and pilot holes **332**, **334** in the pelvis **22**, near the acetabular rim **24**. The pilot hole **330** could be made by drilling through guiding elements **106**, **206**, **306** of patient-specific acetabular guides **100**, **200**, **300** shown in FIGS. **1-3**. Pilot hole **330** can be used to guide an instrument, such as a reamer **336** having a protruding guide feature **338**. The reamer can be properly aligned with the acetabulum **20** by inserting the protruding guide feature **338** of the reamer **336** into pilot hole **330**.

[0047] As shown in FIG. **6**, alignment pins **340**, **342** can be drilled into the pelvis **22** by guiding them through guiding elements **312**, **316** of the patient-specific acetabular guide **300** shown in FIG. **4**. A secondary guide **350** can be guided down the alignment pins **340**, **342** after guide **300** is removed. The secondary acetabular guide **350** can include a reaming alignment pin inserted into a cannulated feature **352** on the secondary guide **350** having a bore **354**. The reaming alignment pin can be used to further align a reamer, such as the reamer **336** of FIG. **5**, to ensure the reamer **336** is centered relative to the acetabulum **20**, and to ensure the reaming is performed at a correct angle and orientation in relation to the acetabulum **20** and the pelvis **22**. In various embodiments, the alignment pin can be coupled to the reamer **336** as a further aid to orient it in a desired position. Additional embodiments and a more detailed discussion on the use of the guide bores and pins can be found in U.S. Patent Publication No. 2012/0226283, published Sep. 6, 2012, which is incorporated herein by reference.

[0048] With reference to FIG. **7**, the present teachings further provide various exemplary patient-specific tibial guides, such as patient-specific tibial guide **400**. The tibia guide **400** can be used in connection with various other instruments to facilitate guided resecting of a proximal end of a tibia of a specific patient and guided insertion and implantation of a tibial implant. The patient-specific tibial guides **400** engage the proximal tibia of the specific patient in only one position. The tibial guides **400** can also provide secure fitting and rotational stability.

[0049] FIG. **7** illustrates the patient-specific tibial guide **400**, having a first patient-specific soft tissue mating feature **402**, a second patient-specific soft tissue mating feature **404**, and optionally a third patient-specific soft tissue mating feature **406**. The tibial guide **400** also comprises a patient-specific body **408** with a first surface **409** that contacts an anterior surface of a tibia **410** and a second surface **411** that contacts a superior surface of a tibia **412**, anterior guiding or pilot elements **414**, **416** having elongated bores **418**, **420** positioned on the anterior surface **409**, and superior guiding or pilot elements **422**, **424** having elongated bores **426**, **428** positioned on the superior surface **411**. The soft tissue mating features **402**, **404**, **406** comprise substantially parallel surfaces **409**, **411** that are coupled at a stop **413**, thereby forming a U-shaped slot **415**. The position of the soft tissue mating features **402**, **404**, **406** can be predetermined by referencing three dimensional CT or MRI scans, or by referencing two-dimensional X-rays and light of typical ligament locations in

a knee. The patient-specific tibial guide **400** is positioned on a proximal end **90** of a tibia **92** with the first soft tissue mating feature **402** mating with a medial collateral ligament (MCL) **94**, the second soft tissue mating feature **404** mating with an anterior cruciate ligament (ACL) **96**, and the optional third soft tissue mating feature **406** mating with a lateral collateral ligament (LCL) **98** by positioning the mating features **402**, **404**, **406** to receive the respective ligaments **94**, **96**, **98** in the U-shaped slots **415**. In general, the mating features **402**, **404**, **406** are configured to conform, receive, nest, or engage soft tissue.

[0050] The tibial guide **400** can be provided in various fitment options depending on the desired stability of the tibial guide **400** on the tibia **92**. Each fitment option can include a portion that mates with the ACL **96**, which provides a landmark for rotational stability and unique positioning on the tibia **92**. To additionally improve stability, each fitment option can also include a portion that mates with the MCL **94**. To additionally improve stability, each fitment option can also include a portion that mates with the LCL **98**. Additionally, the patient-specific body **408** of the tibial guide **400** can comprise a bone engaging surface **413** that is a negative or mirror image of boney and/or articular landmarks in the tibia **92**. Accordingly, the body **408** of the tibial guide **400** can nest on the tibia to impart greater stability. Each fitment option allows the tibial guide **400** to have a compact size, and include portions that can fit over various anatomic landmarks in a unique position for the patient. The particular fitment option can be selected for each specific patient based on the patient's anatomy, the procedure to be performed and the surgeon's preference and/or technique.

[0051] The patient-specific soft tissue mating portions **402**, **404** (**406**) of the tibial guide **400** include a feature that is functional to reversibly mate with soft tissue, such as a ligament. The feature can be a hook, notch, slit, slot, or tab. As shown in detail in FIG. **7**, the mating features **402**, **404**, **406** can be slots **415** defined by two substantially parallel surfaces **409**, **411** and a stop **413** that form a U-shape. The mating features **402**, **404**, **406** are designed by using a two-dimensional X-ray of the tibia **92** or by using a three-dimensional image or model of the tibia **92**, and surrounding soft tissues of the specific patient generated by CT or MRI scans. Mating the tibial guide **400** to the ACL **96**, MCL **94**, and optionally to the LCL **98** enables the tibial guide **400** to be oriented in a unique position on the proximal end **90** of the tibia **92**. The tibial guide **400** can be designed to have a generally small thickness, such that it can form a lightweight three-dimensional shell from which the guiding elements **414**, **416**, **422**, **424** extend opposite to the anterior and superior faces **410**, **412** of the tibia **62**. The guiding elements **414**, **416**, **422**, **424** can be formed to be monolithic or integral portions of the tibial guide **400**. Alternatively, the guiding elements **414**, **416**, **422**, **424** can be modularly and removably coupled to the tibial guide **400**, using, for example, a threaded connection, snap-on connectors, or other removable attachments.

[0052] FIG. **8** is a representation of the patient-specific tibial guide **400** positioned on a tibia **92** at the proximal end **90**. Anterior alignment pins **440**, **442** are drilled through a drill guide **444**, through the anterior guiding or pilot elements **414**, **416**, and into the tibia **92**. Likewise, superior alignment pins **446**, **448** are drilled through a drill guide **450**, through the superior guiding or pilot elements **422**. **424**, and into the superior face **412** of the tibia **92**. Because the locations of the guiding or pilot elements **414**, **416**, **422**, **424** are predetermined during the preoperational planning stage, they can be used to guide instruments to exact locations relative to the tibia **92**.

[0053] FIG. **9** is a representation of the tibia **92** with the patient-specific tibial guide **400** and superior alignment pins **446**, **448** removed. Pilot holes **452**, **454** remain where the superior alignment pins **446**, **448** were removed. The anterior alignment pins **440**,**442** remain inserted in the anterior face **410** of the tibia **92**. As shown in FIG. **10**, a tibial cut block **460** can be positioned adjacent to the anterior surface **410** of the tibia **92** by positioning the cut block **460** along the anterior alignment pins **440**, **442**. A resecting tool **462** can then be inserted through a guide slit **464** in the cut block **460** for resecting the proximal end **90** of the tibia **92** at a predetermined location.

[0054] FIG. **11** shows the tibia **92** with the superior alignment pins **446**, **448** reinserted into the pilot holes **452**, **454** shown in FIG. **8**. The anterior alignment pins **440**, **442** have been removed. A trial plate **460** is placed adjacent to a resected superior face **412'** of the tibia **92** by positioning the trial plate **460** along the superior alignment pins **440**, **442**. An alignment instrument **472** comprising a handle with an aperture **474** is placed along the superior alignment pins **440**, **442**, and adjacent to the trial plate **460**. An alignment rod **476** is inserted through the aperture **474**, which can be visualized with reference to the tibia **92** to ensure proper alignment. The alignment instrument **472**, trial plate **470**, and superior alignment pins **446**, **448** can then be removed, and a tibial implant implanted adjacent to the superior face **412'** of the tibia **92**. Additional embodiments and a more detailed discussion on the use of the guide bores and pins can be found in U.S. Patent Publication No. 20120316564, published on Dec. 13, 2012, which is incorporated herein by reference.

[0055] The present teachings also provide a method of manufacturing a guide tool for guiding an instrument to a bone. The method comprises obtaining at least one image of at least a portion of the bone and optionally of a soft tissue at or near the bone; and generating a two-dimensional or three-dimensional model of the bone and soft tissue. The image can be a MRI or CT scan, ultrasound or X-ray. Three-dimensional models can be generated from MRI and CT scans, which include boney and soft tissue structures. X-ray images can also be used to generate a model of bone. The approximate location of ligaments at or near the bone can be determined based on the location of ligaments in a typical patient. The bone can be any bone in the human body. The soft tissue can be a ligament, tendon, muscle, fibrous tissue or fat. The method further comprises fabricating a patient-specific guide tool having a body portion and a patient-specific portion. The body portion includes a guide feature, and the patient-specific portion includes at least one mating feature that is configured to conform to or engage the soft tissue according to the two-dimensional or three-dimensional model. Fabricating can be performed by any method known in the art.

[0056] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the

disclosure, and all such modifications are intended to be included within the scope of the disclosure.

What is claimed is:

1. A patient-specific guide tool for guiding an instrument toward a bone, the guide tool comprising:

a body portion that includes an engagement surface and a guide element configured to guide movement of the instrument toward the bone; and

a patient-specific soft tissue attachment portion that is coupled to the body portion, the patient-specific soft tissue attachment portion including at least one patient-specific soft tissue mating feature that is configured to engage a first soft tissue at or near the bone to thereby position the engagement surface at a predetermined position relative to the bone.

2. The patient-specific guide tool according to claim **1**, further comprising a second patient-specific soft tissue mating feature that is configured to engage a second soft tissue at or near the bone, wherein the second soft tissue is different from the first soft tissue.

3. The patient-specific guide tool according to claim **2**, further comprising a third patient-specific soft tissue mating feature that is configured to engage a third soft tissue at or near the bone, wherein the third soft tissue is different from the first and second soft tissues.

4. The patient-specific guide tool according to claim **3**, wherein the first patient-specific soft tissue mating feature is configured to engage an anterior cruciate ligament (ACL), the second patient-specific soft tissue mating feature is configured to engage medial collateral ligament (MCL), the third patient-specific soft tissue mating feature is configured to engage a lateral cruciate ligament (LCL), and wherein the engagement surface is configured to engage a tibia.

5. The patient-specific guide tool according to claim **1**, wherein the patient-specific soft tissue mating feature is configured to engage a transacetabular ligament and the engagement surface is configured to engage an acetabulum.

6. The patient-specific guide tool according to claim **5**, wherein the engagement surface includes a rim portion that is a negative of an acetabular rim, the rim portion configured to engage the acetabular rim in only one position.

7. The patient-specific guide tool according to claim **1**, wherein the soft tissue mating feature is a hook, notch, slit, slot, or tab.

8. The patient-specific guide tool according to claim **1**, wherein the soft tissue mating feature is configured to engage a ligament, tendon, muscle, fibrous tissue or fat.

9. The patient-specific guide tool according to claim **1**, wherein the engaging surface is a mirror image of a site on the bone where the guide tool is to be positioned and nests in only one position on the bone.

10. The patient-specific guide tool according to claim **1**, wherein the guide element is a guide bore, slot, or guide surface.

11. A patient-specific guide tool for guiding an instrument toward a bone, the guide tool comprising:

a body portion that includes a guide feature having a guide surface, the guide surface configured to guide movement of the instrument toward the bone;

a first patient-specific portion extending from the body portion, the first patient-specific portion including at least one patient-specific soft tissue engaging feature that is configured and shaped to engage soft tissue at or near the bone; and

a second patient-specific portion extending from the body portion, the second patient-specific portion including a patient-specific bone engaging surface configured to nest with the bone,

wherein the guide tool thereby positions the guide feature at a predetermined position relative to the bone.

12. The patient-specific guide tool according to claim **11**, wherein the soft tissue engaging feature is configured to engage a transacetabular ligament.

13. The patient-specific guide tool according to claim **12**, wherein the patient-specific bone engaging surface comprises a concave surface portion configured to engage and nest with a convex rim of the acetabulum in only one position.

14. The patient-specific guide tool according to claim **11**, further comprising a second patient-specific soft tissue engaging feature that is configured to engage a second soft tissue, the second soft tissue being different from the first soft tissue.

15. The patient-specific guide tool according to claim **14**, wherein the first soft tissue engaging feature is configured to engage an anterior cruciate ligament and the second soft tissue engaging feature is configured to engage a medial collateral ligament.

16. The patient-specific guide tool according to claim **15**, wherein the bone engaging surface is configured to engage a tibia.

17. The patient-specific guide tool according to claim **11**, wherein the soft tissue engaging feature is configured in accordance with a two-dimensional or three-dimensional model of the bone and soft tissue of a specific patient reconstructed preoperatively from at least one image scan of the patient.

18. A method of manufacturing a guide tool for use in guiding an instrument to a bone, the method comprising:

obtaining images of at least a portion of the bone;

determining the location of soft tissue at or near the bone;

generating a two-dimensional or three-dimensional model of the bone and soft tissue; and

fabricating a patient-specific guide tool having a body portion and a patient-specific portion, the body portion including a guide feature, and the patient-specific portion including at least one soft tissue mating feature that is configured to engage the soft tissue according to the two-dimensional or three-dimensional model.

19. The method according to claim **19**, wherein determining the location of soft tissue at or near the bone comprises obtaining an MRI, CT scan or ultrasound of the portion of the bone.

20. The method according to claim **18**, wherein determining the location of soft tissue at or near the bone comprises obtaining an X-ray of the bone of the specific patient and locating the position of the soft tissue at or near the bone according to known locations of the soft tissue relative to the bone.

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