US 20120016487A1

(19) **United States**

(12) **Patent Application Publication**

Conway et al.

(10) **Pub. No.: US 2012/0016487 A1**

(43) **Pub. Date: Jan. 19, 2012**

(54) **IMPLANT COMPONENTS AND METHODS**

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(73) Assignee: **SMITH & NEPHEW, INC.**, Cordova, TN (US)

(21) Appl. No.: **13/156,242**

(22) Filed: **Jun. 8, 2011**

Related U.S. Application Data

(60) Provisional application No. 61/352,705, filed on Jun. 8, 2010, provisional application No. 61/352,722, filed on Jun. 8, 2010, provisional application No. 61/422,903, filed on Dec. 14, 2010, provisional application No. 61/466,817, filed on Mar. 23, 2011.

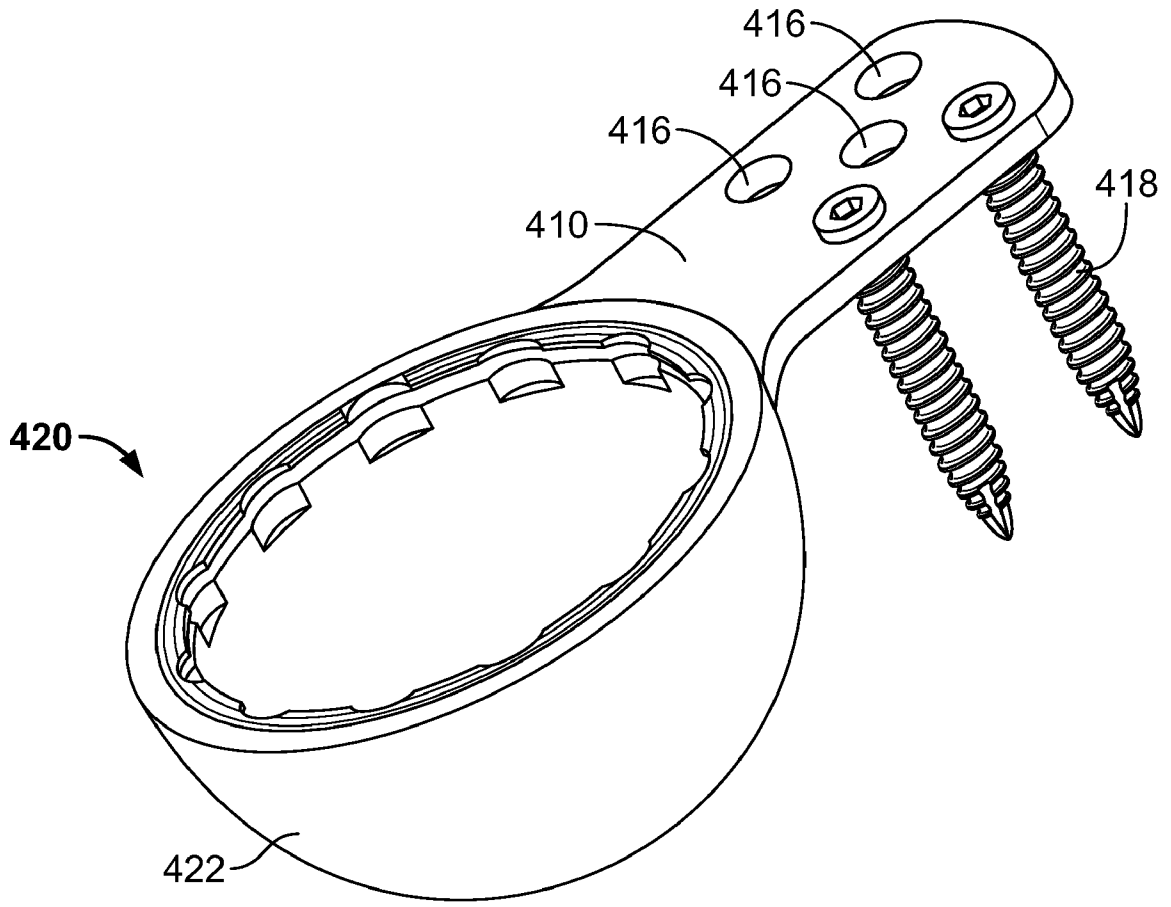
Publication Classification

(51) **Int. Cl.**
A61F 2/34 (2006.01)

(52) **U.S. Cl.** **623/22.38**

(57) **ABSTRACT**

Systems, devices, and methods are provided for orthopedic implants. The implants may include a base member, such as an acetabular shell or an augment, that is configured to couple with an augment, flange cup, mounting member, or any other suitable orthopedic attachment. An augment provided for an acetabular implant may be adjustably positionable around the implant. An implant may have one or more slots that mate with connections on the augment and allow the augment to move within the slot. An augment may be translated, rotated, or moved in any other way to achieve a desired orientation prior to locking the augment in place relative to the implant. The augment may be locked by a screw or other locking mechanism that holds the augment in place. The locking mechanism may be releasable to allow for repositioning of the augment.



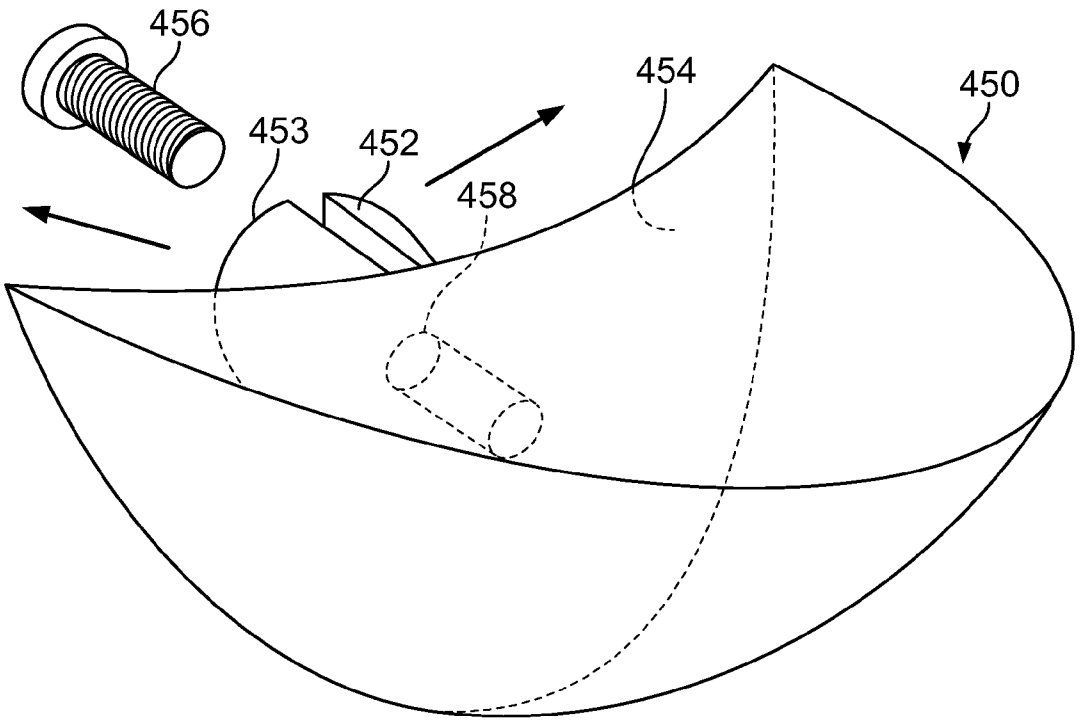


FIG. 1

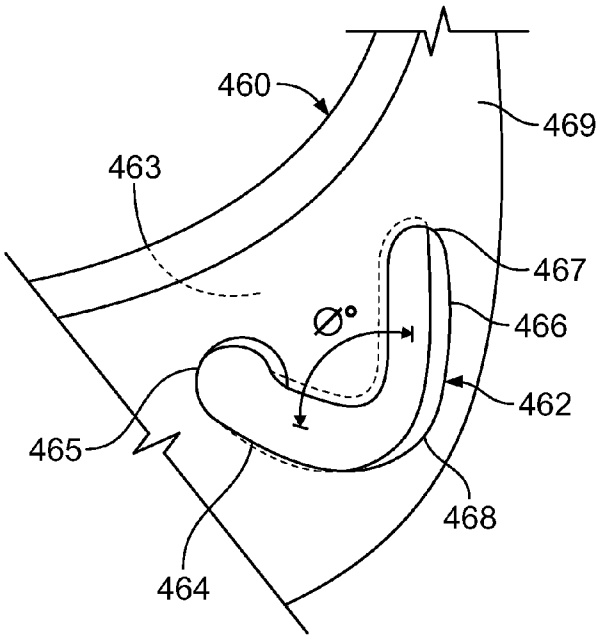
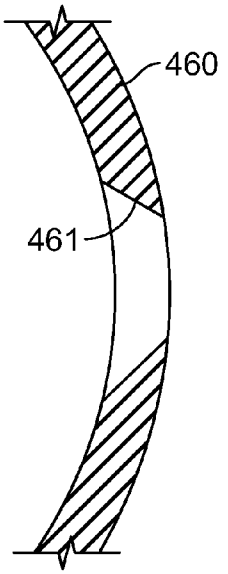


FIG. 2



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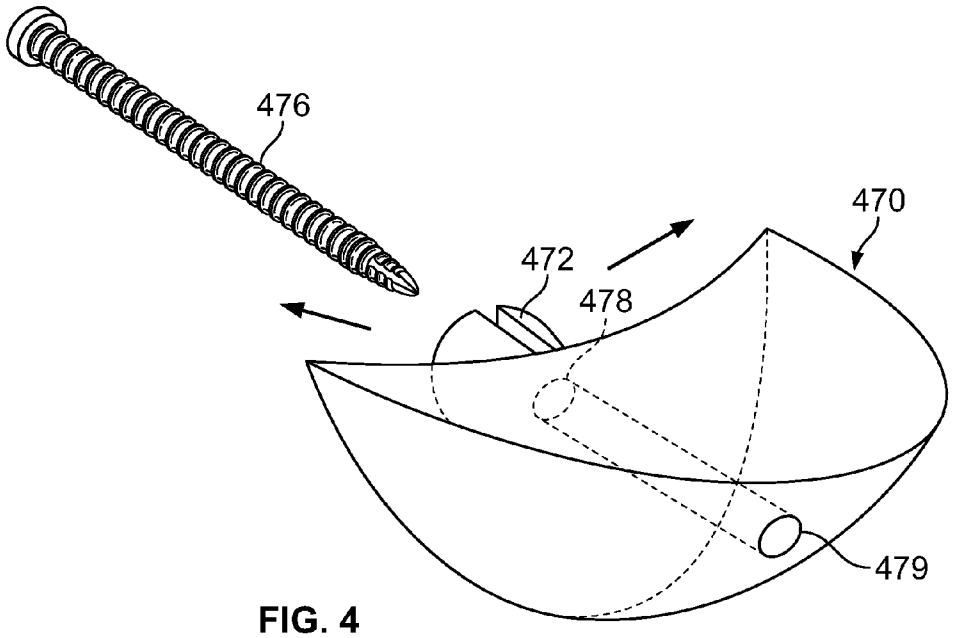
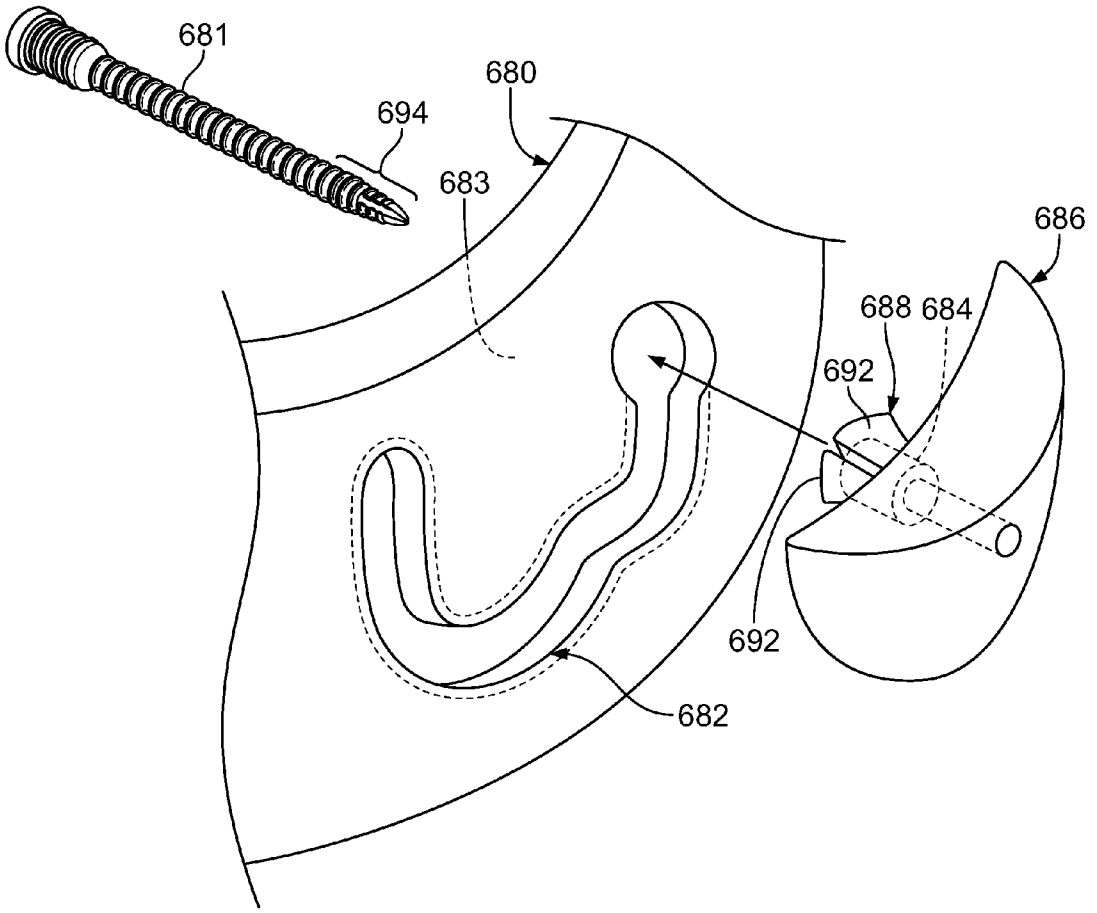


FIG. 4



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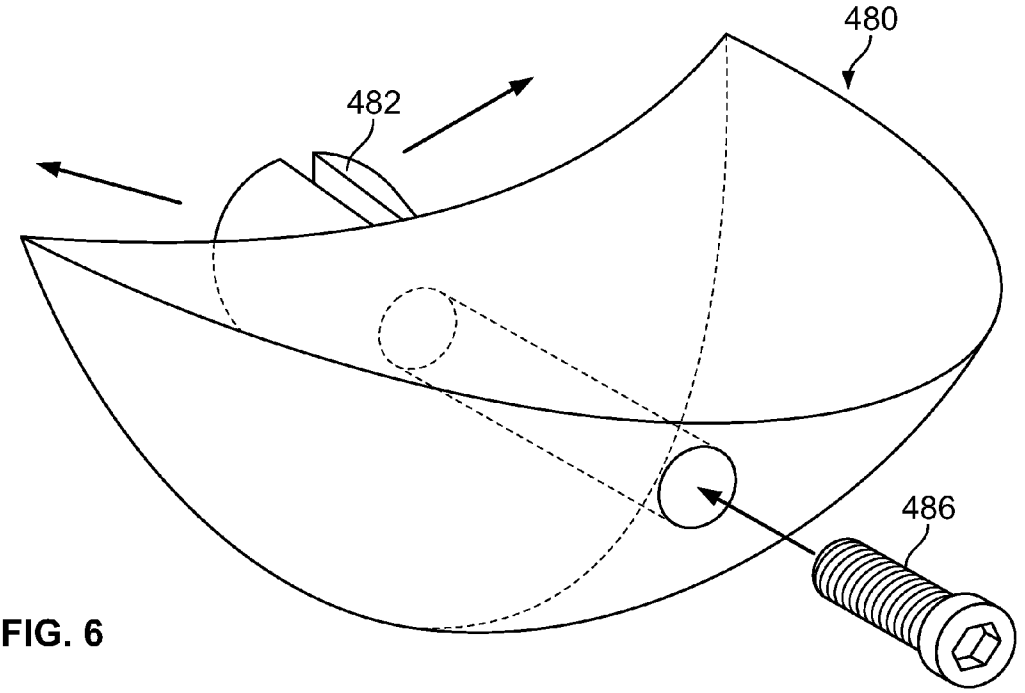

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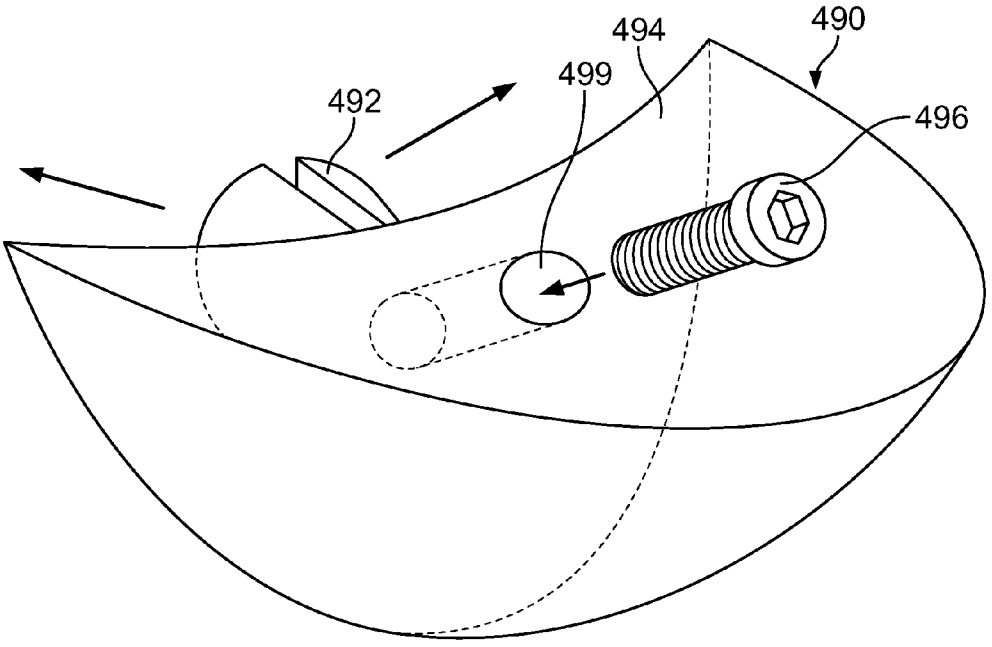

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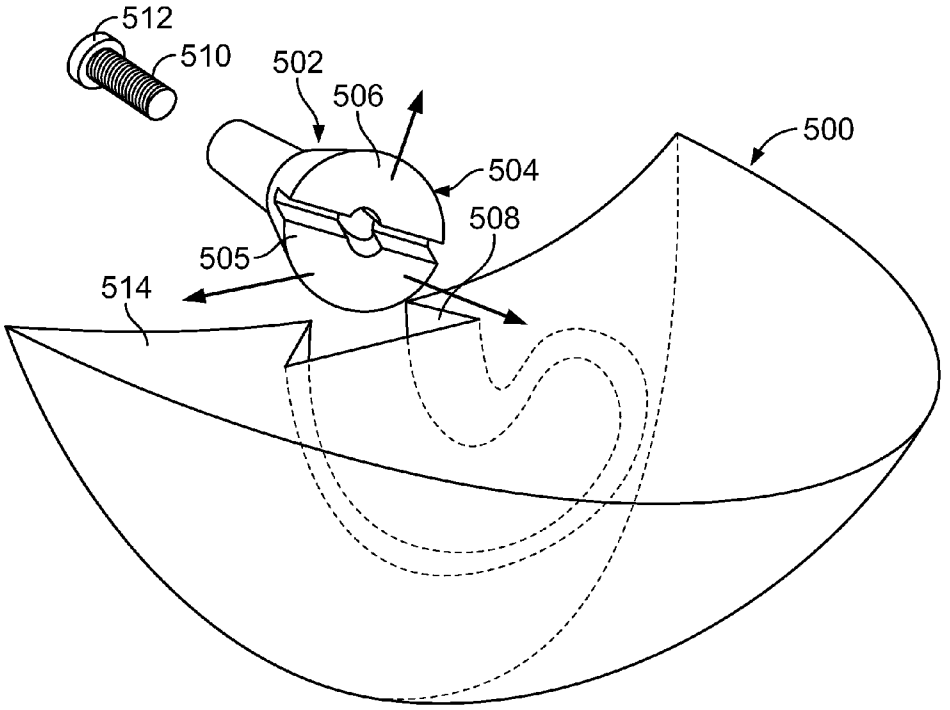

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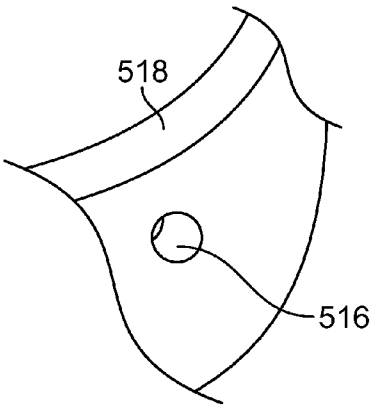

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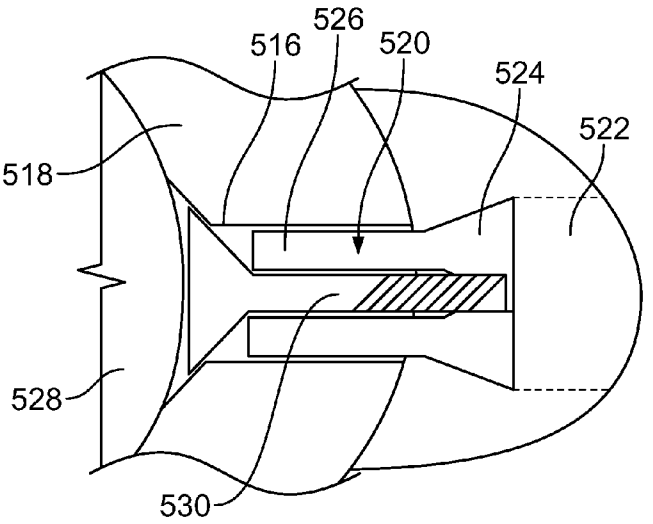

FIG. 10

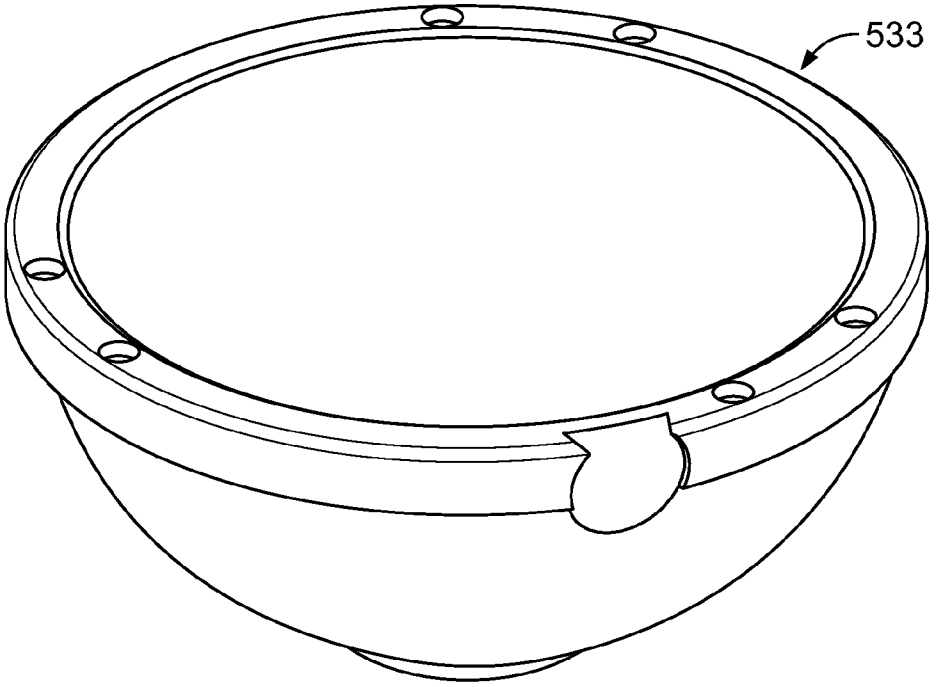

FIG. 11
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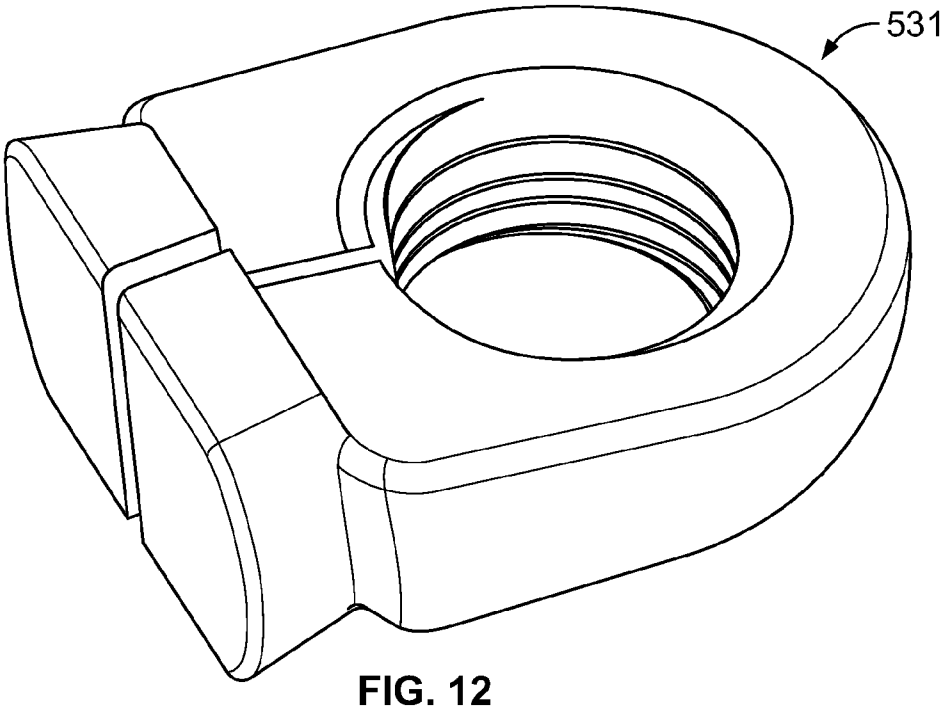


FIG. 12
(Prior Art)

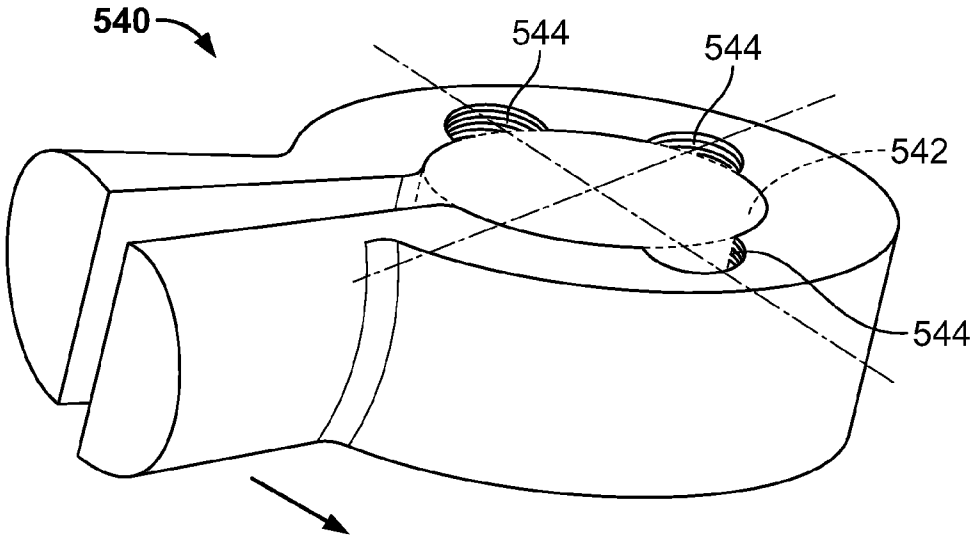
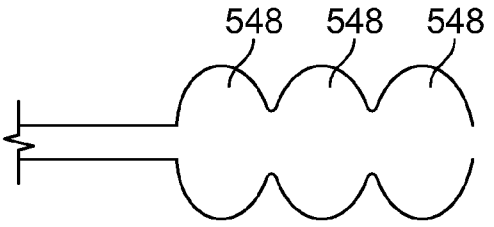


FIG. 13



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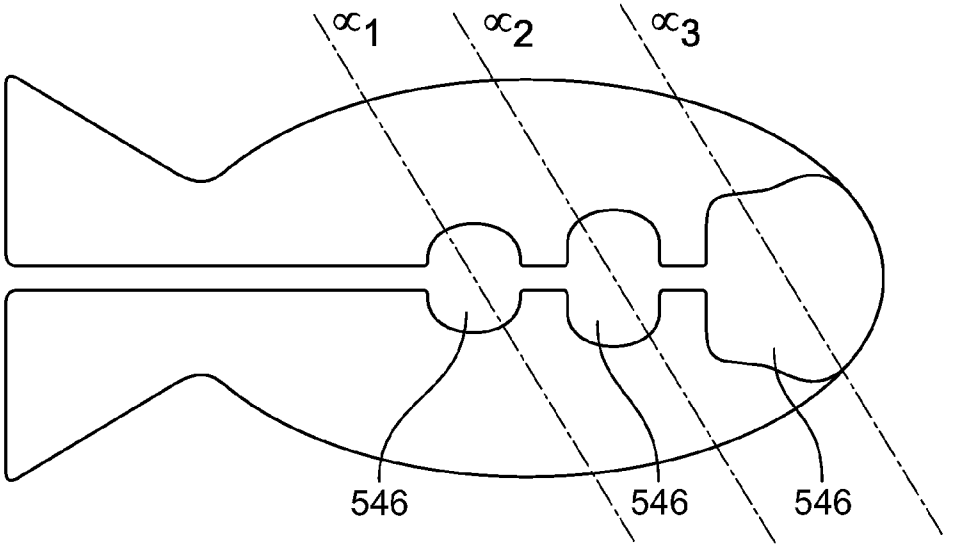

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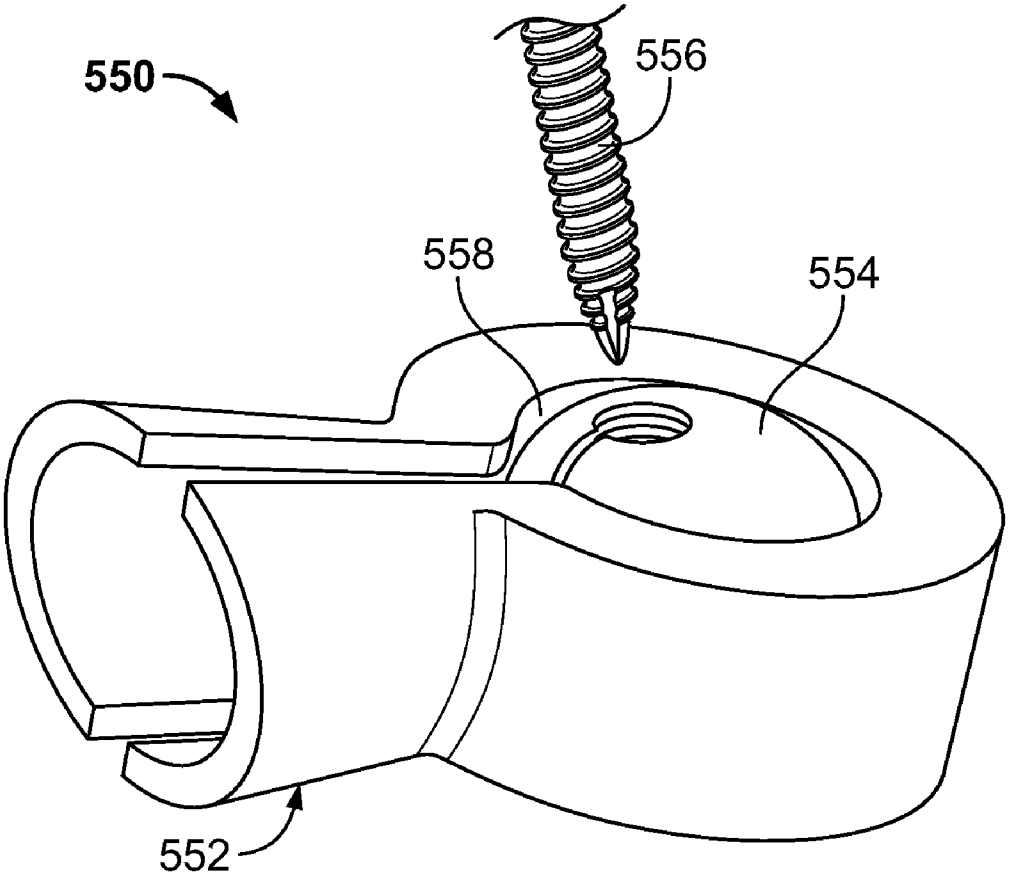
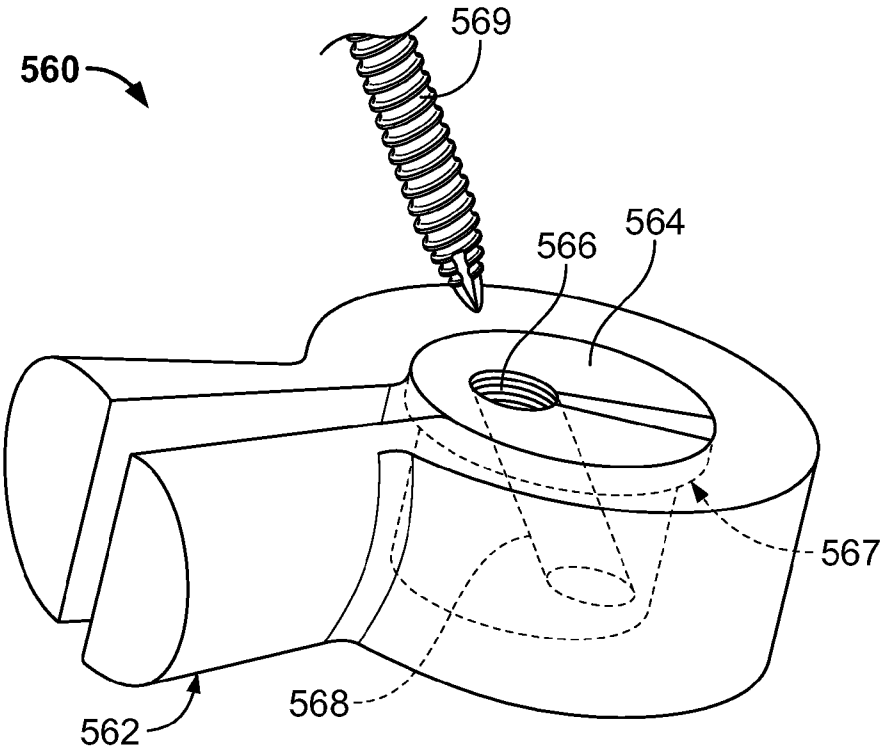


FIG. 16



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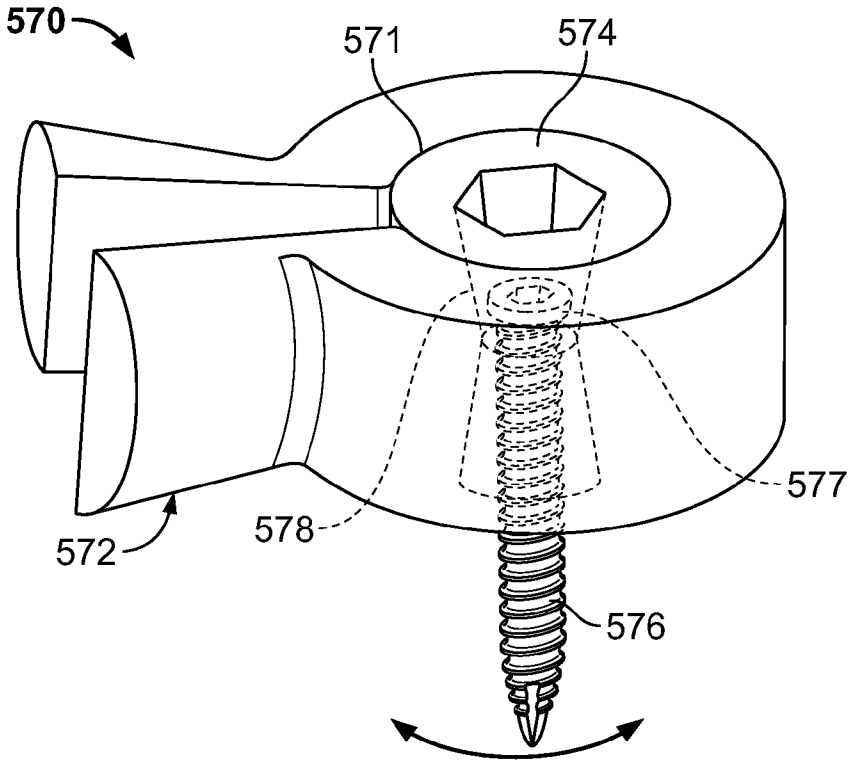

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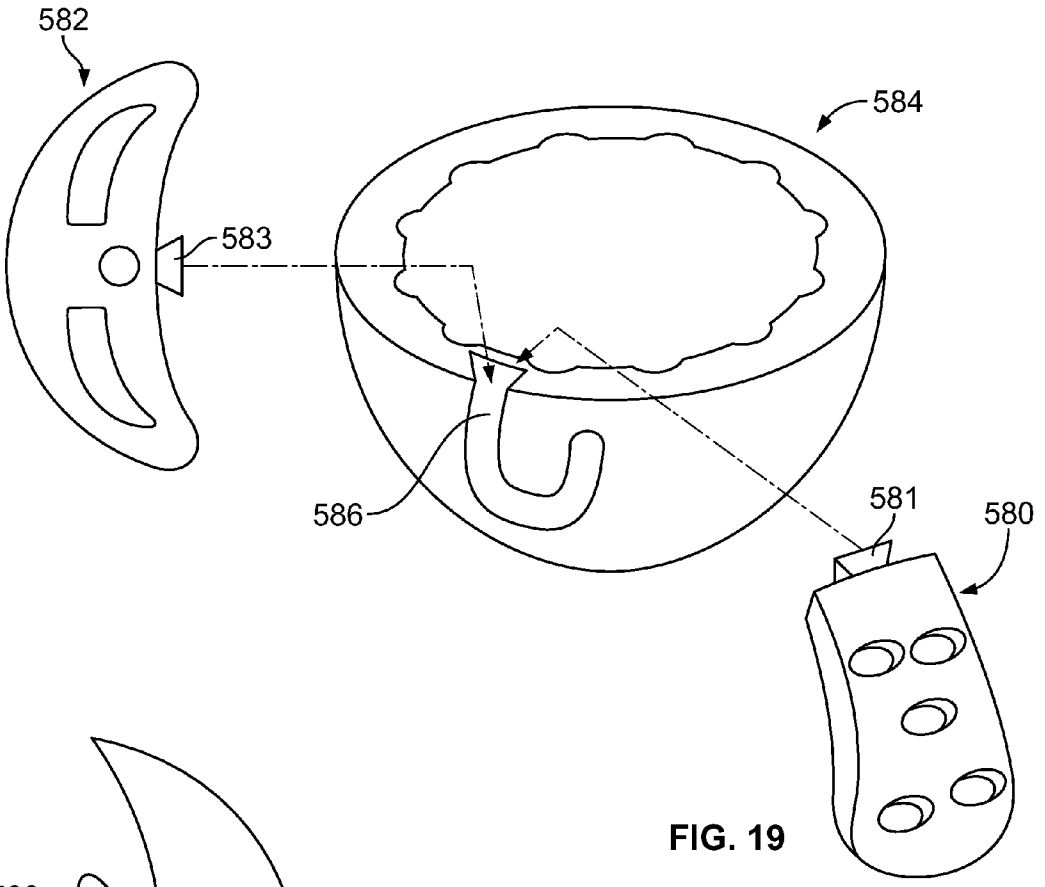

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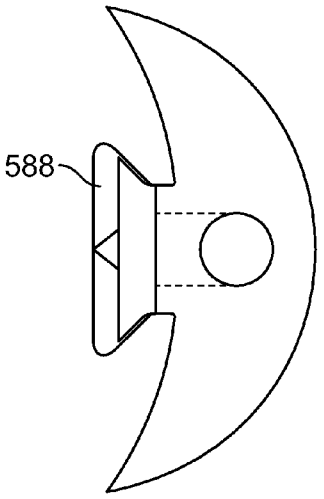

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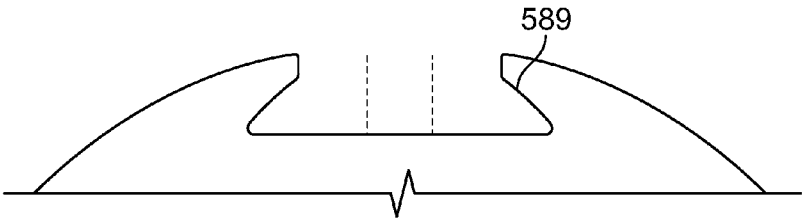

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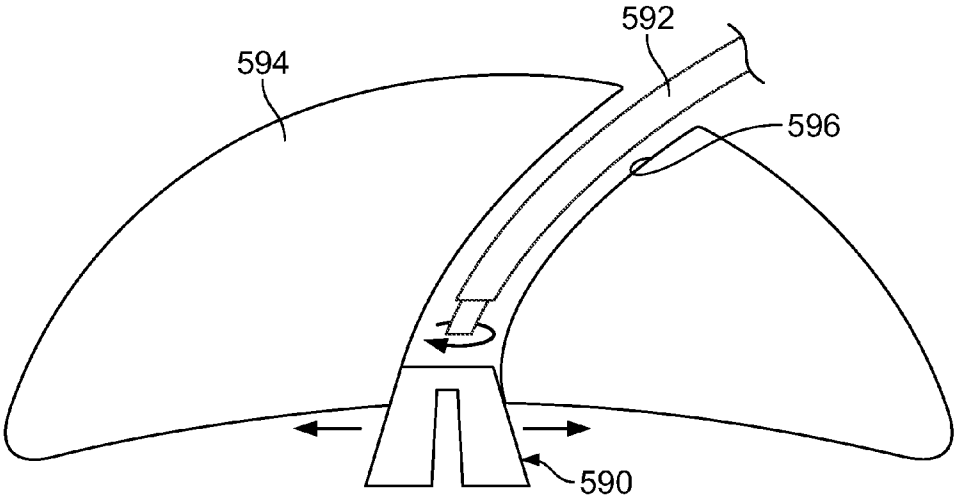

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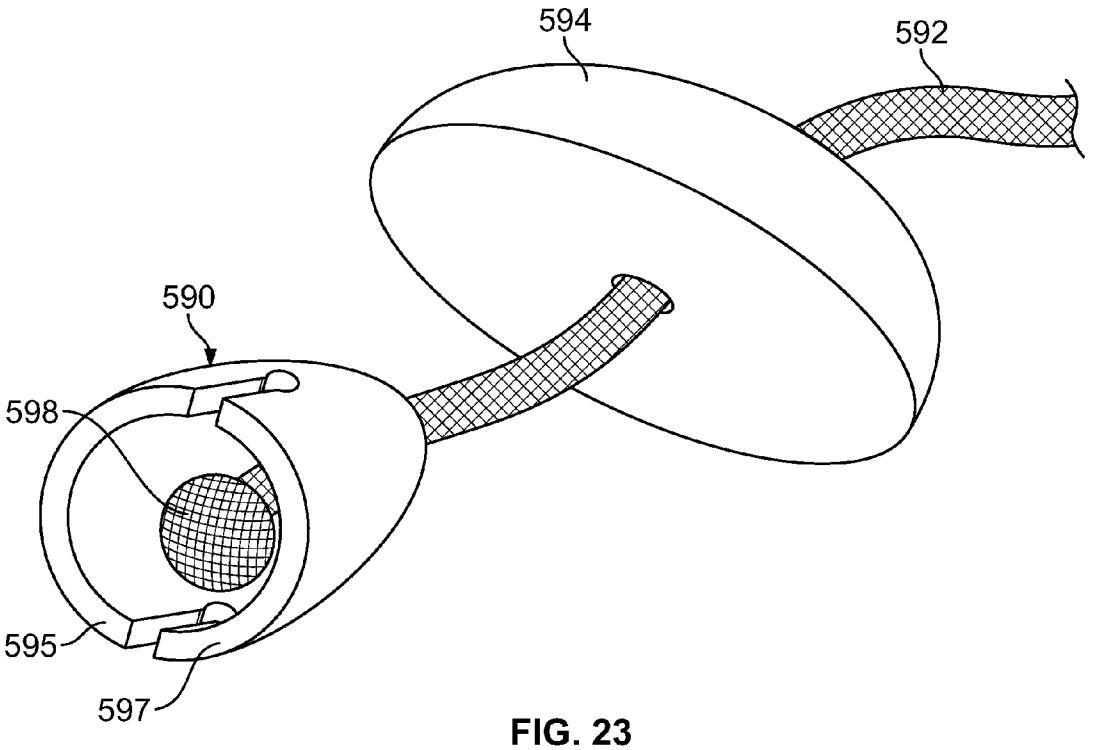

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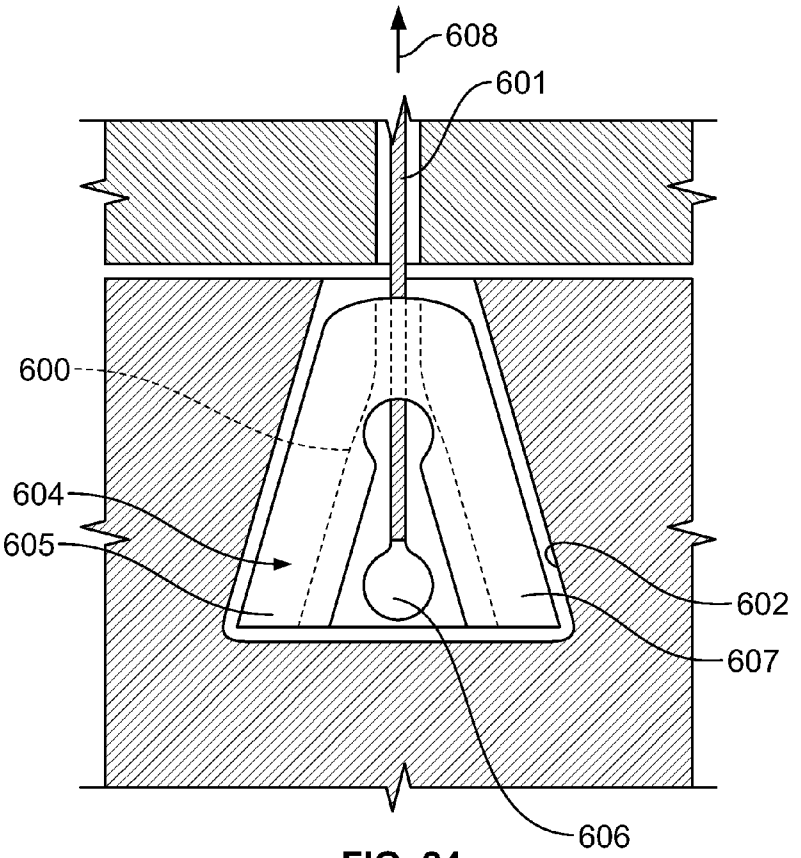

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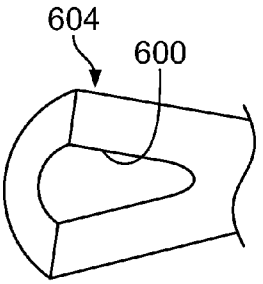

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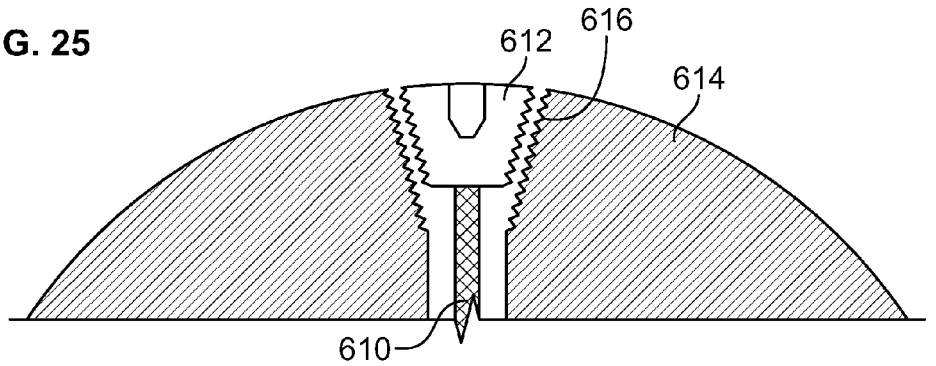

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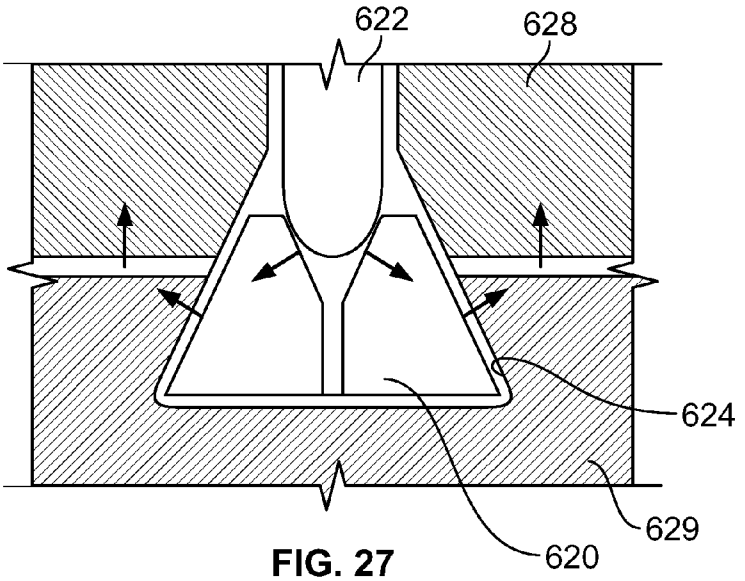

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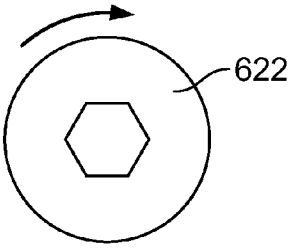
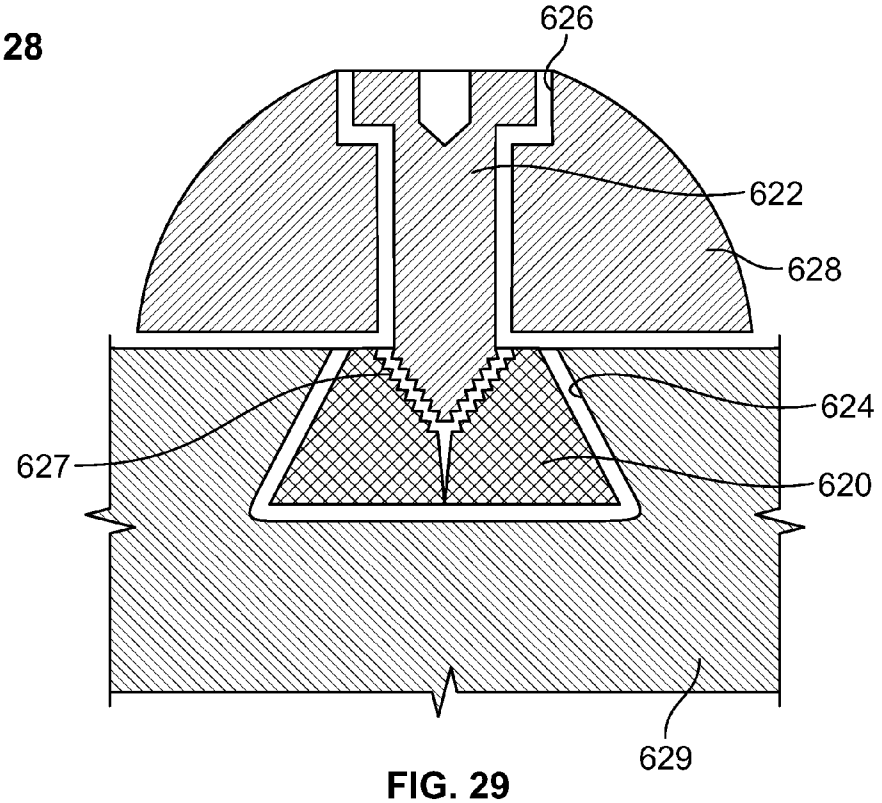


FIG. 28



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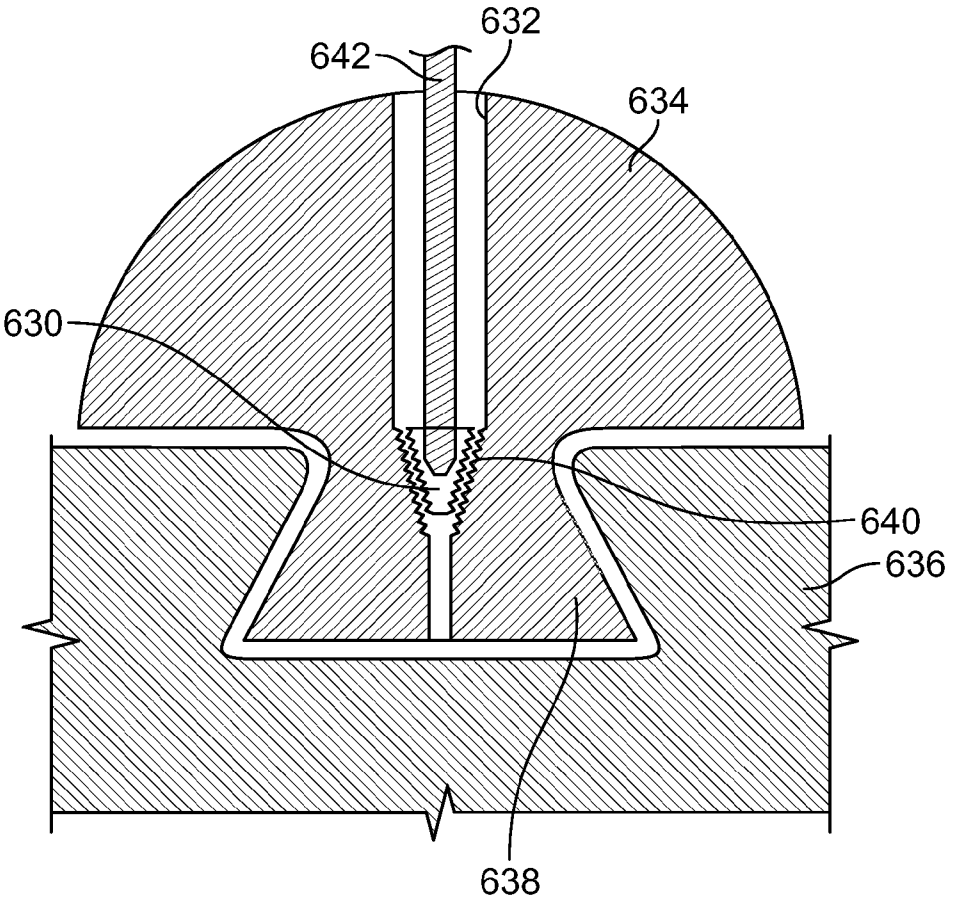


FIG. 30

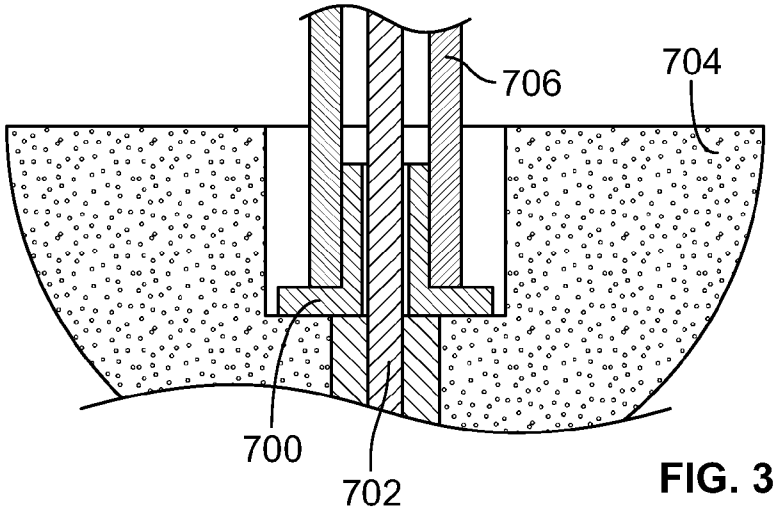


FIG. 31

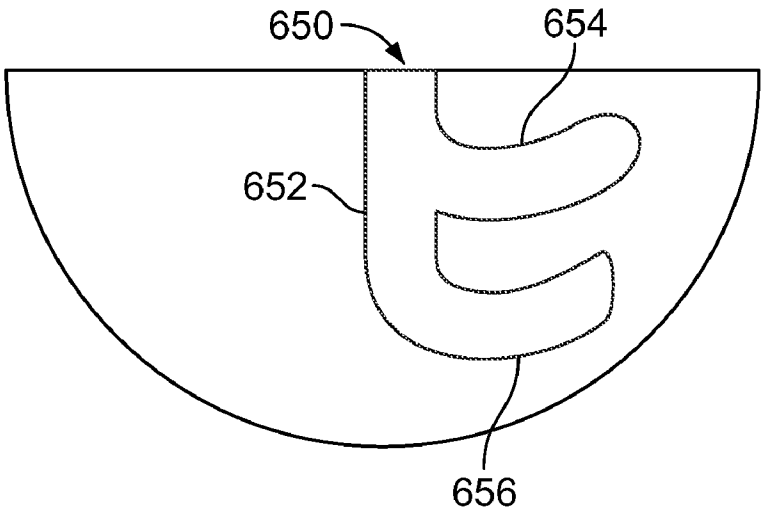


FIG. 32

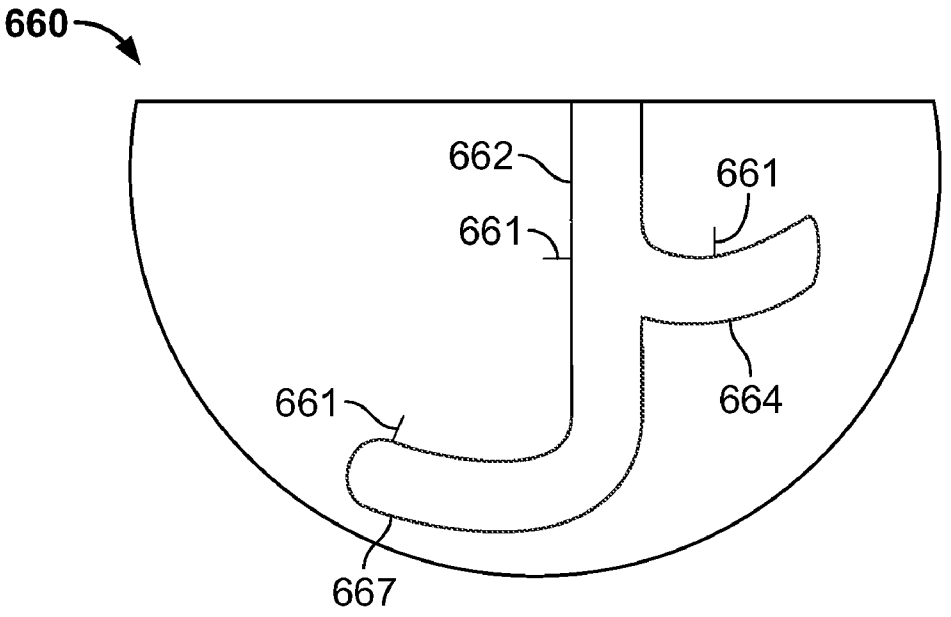
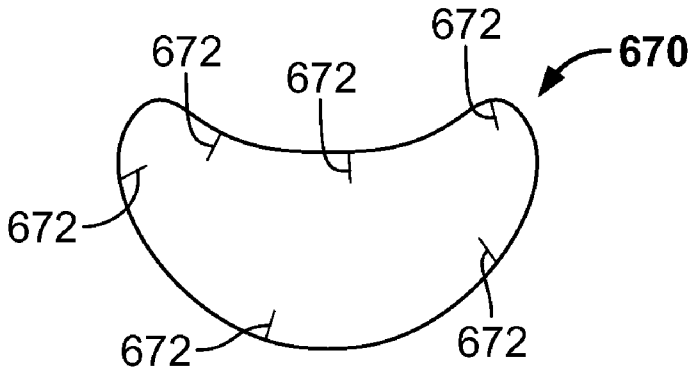


FIG. 33



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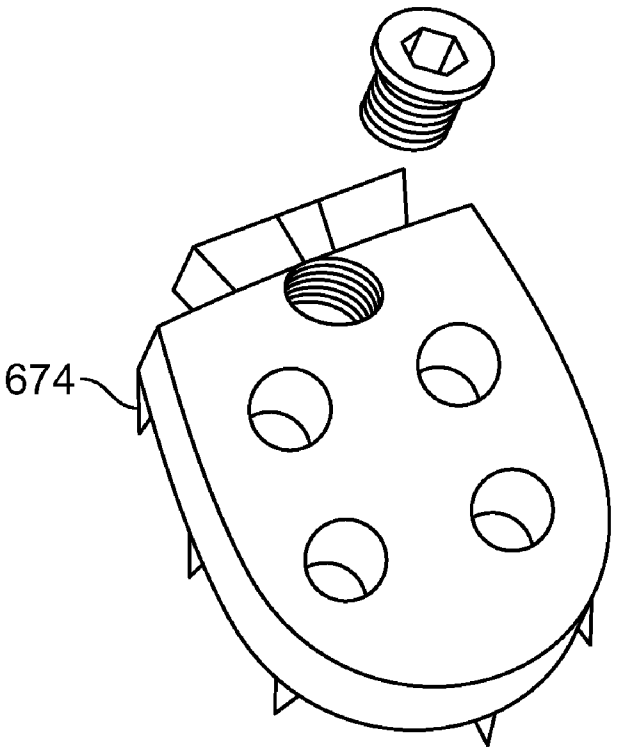

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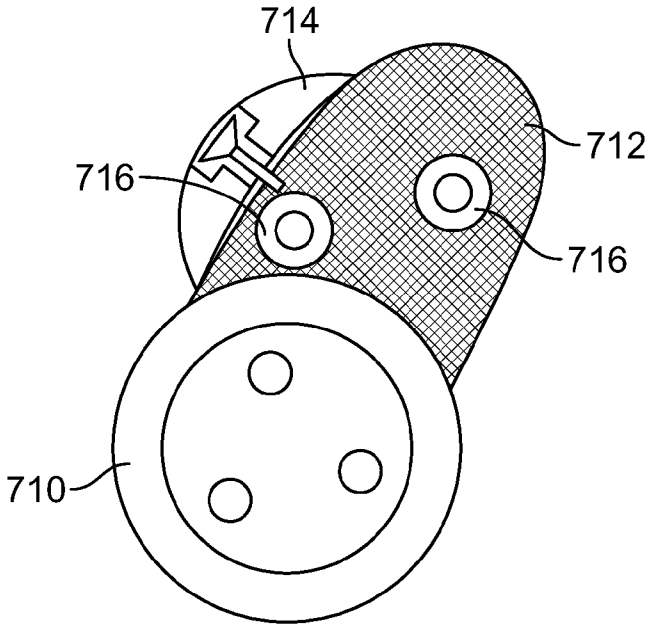

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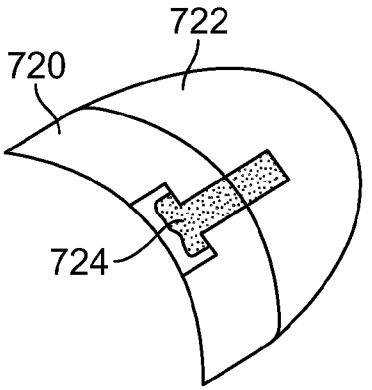

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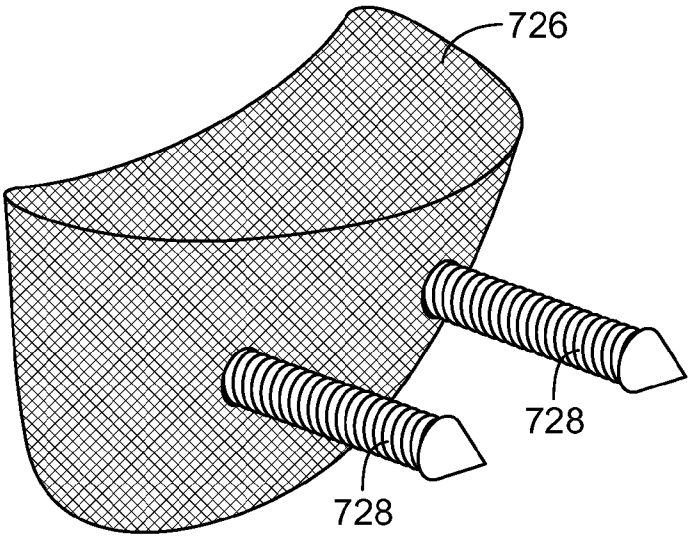


FIG. 38

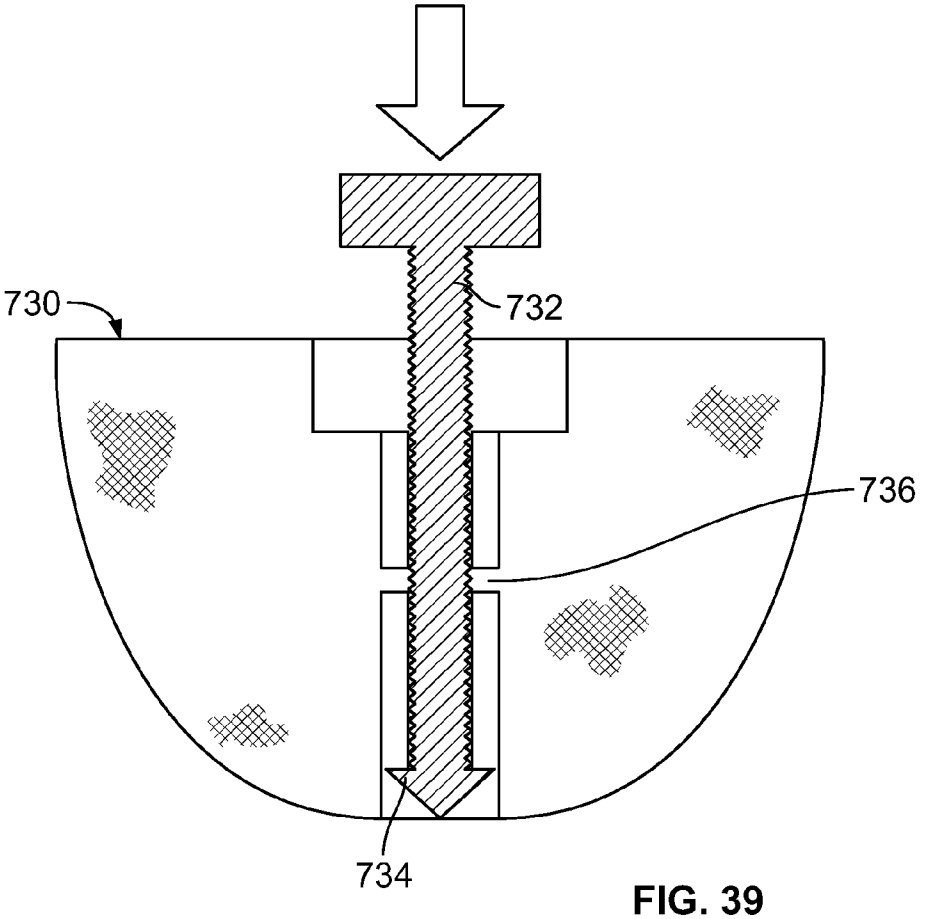


FIG. 39

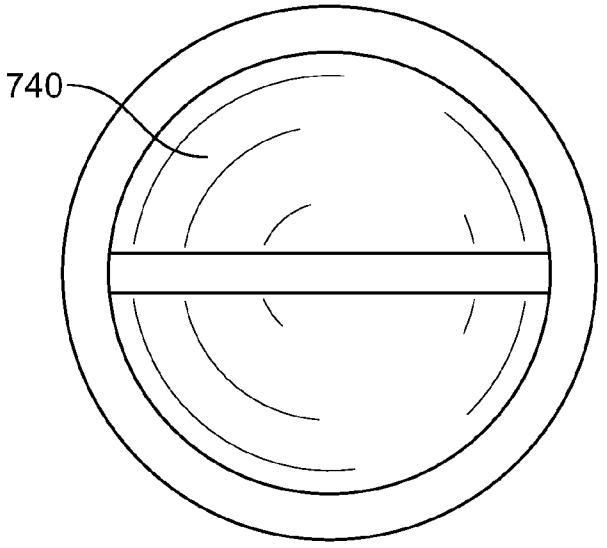
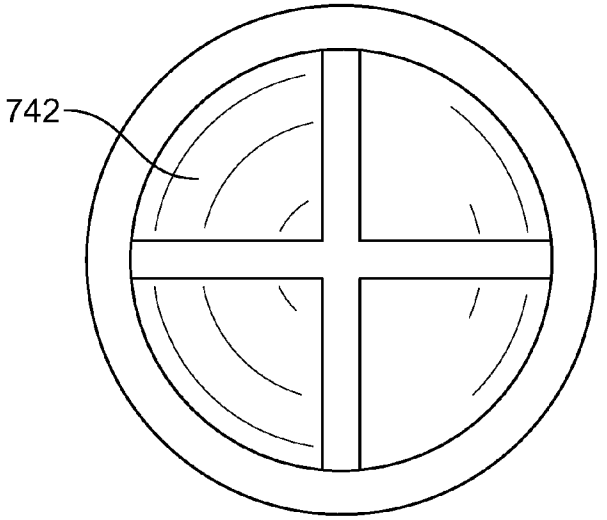


FIG. 40



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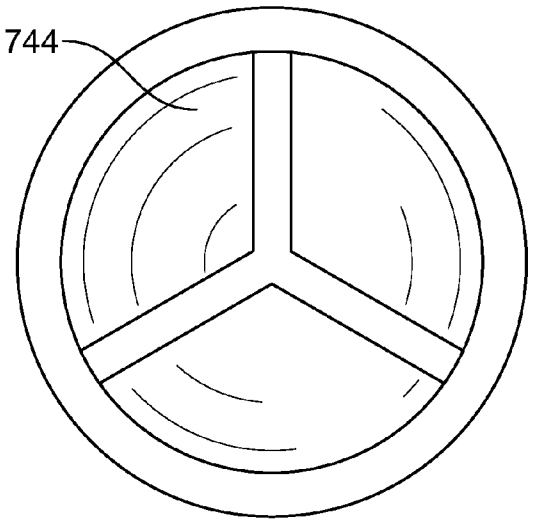

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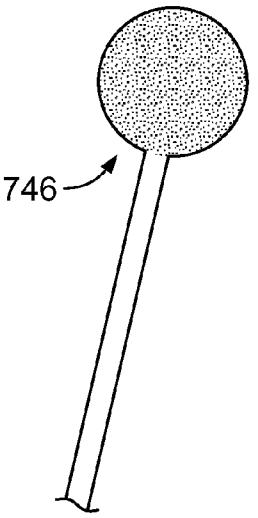

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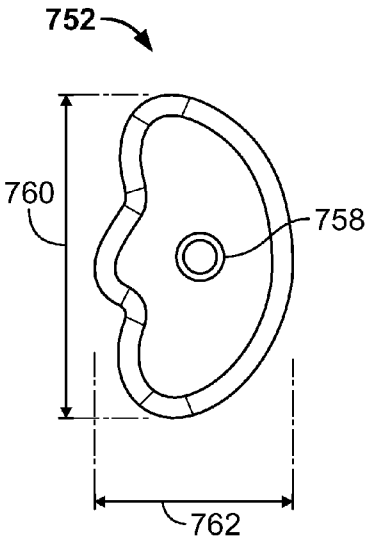


FIG. 44

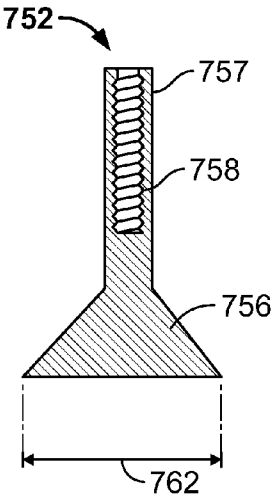
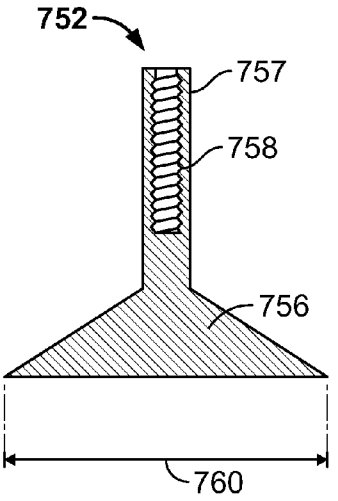


FIG. 45



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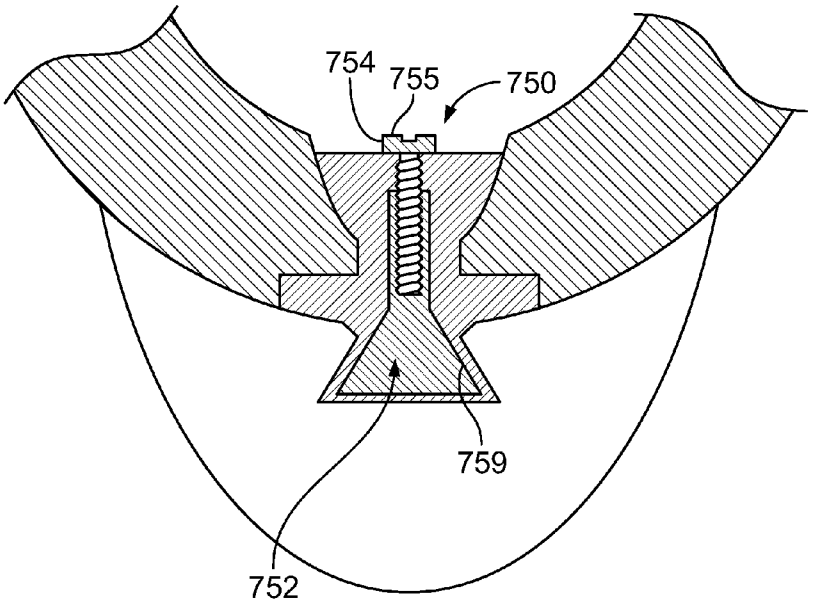

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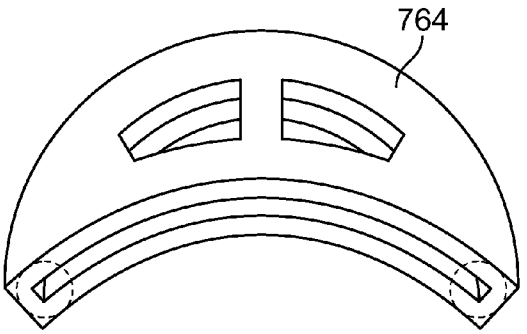

FIG. 48

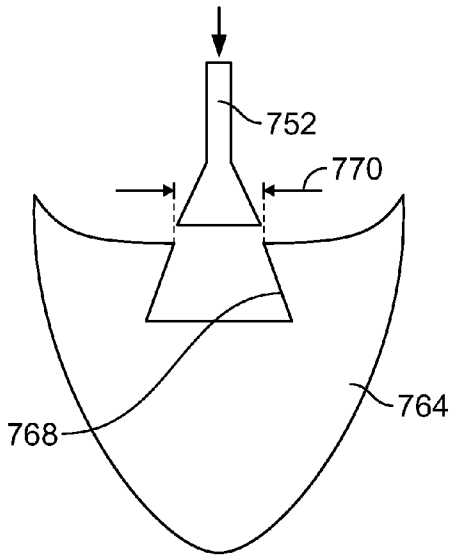

FIG. 49

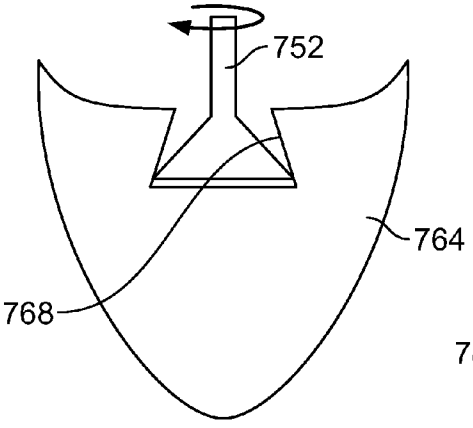

FIG. 50

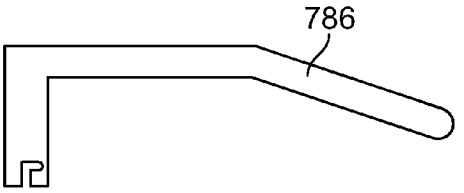

FIG. 51

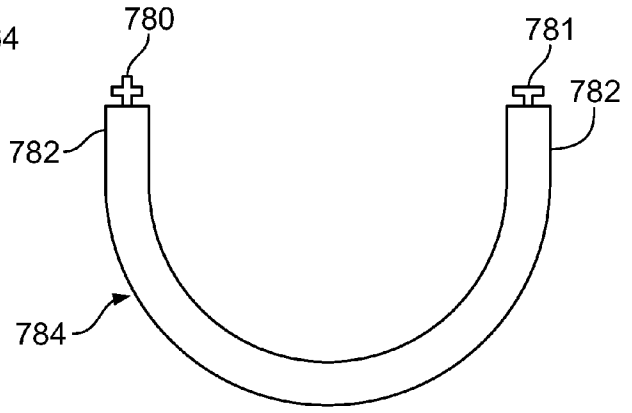

FIG. 52

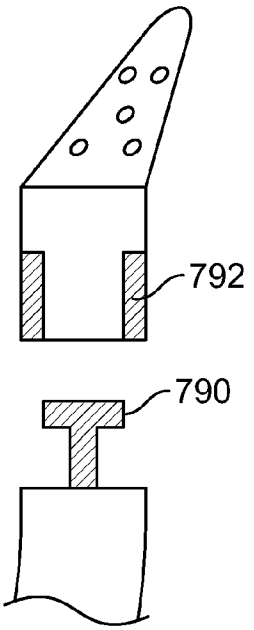

FIG. 53

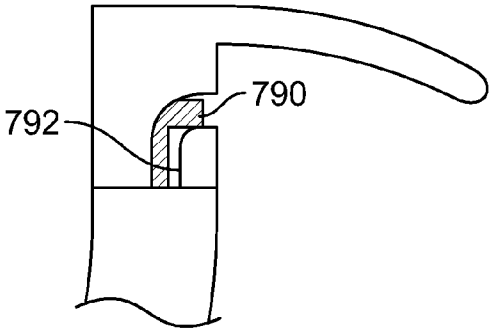

FIG. 54

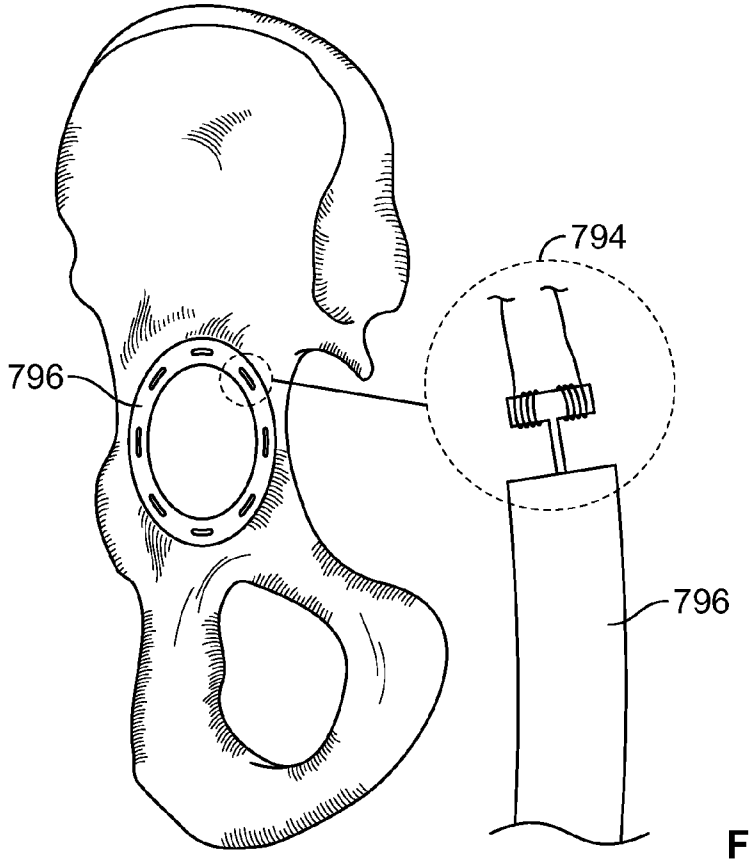

FIG. 55

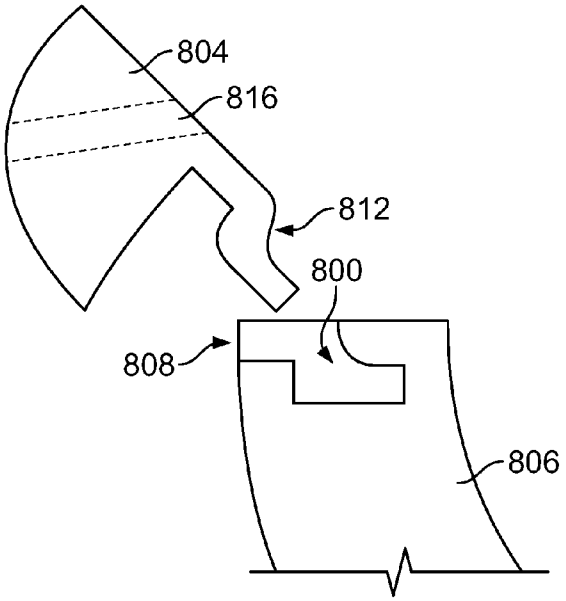

FIG. 56

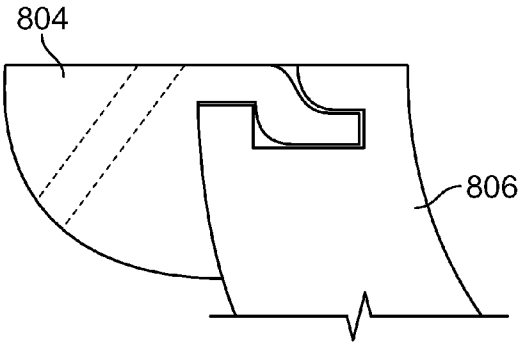

FIG. 57

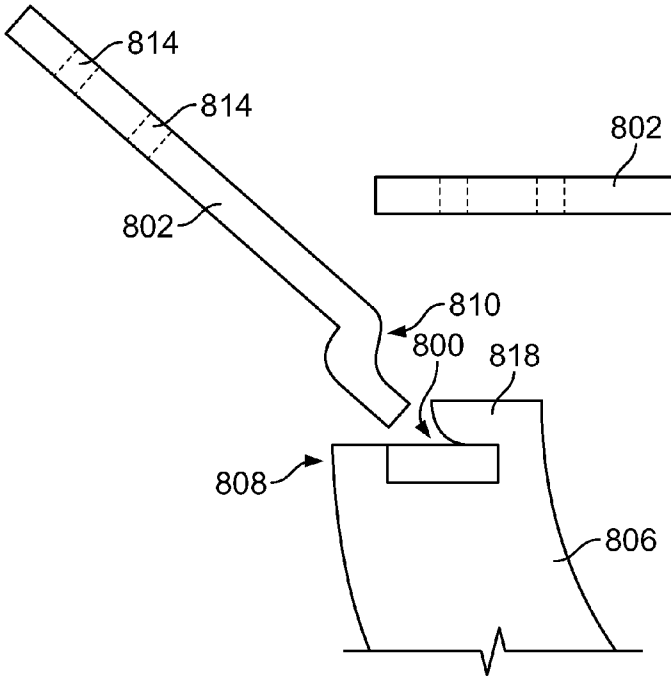

FIG. 58

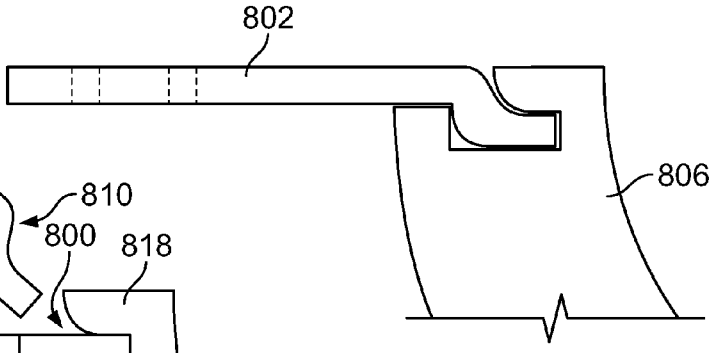

FIG. 59

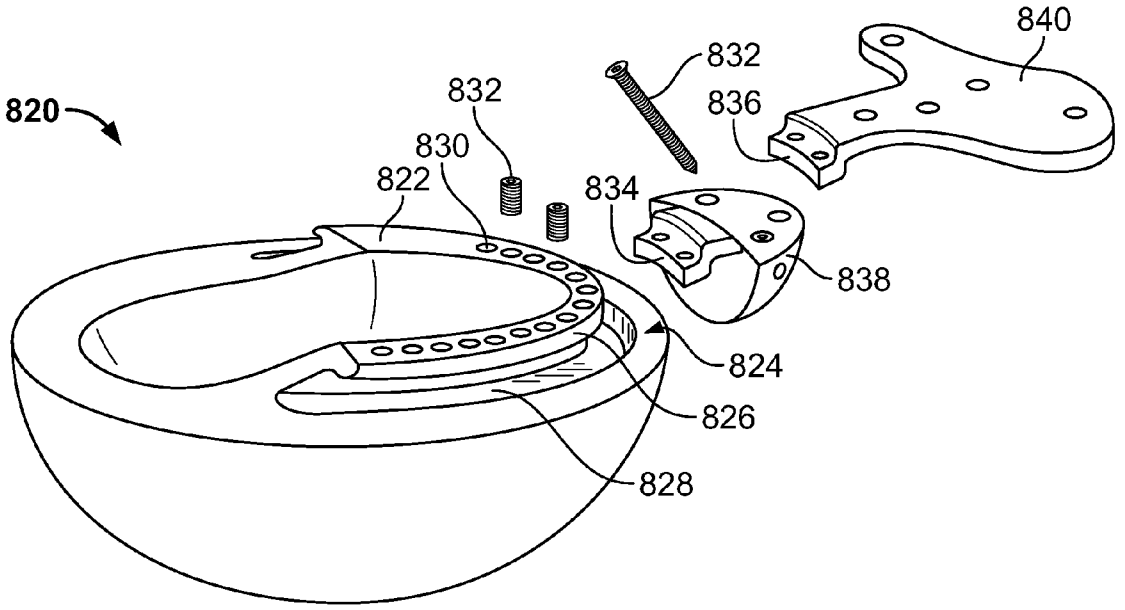

FIG. 60

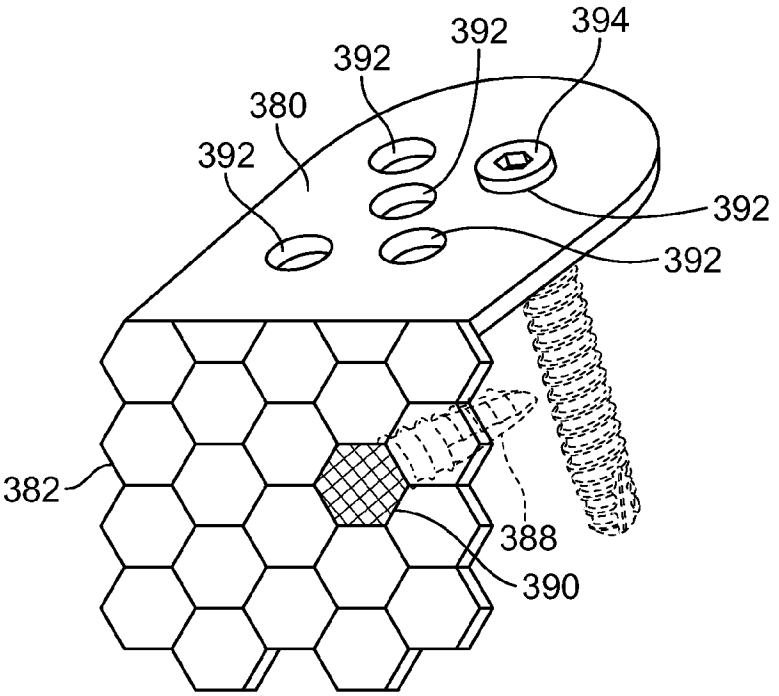

FIG. 61

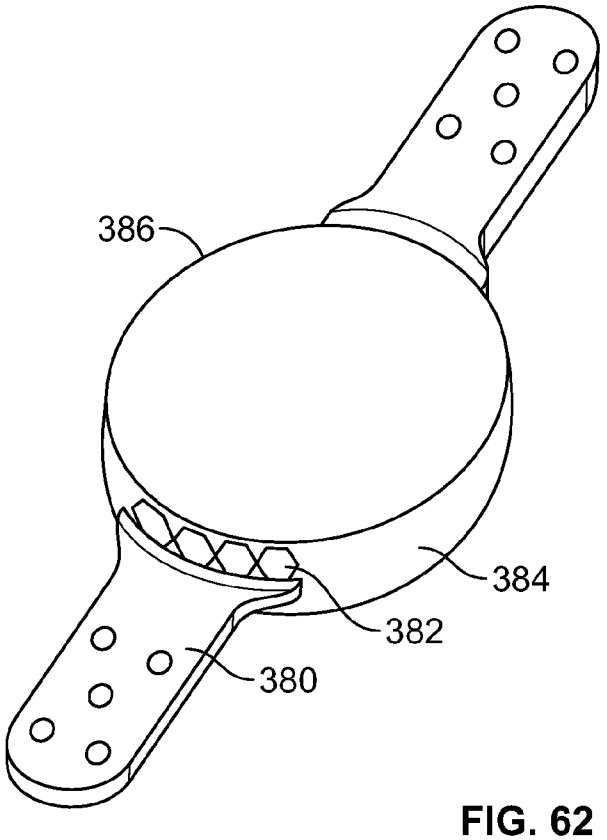

FIG. 62

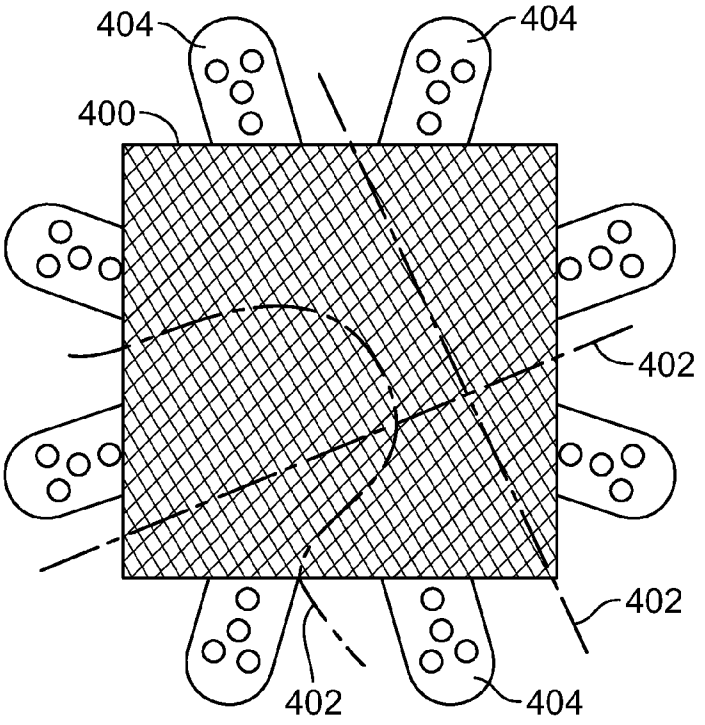

FIG. 63

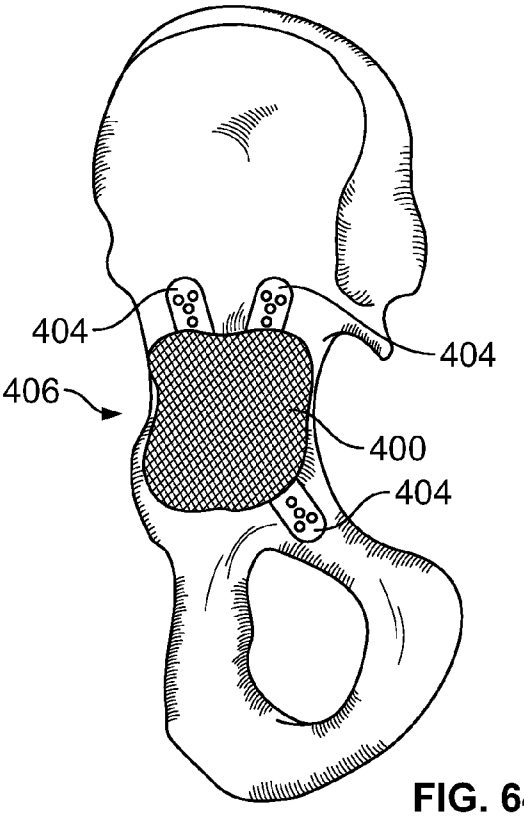

FIG. 64

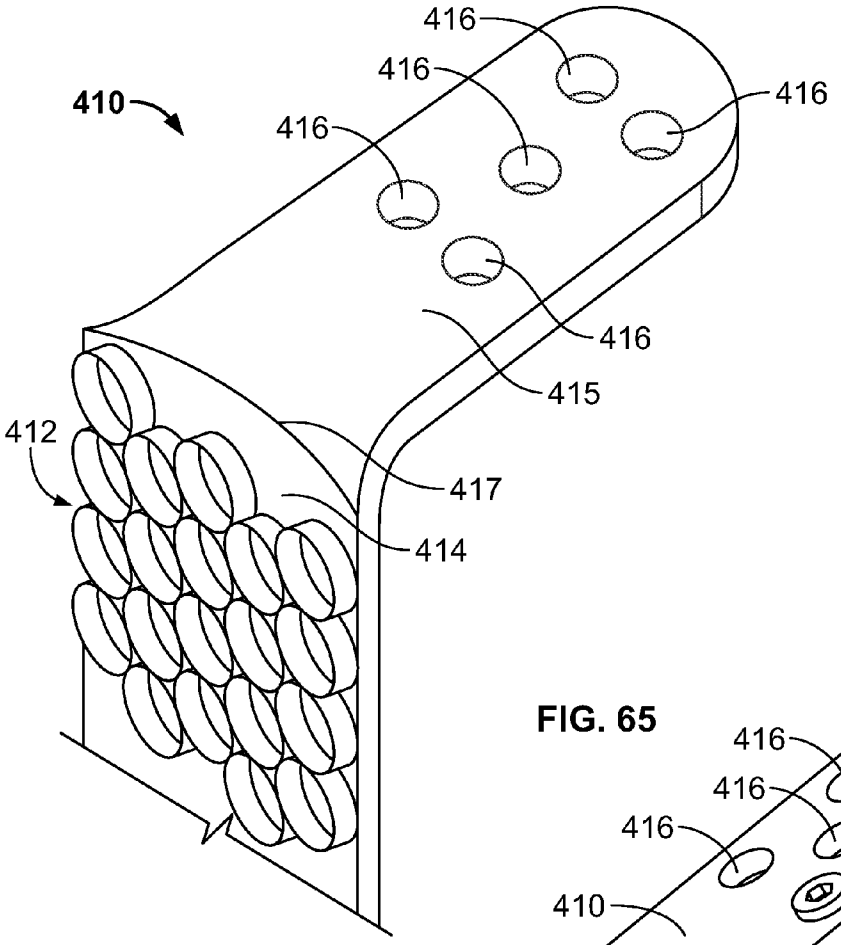
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FIG. 65

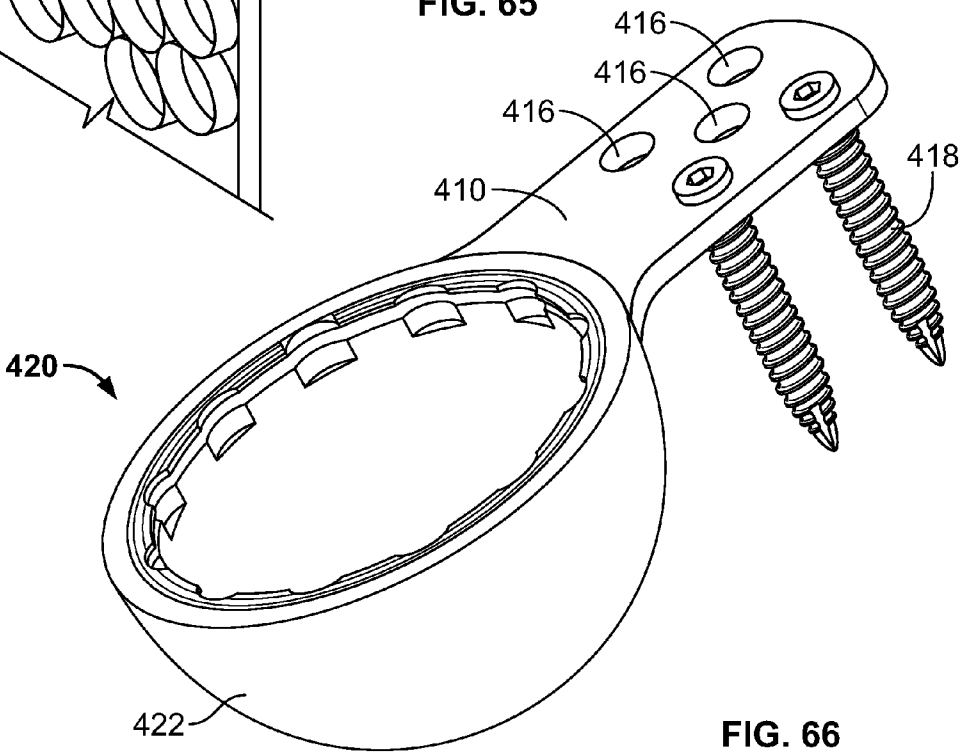
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FIG. 66

IMPLANT COMPONENTS AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 61/352,705, filed Jun. 8, 2010, U.S. Provisional Application No. 61/352,722, filed Jun. 8, 2010, U.S. Provisional Application No. 61/422,903, filed Dec. 14, 2010, and U.S. Provisional Application No. 61/466,817, filed Mar. 23, 2011, which are hereby incorporated by reference herein in their entireties.

BACKGROUND

[0002] Joints often undergo degenerative changes due to a variety of reasons. When joint degeneration becomes advanced or irreversible, it may become necessary to replace the natural joint with a prosthetic joint. Artificial implants, including hip joints, shoulder joints, and knee joints are widely used in orthopedic surgery. Specifically, hip joint prostheses are common. The human hip joint acts mechanically as a ball and socket joint, wherein the ball-shaped head of the femur is positioned within the socket-shaped acetabulum of the pelvis. Various degenerative diseases and injuries may require replacement of all or a portion of a hip using synthetic materials, typically metals, ceramics, or plastics.

[0003] More particularly, natural hips often undergo degenerative changes, requiring replacement of the hip joint with a prosthetic joint. Often, the hip is replaced with two bearing surfaces between the femoral head and the acetabulum. The first bearing surface is typically a prosthesis shell or acetabular cup, which may be formed of metal, ceramic material, or as otherwise desired. A liner (conventionally formed of polyethylene material such as ultra high molecular weight polyethylene, a ceramic material, or in some cases, even a metal liner) is then fit tightly within the shell to provide an inner bearing surface that receives and cooperates with an artificial femoral head in an articulating relationship to track and accommodate the relative movement between the femur and the acetabulum.

[0004] The cup (or a cup and liner assembly) is typically fixed either by placing screws through apertures in the cup or by securing the cup with cement. In some cases, only a liner is cemented in a patient due to poor bone stock. In other cases, a cup having a porous surface may be press fit into the reamed acetabular surface.

[0005] It may become necessary to conduct a second or subsequent surgery in order to replace a prosthetic joint with a (often larger) replacement joint. Such surgeries often become necessary due to further degeneration of bone or advancement of a degenerative disease, requiring removal of further bone and replacement of the removed, diseased bone with a larger or enhanced prosthetic joint, often referred to as a revision prosthesis. For example, bone is often lost around the rim of the acetabulum, and this may provide less rim coverage to securely place a press-fit cup. Such surgeries may thus be referred to as revision surgeries.

[0006] In acetabular revision surgery, an acetabular prosthesis generally includes additional mounting elements, such as augments, flanges, hooks, plates, or any other attachment or mounting points or members that provide additional support and/or stability for the replacement prosthesis once positioned. These additional mounting or attachment members are often required due to bone degeneration, bone loss, or bone defects in the affected area (in this instance, the hip joint).

[0007] Various types of these mounting members (which term is intended to include but not be limited to flanges, blades, plates and/or hooks) may be provided in conjunction with a prosthesis system in order to help the surgeon achieve optimal fixation, non-limiting examples of which include iliac flanges (providing securement and fixation in and against the ilium region of the pelvis), ischial blades (providing securement and fixation in and against the ischium), and obturator hooks (providing securement and inferior fixation by engaging the obturator foramen). Although there have been attempts to provide such mounting attachments with modularity, the solutions to date have generally fallen short of providing true modularity. Instead, they typically provide a few discrete positions at which the mounting members may be positioned, without providing the surgeon a fuller range of decision options.

[0008] Additionally, in some primary surgeries and more often in revision surgeries, the acetabulum may have a bone defect or void that the surgeon must fill with bone grafts before inserting a new shell. This can be time consuming and expensive, and may subject the patient to additional health risks. Some techniques use an augment in connection with the acetabular shell, which can be coupled to or otherwise attached to the outer surface of the shell.

[0009] With current augments, the surgeon can attach the augment to the bone and then implant the cup. However, many acetabular shells rely on bone screws to achieve proper fixation and the augment often gets in the way of a screw. In short, surgeons need the freedom to place screws in the best location, but this compromises their ability to use augments. With current systems, it also takes an increased amount of time surgical time to trial the component orientation and then try to find good bone fixation for the cup. The surgeon will often have to free-hand the amount of bone removed while estimating the size of augment needed. In the cases where bone is often deficient, surgeons are hesitant to take away any more bone than necessary.

[0010] Various additional features and improved features intended for use and application with various types of joint implants are also described herein, such as improved bone screws, improved coatings, and various augment removal and insertion options.

SUMMARY

[0011] Disclosed herein are systems, devices, and methods for providing modular orthopedic implants. The implants may include a base member, such as an acetabular shell or an augment, that is configured to couple with an augment, flange cup, mounting member, any other suitable orthopedic attachment, or any combinations thereof. Mounting members include, for example, flanges, blades, hooks, and plates. In some embodiments, the orthopedic attachments may be adjustably positionable about the base member or other attachments thereby providing modularity for assembling and implanting the device. Various securing and/or locking mechanisms may be used between the components of the implant. In certain embodiments, the orthopedic attachments are removably coupled to the base member or other components. In certain embodiments, the orthopedic attachments are integrally provided on the base member or other components, yet may still be adjustably positionable thereabout. In

some embodiments, expandable augments, base members, or other bone filling devices are provided. In some embodiments, surface features are provided that create friction and allow for surrounding bone ingrowth at the interface of the implants and a patient's bone.

[0012] Systems, devices, and methods described herein provide implants having augments configured to attach to acetabular shells or cages, mounting members, or other augments with or without cement and configured to allow fine positional adjustments for best bone fit, coverage, and stability. In certain embodiments, an orthopedic implant includes an acetabular implant having a track that includes a plurality of slots and an exterior surface, an augment having a protrusion that moves within the plurality of slots, the augment having a first cam surface that forms an interface with the exterior surface, where the protrusion has an adjustable fastener that, upon adjusting, fixes the augment with respect to the implant to impede further movement. In some embodiment, the augment may rotate about the exterior surface. The adjustable fastener may be a tightening screw that extends through a through-hole in the augment and, upon tightening, expands the protrusion (which may be flared outwardly) and thereby tightens the augment within the track. In some embodiments, the tightening screw has a head that fits within a slot and faces an interior portion of the implant, where the slot has an interior opening that aligns with the head, and where the interior opening receives a tightening rod to tighten the screw. In some embodiments, the track includes a dovetail joint that receives the protrusion. In some embodiments, the track includes a straight portion and a curved portion. For example, the track can include two straight slots and a curved portion. In some embodiments, the track includes a J-shaped slot with a wall of the implant. The protrusion may be part of an intermediate locking member that is integral to the augment. In some embodiments, the first cam surface of the augment includes at least one trough that receives cement to bind the augment to the shell. In some embodiments, the augment includes a plurality of projections that form a gap and may further include a flange attached to the augment.

[0013] In certain embodiments, a method of preparing an orthopedic implant includes the steps of providing an implant having a curved external surface and an opening in the surface, the opening having at least two portions that join at a common region but are separated by an angle of less than 180°, providing an augment having a first surface that interfaces with the curved external surface, coupling the augment and implant by an intermediate locking member, and tightening the intermediate locking member. In some embodiments, the method may further include the step of securing the augment to the implant by disposing cement within a trough located on the first surface. In some embodiments, the method may further include the step of rotating the augment with respect to the implant about the curved external surface prior to tightening the intermediate locking member, and moving the intermediate locking member within the opening prior to tightening. In some embodiments, the method may further include the steps of applying a fastener to the implant, so that the fastener extends outwardly from the external surface, and positioning the augment about the external surface so that the extended fastener fits between two protrusions of the augment, where the intermediate locking member is tightened with respect to the augment by a screw.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The foregoing and other objects and advantages will be apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

[0015] FIG. **1** shows an illustrative augment configured to attach to acetabular shells or cages, mounting members, or other augments;

[0016] FIGS. **2** and **3** show an illustrative acetabular shell or cage that includes a track;

[0017] FIG. **4** shows an illustrative augment that includes a through hole;

[0018] FIG. **5** shows an illustrative fastener having an expanding portion configured to be inserted through a track on an acetabular shell and into an augment;

[0019] FIGS. **6** and **7** show illustrative augments configured to secure to an acetabular shell or cage, mounting member, or other augment prior to insertion into a prepared bone void;

[0020] FIG. **8** shows an augment having an illustrative intermediate adapter member;

[0021] FIG. **9** shows an illustrative insertion opening in a shell adapted to receive features of the intermediate adapter system of FIG. **8**;

[0022] FIG. **10** shows an illustrative expansion member inserted into an intermediate adapter member to secure the adapter in a desired location;

[0023] FIGS. **11** and **12** show examples of a prior mounting member or augment adapted for securement to a shell;

[0024] FIGS. **13-15** show an illustrative mounting member or augment provided with an opening having multiple fixed directional threaded screw holes;

[0025] FIG. **16** shows an illustrative mounting member or augment having an expandable or deformable spherical ball member;

[0026] FIG. **17** shows an illustrative mounting member or augment having a rotatable inner cylinder insert member;

[0027] FIG. **18** shows an illustrative mounting member or augment similar to FIG. **17** that is configured for use with a polyaxial fastener;

[0028] FIG. **19** shows an illustrative mounting member and an illustrative augment member provided with a dovetail feature;

[0029] FIGS. **20** and **21** show an illustrative dovetail feature configured to receive a fastener;

[0030] FIGS. **22** and **23** show an illustrative chock distally-connected to a surgical cable and positioned within a portion of an augment;

[0031] FIGS. **24** and **25** show an illustrative chock having an angled or inclined surface configured to receive an expansion member;

[0032] FIG. **26** shows an illustrative cable tensioning device provided on a mounting member or augment;

[0033] FIGS. **27-29** show an illustrative mounting member or augment that may be attached to an acetabular shell, cage or other augment using a separate expandable chock member and an intermediate connecting member;

[0034] FIG. **30** shows an illustrative expanding element that may be provided in an aperture of a mounting member or augment;

[0035] FIG. **31** shows an illustrative ferrule on a cable that may be positioned against an augment;

[0036] FIGS. **32** and **33** show illustrative geometries for a receiving portion of a shell, cage, or augment;

[0037] FIG. **34** shows illustrative indicia for indicating a positional relationship between the mounting member or augment and the implant to which it is to be attached;

[0038] FIG. **35** shows illustrative spikes that may be provided on mounting members or augments for improving fixation;

[0039] FIG. **36** shows an illustrative bi-lobe cup or shell;

[0040] FIG. **37** shows two augments attached together via an illustrative fastening device;

[0041] FIG. **38** shows an illustrative augment with integral spikes;

[0042] FIG. **39** shows an illustrative augment with built-in securement features;

[0043] FIG. **40-42** show various illustrative augments or porous coating portions having one or more cross-sectional areas of reduced material;

[0044] FIG. **43** shows an illustrative rotary tool;

[0045] FIGS. **44-47** shows various connection devices for securing a mounting member or an augment to an acetabular shell or cage;

[0046] FIGS. **48-50** show illustrative augments provided with an elongated undercut groove configured to receive a cam locking pin;

[0047] FIG. **51-54** show illustrative cleats provided proximate to a rim of an acetabular shell or cage, mounting member, or augment;

[0048] FIG. **55** shows illustrative cleat portions configured for securing soft tissues;

[0049] FIGS. **56** and **57** show an illustrative augment attached peripherally to an acetabular shell or cage via a recess;

[0050] FIGS. **58** and **59** show an illustrative mounting member attached peripherally to an acetabular shell or cage via a recess;

[0051] FIG. **60** shows an acetabular shell or cage having an illustrative annular protrusion;

[0052] FIG. **61** shows a mounting member having an illustrative orthopedic mesh;

[0053] FIG. **62** shows an illustrative mesh portion placed on an outer portion of a shell;

[0054] FIG. **63** shows an illustrative mesh that includes a plurality of trim lines that may be cut to separate the mounting members attached thereto;

[0055] FIG. **64** shows illustrative separated mounting members from the mesh of FIG. **63** placed into a patient's hip region; and

[0056] FIGS. **65** and **66** show an illustrative honeycomb design that may be provided on a mounting member or augment.

DETAILED DESCRIPTION

[0057] To provide an overall understanding of the systems, devices, and methods described herein, certain illustrative embodiments will be described. Although the embodiments and features described herein are specifically described for use in connection with acetabular systems, it will be understood that all the components, connection mechanisms, adjustable systems, fixation methods, manufacturing methods, coatings, and other features outlined below may be combined with one another in any suitable manner and may be adapted and applied to medical devices and implants to be used in other surgical procedures, including, but not limited to: spine arthroplasty, cranio-maxillofacial surgical procedures, knee arthroplasty, shoulder arthroplasty, as well as foot, ankle, hand, and other extremity procedures.

[0058] Various implants and other devices described herein in their various embodiments may be used in conjunction with any appropriate reinforcement material, non-limiting examples of which include bone cement, appropriate polymers, resorbable polyurethane, and/or any materials provided by PolyNovo Biomaterials Limited, or any suitable combinations thereof. Further non-limiting examples of potential materials that may be used are described in the following references: U.S. Patent Application Publication No. 2006/0051394, entitled "Biodegradable Polyurethane and Polyurethane Ureas," U.S. Patent Application Publication No. 2005/0197422, entitled "Biocompatible Polymer Compositions for Dual or Multi Staged Curing," U.S. Patent Application Publication No. 2005/0238683, entitled "Biodegradable Polyurethane/Urea Compositions," U.S. Patent Application Publication No. 2007/0225387, entitled "Polymer Compositions for Dual or Multi Staged Curing," U.S. Patent Application Publication No. 2009/0324675, entitled "Biocompatible Polymer Compositions," U.S. Patent Application Publication No. 2009/0175921, entitled "Chain Extenders," and U.S. Patent Application Publication No. 2009/0099600, entitled "High Modulus Polyurethane and Polyurethane/Urea Compositions." Each of the prior references is incorporated by reference herein in its entirety.

[0059] The embodiments shown in FIGS. **1-15** provide augments that may be configured to attach to acetabular shells or cages, mounting members, or other augments without cement, and are also configured to allow fine positional adjustments for best bone fit, coverage, and stability. It will be understood that the features and components described in connection with the augments of FIGS. **1-15** may also be applied to mounting members, such as hooks, flanges blades, or any other suitable mounting members, that may be configured to attach to acetabular shells or cages, augments, or other mounting members. FIG. **1** illustrates certain embodiments wherein an augment **450** may be placed on a periphery of a hemispherical acetabular shell, cage, or other augment. As shown in FIGS. **2** and **3**, a shell or cage **460** may comprise a track **462** that is undercut so as to form a dovetail joint **461** with a mounting member or an augment. The track **462** may be provided as a J-shaped slot (as shown), T-shaped slot, H-shaped slot, or any other shape involving combinations of straight and/or curved segments. The track **462** preferably includes at least two portions or slots, at least one of which can receive a complementary connector or protrusion from the augment or mounting member. As shown in FIG. **2**, for example, the first portion or slot **464** and second portion or slot **466** join about common region **468** but are separated out at distal ends **465** and **467** by angle Ø, which is less than 180° in the example. The at least two portions thereby permit the augment or mounting member to be adjustably positioned along the surface of the shell, cage, or other augment by sliding the augment (and its connector) along the track and securing it at the desired location. For example, the augment could be secured in one of the at least two portions (such as slot **464**), or the other of the at least two portions (such as slot **466**), or in between.

[0060] The mounting member or augment may have a protrusion that is flared outwardly, and may be generally frustoconical, bulbous, or otherwise forms a portion of a male portion of a dovetail joint. For example, as shown in FIG. **1**, augment **450** includes protrusion **452** that is flared outwardly.

The flared protrusion **452** may be expandable when used with a central mandrel or expanding fastener. Additionally or alternatively, it may be made from a deformable material and/or may be provided as a bifurcated member having one or more leg portions to facilitate expansion of the protrusion.

[0061] The outer peripheral surface portions **453** of the protrusion **452** may be rounded (e.g., a frustoconical shape), and the augment **450** (or, in some embodiments, mounting member) may not only be translated within and along the track **462** on the shell **460**, but also rotated within the track **462** on the shell **460**. A fastener **456** such as a screw, setscrew, mandrel, shank, rivet, or any other fastener having a low profile head which is accessible from the inside dome portion of the shell or cage **460** (or another augment) is configured to engage an inner bore or opening **458** located in the flared protrusion **452**, thereby expanding the protrusion **452**. The term "expansion member" is used herein to refer to any appropriate member, including but not limited to the fasteners listed above, that can be used to engage and/or otherwise expand another feature. One example of an expansion member that may be used in connection with this embodiment comprises a setscrew/mandrel/fastener that has a tapered outer portion or a surface having an outer diameter that is greater than the receiving portion of the protrusion, such that when the expansion member is threaded into the protrusion, the protrusion expands. The expansion of the flared protrusion causes the protrusion to frictionally engage the track in the shell/cage/augment, thereby forming a locked dovetail connection which secures the mounting member or augment to the shell. Once the expansion member is completely tightened, the mounting member or augment is locked to the shell/cage/augment in both translation and rotation with a strong dovetail locking joint. For example, augment **450** can be attached to the track **462** by the protrusion **452**. Before tightening the protrusion **452**, the augment **450** can be rotated with respect to the shell **460**, such that the augment interior surface **454** and the shell exterior surface **469** remain generally interfaced while the augment **450** rotates about the shell **460** like a cam, until the augment **450** is in the desired position. The protrusion **452** is then tightened to secure the augment **450** in that position.

[0062] One advantage of such a mechanism is that the assembly of the shell/cage/augment and the mounting member or augment may be loosely assembled, then placed into a bone void such as an irregularly shaped bone void. Once generally positioned, the assembly components may be adjusted with respect to each other to best fit an existing or prepared bone void. The assembly components may then be tightened together such that the assembly closely approximates the size, shape, and orientation of the existing or prepared bone void.

[0063] While the particular embodiment shown in FIG. **1** illustrates an expansion member **456** seated in a "blind" interior opening or bore **458** in augment **450**, an augment may alternatively or additionally comprise a through hole such as through hole **478** of augment **470** in FIG. **4**, configured to receive an expansion or tightening member **476**, for example a long bone screw, long fastener, or other long expansion member (such a tightening configuration will be referred to throughout as a "long bone screw," but it will be understood that any appropriate fastener that can secure two components together, while also potentially gain purchase into bone is considered appropriate for use in connection with the described embodiment). The tightening member **476** may be configured to gain purchase in the augment **470** and/or surrounding bone as illustrated in FIG. **4**. The opening **487** in the flared protrusion **472** that receives the bone screw **476** may generally continue through the augment **470** and out a hole **479** in a side of the augment **470** opposite the protrusion **472**. In such embodiments, the bone screw **476** enters the augment **470** through an opening in the track **462** on the inside surface **463** of the shell/cage **460** (or, in some embodiments, another augment), and protrudes through the entire augment **470**, including the flared protrusion **472** which, during insertion of the bone screw **476**, will expand into the undercut track **461** on the shell/cage **460**. Essentially, the bone screw **476** locks the augment **470** to the shell/cage **460** and secures the entire assembly to surrounding bone, thereby stabilizing the assembly with respect to hip anatomy. In this sense, not only does the bone screw **476** serve to rigidly secure the augment **470** to the shell/cage **460** before necessarily securing purchase of the bone screw **476** into surrounding bone, the bone screw **476** further provides secondary fixation of the assembly to surrounding bone by then subsequently securing purchase with surrounding bone.

[0064] The embodiment shown in FIG. **4** allows a surgeon to lock the augment **470** to a second component from an inside portion (e.g., an inside portion **463** of a shell **460**), after the loose assembly is placed into the prepared bone void. In other words, the augment **470** may be loosely coupled to the shell **460** or other second component in the patient's bone void, and a fastener is used to secure the augment to the second component (not shown, but which may be the shell, cage, or a second augment) and to the patient's bone. The head is arranged within the slot of track **462** so that it is aligned with the interior opening **478** of the augment **470** and extends radially within the shell **460**. The surgeon can then insert a tightening rod through the interior opening **478**, from inside the shell **460**, to access and tighten the screw **476**.

[0065] FIG. **5** illustrates some embodiments related to those shown in FIG. **4**. A bone screw **681** or other fastener having both an expanding portion **694** and a bone engaging portion is inserted through an undercut recess, groove, or track **682** provided on an acetabular shell or cage **680** (or, in some embodiments, provided on an augment). The bone screw **681** or other fastener may be inserted from an accessible inside portion **683** of said shell/cage **680**. The bone screw **681** or other fastener protrudes into and through an opening **684** within an adjacent augment **686** (or, in some embodiments, a mounting member) having a male connection member **688**. The male connection member **688** may be generally cylindrical or flared (e.g., frustoconical) and is configured to be inserted into and move within (translate, rotate, etc.) the undercut recess, groove, or track **682**.

[0066] In use, as the bone screw **681** begins to make purchase with bone, the expanding portion **694** of the bone screw **681** engages a complementary expanding portion **692** of the augment **686** adjacent the male connection member **688**, thereby expanding a portion of the male connection member **688** inside the undercut recess, groove, or track **682** and locking the augment **686** to the shell/cage **680** (or other augment). In some embodiments, one or more of the expanding portions of the bone screw and mounting member or augment may not be threaded. For example, the expanding portion **694** of the bone screw **681** may be threaded, and the expanding portion **692** of augment **686** may be a smooth tapered recess. Alternatively, the expanding portion **694** of the bone screw **681** may be a smooth tapered surface that seats within and

wedges against a smooth tapered expanding portion bore **684** in the augment **686**. The taper angle of the bone screw **681** expanding portion **694** may differ from the taper angle of the expanding portion bore **684**. Furthermore, the expanding portion **694** of the bone screw **681** may be an enlarged threaded section that engages with a smooth undersized bore **684** in expanding portion **692** of the augment **686**.

[0067] In further embodiments, as shown in FIGS. **6** and **7**, it may be desirable to secure a mounting member or augment to an acetabular shell or cage, or other augment or mounting member prior to insertion into a prepared acetabular bone void. In such instances, the expansion member used to expand the protrusion may be made relatively shorter, so as to be partially or completely encased by the mounting member or augment. For example, expansion member **486** of augment **480** and expansion member **496** of augment **490** may be relatively shorter than bone screw **476** of augment **470**. The insertion direction of the expansion member may be reversed with respect to the aforementioned embodiments, and move in a securing direction which is towards the acetabular shell/cage or other augment. In this way, the mounting member or augment may be attached to the shell/cage or other augment in a predetermined configuration, prior to insertion of the assembly into the prepared bone cavity.

[0068] The embodiment shown in FIG. **6** allows a surgeon to lock the augment **480** to the shell **460** prior to insertion into the prepared bone void, outside of the body cavity. The attachment prior to insertion may be a tight securement or a loose coupling. If a loose coupling is desired, such that complete securement can be completed once the assembly has been fully positioned, an opening **499** on an upper surface **494** of the augment **490**, as shown in FIG. **7** allows tightening once the completed assembly is positioned in the bone cavity. In other words, this embodiment allows a surgeon to lock the augment **490** to the shell **460** from an outside portion on exterior surface **469** of the shell **460**, after the loose assembly is placed into the prepared bone void.

[0069] In use, the surgeon may place a frustoconical or otherwise flared protrusion of the mounting member or augment into an insertion clearance opening in the shell/cage or other augment, and then may move the augment within a track extending from and connected to the opening (as shown in FIG. **8**) to a desired rotational angle and/or location along the track. The surgeon may rotate, translate, or otherwise position or move the mounting member or augment as desired within the track. When the augment is positioned and located in a desired spatial orientation relative to the shell/cage or other augment, the expansion member can be inserted into and through the augment, and tightened within a threaded bore located in the protrusion.

[0070] It will be appreciated by one having ordinary skill in the art that, while not shown, the expansion member may be internally threaded and engageable with a male thread located within an opening in the protrusion. It will also be appreciated that, while not shown, the expansion member may only threadingly engage the bulk body of the mounting member or augment and may have a distal wedge portion provided thereon which engages a smooth tapered opening in the protrusion. In this embodiment, when the expansion member moves toward the protrusion in threaded engagement with the bulk body of the mounting member or augment, its distal wedge portion wedges open the flared projection via inclined surfaces without actually "threadably" engaging in inner surface of the protrusion. It should also be noted that the use of other fasteners such as the rivet-type, or any other suitable fastener, or combinations thereof, is envisioned.

[0071] When the expansion member is tightened or otherwise adjusted, the arms of the bifurcated protrusion expand and move away from each other, and therefore, the outer flared portions of the protrusion engage the undercut walls of the track provided on the shell/cage/augment. For example, when expansion member **456** of FIG. **1** is tightened or otherwise adjusted, the arms of protrusion **452** may expand and engage the undercut walls **461** of the track **462** provided on shell **460** of FIG. **2**. The arms of protrusions **472**, **482**, and **492** may similarly be expanded when an expansion member is tightened or otherwise adjusted. Friction between the walls of the track and the expanded bifurcated protrusion maintain the mounting member or augment in fixed relationship relative to the shell/cage/augment, and the assembly may be inserted into the prepared bony site.

[0072] As shown in FIG. **8** and for potential use in connection with or interchangeably with the embodiments shown in FIGS. **44-47**, an intermediate adapter member may be used to secure a mounting member or augment to an acetabular shell, cage, or other augment. For example, adapter **502** comprises a portion that is received in an opening (e.g., tapered hole or undercut track) in the shell/cage/augment, and sits flush or recessed with respect to an inner surface of the shell/cage/augment, so as to not protrude into the inside portion of the shell/cage/augment where a liner might be seated. The adapter **502** may have an expanding tapered or flared head **504** (e.g., frustoconical) that protrudes outwardly from the shell and engages an undercut slot, blind or through-slot, or a tapered aperture in the mounting member or augment. For example, adapter **502** includes an expanding tapered or flared head **504** that engages undercut slot **508** of augment **500**. The adapter **502** may be entirely or partially cannulated and may be non-threaded, threaded partially, or threaded all the way through its length. The expanding tapered or flared head **504** of the adapter **502** may be made bifurcated so as to have two or more arm portions **505** and **506** that are configured to move away from each other to expand the head **504** and create a locking interference between the expanding head **504** and the undercut slot or tapered aperture **508**. A small expansion member **510**, a long bone screw (not shown), or any other suitable fastening member may be threadably received in the adapter **502** such that when the expansion member **510**, long bone screw, or other fastening member threads into the bifurcated head portion **504**, the arms **505** and **506** of the head portion **504** expand and frictionally engage the walls of the slot or aperture **508** to lock augment **500** to the shell/cage **600** or other augment. A mounting member may similarly locked to an acetabular shell or cage **600** or an augment. The head **512** of the expansion member **510**, long bone screw, or other fastening member may lie flush with, or slightly recessed from the inside (e.g., concave) surfaces of the shell/cage/augment, so that a liner may be properly seated.

[0073] FIG. **9** shows an insertion opening **516** in a shell **518** adapted to receive features of the adapter system of FIG. **8** according to some embodiments. FIG. **10** shows a side cross-sectional view of an adapter **520** in place within the shell **518** and an augment **522**, used to secure the two components to one another. As shown, the adapter **520** may have a frustoconical head **524**, and specifically, may have a head **524** that is bifurcated and expandable. The head **524** of the adapter **520** may be received in an augment **522** or any other first component (e.g., a mounting member) that is desired to be coupled

or otherwise secured to a second component (e.g., an acetabular shell or cage). The augment **522** may have a J-slot (e.g., as shown in more detail in FIG. **8**), a dovetail configuration, or may have any other appropriate shape, such as an undercut design, or any other appropriate track-type slot or groove. This feature may extend to the upper edge of augment **522** or first component (e.g., as shown in FIG. **8** where slot **508** extends to upper surface **514** of augment **500**) or it may be positioned in the side wall only of the augment **522** or first component (e.g., as shown in FIG. **2** where track **462** is provided through surfaces **463** and **469** of shell **460**).

[0074] In use, the adapter head **524** slides into or is otherwise positioned in the slot/track/undercut. The adapter tail end **526** may extend slightly from the augment **522** or first component and extend toward and slightly into an insertion opening in the shell **518** or second component. As discussed above and shown clearly in FIG. **10**, it is preferable that the adapter tail **526** not extend completely into the internal cavity of the shell **518** or second component so that a liner **528** may be used without having the liner **528** directly abut or otherwise contact the adapter **520**. Once positioned, an expansion member **530** is inserted into the adapter **520** to cause the bifurcated head **524** to expand and lock, plug, or otherwise securely lodge the adapter **520** in the desired location.

[0075] FIGS. **11** and **12** illustrate an example of a prior mounting member or augment **531** adapted for securement to a shell **533** as disclosed in U.S. Patent Application Publication No. 2007/0093133, entitled "Fixing Assembly," which is incorporated by reference herein in its entirety.

[0076] FIGS. **13-15** illustrate various embodiments of an improvement of the devices shown in FIGS. **11** and **12**. A mounting member or augment may be provided with an opening having multiple fixed directional threaded screw holes. For example, mounting member or augment **540** of FIG. **13** includes an opening **542** having a plurality of fixed directional threaded screw holes **544**. In the specific embodiments shown, there are three fixed directional threaded screw holes (e.g., screw holes **544**), but it will be understood that more or fewer holes may be provided. The holes may be fixed in various orientations in space with respect to each other. The holes may be spaced apart from each other as shown by holes **546** in FIG. **15**. The holes may intersect radially as shown by holes **544** in FIG. **13**. The holes may be positioned linearly as shown by holes **548** in FIG. **14**. In use, a protrusion member that extends from a mounting member or augment is received in rotating engagement by a round blind undercut recess on an acetabular shell, cage, or augment as shown in FIG. **11**. Alternatively, the protrusion member may be received in an undercut track (e.g., as shown in FIGS. **2** and **3**) provided on an acetabular shell, cage, or augment. As shown, the projection may be bi-forked in configuration to facilitate its expansion when one or more screws or other fastening members are inserted through one or more of the threaded screw holes in the mounting member or augment. The protrusion on the mounting member or augment is generally configured to expand upon partial screw insertion and is also generally configured to secure and lock the mounting member or augment to the shell/cage/augment in a desired relative spatial orientation, regardless of whether or not the screw secures purchase within the bone.

[0077] FIG. **16** illustrates a mounting member or augment **550** according to certain embodiments that may be used for coupling to an acetabular shell, cage, or other augment having a round blind undercut on the shell, one example of which is shown in FIG. **11**. Alternatively, as previously mentioned, the protrusion member **552** may be received in an undercut track (e.g., as shown in FIGS. **2** and **3**) provided on an acetabular shell, cage, or augment. As shown in FIG. **16**, an expandable or deformable spherical ball member **554** is adapted to be positioned within, located inside, or otherwise captured within an opening **558** in a split or bifurcated mounting member or augment **550** and captured therewithin. The ball member **554** may be undersized so as to expand when an expansion member (e.g., screw **556**) or other fastener is inserted therein. Alternatively, the ball member **554** may be formed of a deformable material to allow the ball **554** to expand upon insertion of an expansion member (e.g., screw **556**) or other fastener. Moreover, the ball member **554** may be split to facilitate expansion of the ball member **554**. The ball member **554** is generally captured within, secured to, or otherwise operable with the mounting member or augment **550** so as to form a ball joint.

[0078] The ball member **554** may have a deformable smooth bore which is ultimately deformed to be threaded by the screw fastener during insertion. Alternatively, the ball member **554** may comprise a threaded bore which is slightly undersized in inner diameter with respect to the inserted screw. Alternatively, the bore in the ball member **554** may be smooth and the ball member **554** expanded when engaged by an expansion member or other fastener. In some instances, as shown, a screw **556** or other fastener may be provisionally positioned adjacent an aperture of the cannulated ball member **554**, and then oriented to a desired spatial location and angulation with respect to a patient's anatomy for insertion into adjacent pelvic or other bone. The expansion member (e.g., screw **556**), long bone screw, or other fastener may be used as a lever to move the ball **554** at any angle relative to the mounting member or augment **550** and then inserted to secure bone purchase.

[0079] When the screw or fastener **556** passes through the aperture in the ball **554**, the ball **554** spreads open or deforms via the aforementioned undersized, deformable, or expandable means. In this instance, the ball **554** expands, and in turn, also further expands the mounting member or augment **550**, which may be bifurcated, one example of which is described above. When the mounting member or augment **550** is expanded, the protrusion member **552**, shown here as a generally flared and bifurcated frustoconical projection, expands within and may lock into a round, blind undercut recess or undercut groove in the shell/cage/augment in the desired angular spatial orientation. The mounting member or augment **550** is generally configured to allow fixing of itself to the shell/cage/other augment regardless of whether or not the screw **556** secures purchase within the bone. Moreover, the ball member **554** captured within the mounting member or augment **550** also allows the screw **556** to be inserted in any orientation relative to both the mounting member or augment **550** and the shell/cage/other augment.

[0080] In some embodiments, such as those shown in FIGS. **17** and **18**, an optional rotatable inner cylinder insert member may be used. The cylinder may be split along its length and may have one or more threaded bores extending along its length at one or more various angles, offsets, and eccentricities for engagement with a long bone screw or other fastener. For example, as shown in FIG. **17**, a single bore **566** may be provided in a cylindrical insert **564**, the bore **566** having a smooth outer bearing surface **568** that is angled and offset. The insert **564** shown is captured within the mounting

member or augment **564** by a knurl, step, flange, or lip **567** so as to be rotatable with respect to the mounting member or augment **560**, but not axially displaceable from the mounting member or augment **560**. When the screw or fastener **569** is inserted into the bore **566**, the insert **564** expands, and in turn, expands a projection member **562** on the mounting member or augment **560** or alternatively or additionally expands the entire mounting member or augment **560**. The projection member **562** may expand within the round blind undercut on the shell, cage, or other augment shown in FIG. **11**, or alternatively may expand within an undercut groove within said shell, cage, or other augment as shown in FIGS. **2** and **3**.

[0081] FIG. **18** depicts a mounting member or augment **570** that is similar to the embodiment shown in FIG. **17**, but instead, is configured for use with a polyaxial screw or fastener **576** having a smooth rounded head **577**. In this exemplary embodiment, the inner cylindrical insert **574** is not split, but is instead provided as a larger diameter, externally-threaded body configured to be received in a smaller diameter threaded bore **571** in the mounting member or augment **570**. The inside of the cylindrical insert **574** has one or more "hourglass"-shaped bores **578**, for instance, those that can be used with polyaxial screw heads having rounded or spherical screw heads. Various examples of polyaxial locking systems and methods are shown and described in U.S. Patent Application Publication No. 2002/0147499, entitled "Locking Systems for Implants," U.S. Patent Application Publication No. 2008/0300637, entitled "Systems and Methods for Using Polyaxial Plates," and U.S. Provisional Patent Application No. 61/178,633, entitled "Polyaxial Fastener Systems and Methods," all of which are intended for potential use in connection with the described systems and are incorporated by reference herein in their entireties.

[0082] The bore **578** may comprise portions engageable with threads of the polyaxial screw **576**, or may contain deformable tabs in regions proximate the head **577** for use with threaded heads. The angle of the screw or fastener **576** can be varied within the bore **578** of the cylindrical insert **574**. Regardless of whether or not the polyaxial screw **576** is inserted into the bore **578**, the mounting member or augment **570** is positively secured and locked to the shell/cage/augment in a desired spatial orientation and angulation due to the expansion of the projection member **572** or the mounting member or augment **570** as a whole. This occurs, for example, after inserting and threadably engaging the cylindrical insert **574** with an undersized threaded recess (e.g., bore **571**) provided in the mounting member or augment **570**.

[0083] FIGS. **19-35** show certain embodiments for attaching mounting members or augments to an acetabular shell, acetabular cage, or other augment. Disclosed is an apparatus and method for attaching the acetabular mounting members or augments to shells, cages, and other augments with an amount of adjustability. A kit of different augments may be provided for use with the same acetabular shell, cage, or augment. Relative spatial adjustments between the mounting member or augment position and the shell/cage/augment may be made with multiple degrees of freedom. The mounting members and/or augments may be attached and subsequently permanently and irremovably secured and locked to the shell/cage/augment prior to or after its insertion into a prepared acetabulum and/or surrounding bone voids.

[0084] In certain embodiments shown in FIG. **19**, a mounting member **580** or augment member **582** is provided with a dovetail feature **581** and **583** (that may be male or female), respectively, to connect it to an acetabular shell or cage **584** (or, in some embodiments another augment) having the other complementary mating female or male dovetail feature **586**. In the embodiment shown, the complementary feature **586** on the shell **584** is a J-shaped track or J-slot, but it will be understood that any mating features or configurations may be used. In the specific embodiment described, the dovetail feature **586** is configured to allow the mounting member **580** or augment member **582** to rotate and/or translate with respect to the shell **584** in a semi-locked state. The semi-locked state generally allows some independence of movement between the two pieces, which can be desirable to allow a surgeon to toggle between relative positions or otherwise continue to position and adjust the members. Such a semi-locked or loose connection can be particularly useful for revision surgeries.

[0085] The mounting member **580** or augment member **582** may be provided in a number of various shapes, sizes, textures, and configurations configured to fill bone defects and voids of varying degrees and locations with respect to a patient's anatomy. For instance, an implant may comprise a flange member that does not necessarily serve to fill a bone void/defect, but is instead configured to couple with a bone surface. Dovetail features according to FIGS. **19-35** generally mate by providing a flared male member (e.g., member **581** or **583**) that is configured to slidingly engage one or more complementary female members such as one or more separated or intersecting undercut grooves or recesses (e.g., member **586**). The undercut grooves or recesses may be provided on either component or vise versa, without limitation. A third member, for example an expansion member (e.g., setscrew, fastener, rivet, wedge, pin, cam, long bone screw, or any other fastener), may further be provided and used to securely lock the two pieces together to form a locked assembly. In some instances, the third member will engage one or more portions of the dovetail features to cause the male member to expand in the female member.

[0086] In other instances, for example, as shown in FIGS. **20** and **21**, a fastener such as a setscrew may be inserted through a male portion **588** of the dovetail features to move the male member **588** away from a blind portion of the female member **589**, thereby spreading the two pieces such that tapered surfaces of the dovetail features frictionally engage each other.

[0087] FIGS. **22-26** illustrate some embodiments wherein one or more locking chocks are distally-connected to a surgical cable and are configured to be received and/or captured within a portion of a mounting member or augment. For example, FIGS. **22** and **23** show a locking chock **590** distally-connected to a surgical cable **592** and positioned within a portion of augment **594**. The cable **592** may be introduced through a through-bore in a mounting member or augment (e.g., bore **596** of augment **594**) and tightened via a clamping device. The chock **590** is shaped to complement a tapered hole or an undercut groove or recess provided in an acetabular shell, cage, or other augment (e.g., undercut recess or groove **602** of FIG. **24**). When the surgical cable **592** is tightened around the mounting member or augment adjacent bone or to any other plating structures, the chock **592** is pulled toward the undercut surfaces of the tapered hole undercut groove/recess and is expanded by an expansion member **598**, for example, by a ball crimped to a distal portion of the surgical cable or any of the other expansion members described herein. The chock **590** may engage the undercut groove or recess. As shown in FIGS. **24** and **25**, an internal portion of a

chock **604** may have an angled or inclined surface **600**, which is adapted to receive an expansion member **606**.

[0088] In use, the chock rides along the cable and once positioning is desired, the wings of the chock may be forced apart for securement. For example, wings **595** and **597** of chock **590** shown in FIG. **23** may be forced apart for securement. When the cable is tightened, this can (a) pull the augment towards the shell/cage/other augment and (b) pull the ball or other expansion member at the end of the cable inside the chock so that the wings will expand and the chock will be secured in place. For example, when cable **601** of FIG. **24** is pulled in the direction of arrow **608**, this can pull expansion member **606** inside the chock **604** so that the wings **605** and **607** of chock **604** expand, thereby securing the chock **604** in place.

[0089] Alternatively, while not shown, the chocks may be separate pieces attached to the surgical cable at different portions and provided with inclined surfaces that ride together to facilitate expansion and frictional engagement with the tapered hole or undercut groove/recess. The one or more locking chocks may be oblong for easy insertion into the undercut groove or recess. Once the cable is pulled tight, it may be used as cerclage cable or K-wire and tightened around bone or other anatomical structures, keeping the mounting member or augment attached to the shell, cage, or other augment.

[0090] Alternatively, as shown in FIG. **26**, the cable **610** may be tensioned using a cable tensioning device provided on the mounting member or augment **614**. For instance, as shown, a tensioning screw member **612** may threadingly engage a female thread **616** located in the mounting member or augment **614**. As the tensioning screw member **612** is turned, the cable **610** is pulled into tension, thereby moving an expansion member (e.g., a crimped ball) against inner inclined surfaces located on the one or more locking chocks such as inclined surface **600** of chock **604**. When the expansion member (e.g., expansion member **606**) reaches a point of interference with the one or more locking chocks, the tensioning screw member may be turned further to spread the chocks apart and lock the mounting member or augment to the shell, cage, or other augment via a tightened dovetail joint.

[0091] FIGS. **27-29** illustrate some embodiments wherein a mounting member or augment **628** may be attached to an acetabular shell, cage, or other augment **629** using a separate expandable chock member **620** and an intermediate connecting member **622**. The intermediate connecting member **622** serves to temporarily loosely couple the mounting member or augment **628** to the shell/cage/augment **629**, and also serves to expand the separate chock member **620** and lock the two components together. In some embodiments, it is preferred that the separate expandable chock member **620** is provided as a generally frustoconical portion or a male portion of a dovetail connection. The separate expandable chock member **620** may be inserted into and captured within an undercut recess, groove, or track (e.g., undercut recess, groove, or track **624**) in an acetabular shell, cage, or other augment **629**. In some embodiments, the separate expandable chock member **620** is movably captured and may be positioned at various locations and orientations within said undercut recess, groove, or track.

[0092] The mounting member or augment **628** is then placed adjacent to the shell/cage/other augment **629**, and the intermediate connecting member **622** inserted through an aperture, opening, or recess **626** in the mounting member or augment **628** to engage an undersized or tapered female thread **627** in the separate expandable chock member **620**. The mounting member or augment **628** may be moved to a desired position relative to the shell/cage/augment **629** by virtue of the loose connection and undercut recess, groove, or track, and then locked in a desired relative spatial orientation by engaging the intermediate connecting member.

[0093] In the embodiment shown, the intermediate member **622** is provided as a headed bolt that threadingly engages the separate expandable chock member **620** to expand the separate expandable chock member **620**. When the separate expandable chock member **620** is fully expanded, a frictional dovetail locking connection is achieved, which locks the mounting member or augment **628** to the shell/cage/other augment **629** in the desired relative spatial orientation.

[0094] FIG. **30** illustrates an alternative embodiment to FIGS. **27-29**, which is similar to the embodiment shown in FIGS. **6** and **7**. A small expanding element **630** is provided within an aperture, opening, or recess **632** in a mounting member or augment **634** configured to be loosely attached and locked to an acetabular shell, cage, or other augment **636**. The mounting member or augment **634** includes a male portion of a dovetail. The male portion of a dovetail may be formed by a deformable or expandable protrusion **638** which may be bifurcated and/or initially flared outwardly in an un-deformed/unstressed state. Alternatively, while not shown, in some embodiments, the expandable protrusion **638** may be provided as a generally cylindrical member which can be first introduced into an undercut recess, groove, or track, and then expanded within said undercut recess, groove, or track by the expanding element in order to provide a locking function between the mounting member or augment and the shell/cage/augment. As shown in FIG. **30**, the expanding element **630** may be provided as a small tapered setscrew which engages a complementary tapered or otherwise undersized thread **640** inside the male portion of a dovetail. A flexible driver **642** may be used to access the small expanding element **630**. Upon torsional engagement with the expanding element **630**, a dovetail locking connection is formed, thereby securing the mounting member or augment **634** to the acetabular shell, cage, or other augment **638** in a desired configuration and relative spatial orientation.

[0095] FIG. **31** shows an alternate and additional feature relating to the cable and chock embodiments of FIGS. **22-30**. FIG. **31** shows a ferrule **700** on a cable **702** that may be positioned against an augment **704**. A tensioning tool **706** may be used to hold the cable **702** tight and the ferrule **700** can be crimped onto the cable **702**. When the cable **702** is pulled tight, the chock (e.g., chock **590** of FIG. **22**) engages the dovetail slot and the tension pushes the chock towards or into the augment **704**, held in place by the ferrule **700**.

[0096] FIG. **32** shows one potential geometry for a receiving portion **650** (such as an undercut recess, groove, or track) in a shell, cage, or augment according to some embodiments. In this example, the receiving portion is a double J-slot formed by slots **652**, **654**, and **656**. FIG. **33** shows a further optional geometry, where J-slots are provided in opposing directions formed by slots **662**, **664**, and **667**.

[0097] As shown in FIGS. **33** and **34**, any of the mounting members or augments shown and described herein may comprise tick marks or other indicia for indicating a positional relationship between itself and the implant to which it is to be attached. For example, an augment **670** may comprise a plurality of peripheral markings **672** or central markings (not

shown) for alignment with markings **661** provided in an acetabular shell or cage **660** (or, in some embodiments, another augment). In use, a surgeon may loosely insert the mounting member or augment (e.g., augment **670**) and the shell/cage/augment (e.g., shell **660**) into a patient's bone void, prior to assembling the two. The surgeon may then position both components and possibly other components to determine the best relative spatial orientation to best fill a volume of the void. The surgeon may then observe, compare, and note the relative positions of the markings or indicia between the bodies, thereby receiving repeatable and reproducible information about the desired spatial orientation. The surgeon may then remove both bodies from the surgical environment, realign them in the desired spatial orientations (facilitated by the markings or indicia), and then cement or otherwise secure the two bodies together in said desired spatial orientation. Subsequently, the assembled implant may be introduced into the void and the surgery completed in a normal fashion.

[0098] Moreover, as shown in FIG. **35**, mounting members or augments shown and described in the figures contained herein may comprise tacks, spikes, coatings, or textured surfaces **674** so as to improve initial fixation. The geographic locations of said tack, spike, coatings, or textured surface structures **674** may be strategically placed on select portions so as to evenly load the implant assembly and obtain the best biologic response initially, and over an extended period of time.

[0099] FIG. **36** shows a bi-lobe cup or shell **710**, which is a shell **710** having a lobe **712** extending therefrom. Typical bi-lobe shells are made of solid material, but this embodiment shows a bi-lobe shell **710** having a lobe **712** of porous material. The lobe **712** may have some solid portions for receiving screws other fastening members. As shown, additional augment members **714** may be attached to the lobe **712** of porous material or to the solid shell **710**. Areas of the porous lobe **712** may be provided with areas of solid, non-porous material having apertures or other structures for receiving and locking to screws, such as polyaxial bone screws. Moreover, the porous lobe **712** may comprise holes **716** extending through fully porous sections for insertion of bone screws.

[0100] FIG. **37** shows two augments **720** and **722** attached together via a fastening device **724** such as a screw or a shape-memory polymer peg according to some embodiments. It will be understood that although augments are shown, the securement mechanisms described herein may also be used with any type of mounting member, shell, or cage as well. In some embodiments, a peg of shape memory material may extend from one or more augments and into a prepared hole in bony anatomy. The shape memory peg may then be activated (via thermal changes or an applied electric current) and expanded within the prepared hole to fix an augment or mounting member to the patient's bone. Non-limiting examples of further features for such shape memory plugs are that they may comprise outer textured surfaces, may be porous, and may comprise barbs, flutes, ridges, grooves, spines, any other suitable features, or combinations thereof.

[0101] FIG. **38** shows an augment **726** with integral spikes **728** according to some embodiments. The spikes **728** may allow the augment **726** to be positioned initially in bone, without the augment **726** having to be first secured to a shell, cage, mounting member, or other augment or without the use of bone cement. The augment **726** may be positioned and then impacted or otherwise pressed into a bone void to achieve instant fixation.

[0102] FIG. **39** shows other embodiments of an augment **730** having built-in securement features. Embodiments of this augment may have one or more integral spikes, barbs, screws, or other fasteners pre-positioned therein. For example, augment **730** includes integral fastener **732** which may be a spike having barbs **734**. When the augment **730** is positioned as desired, the surgeon may screw, impact or tack the augment **730** in place, causing the integral fastener **732** to extend and secure bone purchase. One advantage of this embodiment is that is can prevent the surgeon from having to locate and insert separate fasteners. In some embodiments, there is provided a breakable or frangible connector **736** that is sheared once the fastener **732** has been impacted, twisted, or otherwise activated by a force or moment. A further advantage of the described embodiments is that the augment **730** is a one-piece component that can be positioned without additional fasteners or other components attached thereto, simplifying some aspects of insertion. Moreover, the surgeon may desire to place the augment **730** first, and then quickly secure it to the other implant portions to be used. Integral fasteners which are not utilized may be removed by a pulling out force, and breaking the connector. Fasteners such as integral fastener **732** may be configured to connect the augment to bone or to other implant devices such as other augments, acetabular shells, acetabular cages, and/or bone plates.

[0103] FIGS. **40-42** illustrate various augments or porous coating portions comprising one or more cross-sectional areas **740**, **742**, and **744** of reduced material which are "designed" for easy drilling, shaping, and screw insertion. In some embodiments, a bulk porous structure is provided with waffle patterns of recesses defined therein. The recesses may be externally provided, internally provided, or combinations thereof. External recesses may be created using rapid manufacturing, wire EDM, milling, or other processes. Internal recesses may be created using rapid manufacturing (e.g., selective laser sintering with an EOS machine or EBM process using an Arcam machine), cross-drilling processes, any other suitable processes, or any combinations thereof. The areas of reduced cross-section **740**, **742**, and **744** make it easier for a surgeon to drill through the augments or porous coating portions, orient screws, and burr, mill, cut, break, bend, or otherwise shape with a rotary tool **746** such as the one shown in FIG. **43**. Other modification tools such as reciprocating saws or oscillating saws may be utilized to shape the augments or porous coating portions. Recesses may extend in various patterns in two-dimensional or three-dimensional space, and may vary in width, depth, aperture, thickness, density, and length.

[0104] FIGS. **44-47** illustrate some embodiments of a connection device for securing a mounting member or an augment to an acetabular shell or acetabular cage. Certain embodiments of the connection device comprise an intermediate locking member **750** that may be placed between an acetabular shell or cage and a mounting member or augment, the intermediate locking member **750** configured to provide initial loose and adjustable attachment of the mounting member or augment to the acetabular shell or cage. After or before impaction, the mounting member or augment position relative to the shell or cage may be adjusted and then fixed with respect to the shell or cage by engaging a portion of the intermediate locking member **750**. After the intermediate

locking member **750** is engaged to lock the adjacent components together against relative movement, a liner may be inserted into the shell or cage. The intermediate locking member **750** may either be a separate portion or integral to one of the shell, cage, mounting member or augment.

[0105] Portions of the intermediate locking member **750** may be low profile and configured to be received in and locked within an acetabular shell (e.g., via a threaded, smooth, or tapered screw hole). In the embodiment shown, the intermediate locking member **750** is provided within an acetabular shell as disclosed in the '705 application. Intermediate locking member **750** may comprise, as shown, a cam locking pin **752** and a locking head screw **754**. The mounting member or augment may comprise an undercut recess **759** which has an opening of any appropriate shape, such as oblong, scalloped, triangular, dovetail, or any other option. A distal end **756** of the cam locking pin **752** has a complementary shape (oblong, scalloped, triangular, dovetail, or any other appropriate complementary shape) and is flared or tapered radially outwardly to engage one or more undercut surfaces forming the undercut recess **759**.

[0106] As shown in FIGS. **45** and **46**, a proximal end **757** of the cam locking pin **752** may have a shaft **758** with engageable threads axially-disposed therein. A locking head screw (shown for example, as locking head screw **754** of FIG. **47**) is configured to engage the threads on the shaft **758** of the cam locking pin **752**. The threads of the locking head screw may be female or male, and the threads of the cam locking pin **752** may be the other of male or female. Locking screws prevent the cam locking pin **752** from backing out once properly positioned. During use, the cam locking pin **752** is positioned within a receiving groove or recess and rotated to lock the cam locking pin **752** in place. The complementary shapes of the distal end **756** of cam locking pin **752** and a receiving groove or recess allow the cam locking pin **752** to be inserted into the groove or recess in a first orientation and then rotated to a second orientation in which it cannot be removed from the groove or recess.

[0107] The shaft portion **758** of the cam locking pin **752** may be provided with one or more flats on the outside (e.g., a hexagonal outer cross section for the shaft) to allow turning of the cam. Alternatively, a cruciform recess or hexagonal recess or other driving structure may be provided on the cam locking pin **752**. In some embodiments, the female thread in the cam locking pin **752** may be substituted for threads on the outside of the shaft **758** of the cam locking pin **752** which engage a partially cannulated locking screw having an internally-threaded aperture extending axially through the shaft of the locking screw. In such latter embodiments, outer portions of the locking screw may be smooth. The head **755** of the locking head screw **752** may alternatively be rounded for polyaxial movement (exemplary polyaxial locking options are provided in more detail below) within the hole in the acetabular shell or cage. It will be understood by those of ordinary skill in the art that the connection shown in the figures may also be used to connect augments or mounting members together, without limitation.

[0108] FIGS. **48-50** illustrate some embodiments wherein a mounting member or augment, for example, as disclosed in FIGS. **44-47**, is provided with an elongated undercut groove which is configured to receive a cam locking pin. The elongated undercut groove allows the mounting member or augment to be radially adjusted in space and locked in an orbital position around a corresponding acetabular shell or cage. In some embodiments, portions of the mounting member or augment proximate the elongated groove may be made solid, rather than porous for strength, and outer regions of the mounting member or augment may be smooth, textured, coated (e.g., hydroxyapatite), porous, or combinations thereof in order to encourage biologic fixation and ingrowth in select regions.

[0109] FIG. **49** illustrates a cross-sectional view of an augment **764** and a cam locking pin **752** being inserted into an elongated undercut groove **768** of the augment **764** in an insertion position. The cam locking pin **752** is positioned into the groove **768** by rotating the cam locking pin **752** along its axis such that the insert width **762** of the distal end **756** of the cam locking pin **752** (as shown in FIGS. **44-46**) fits through the insert width **770** of the elongated undercut groove **768**. FIG. **50** illustrates a cross-sectional view of the augment **764** with the cam locking pin **752** locked into the elongated undercut groove **768** of the augment **764** in a locking position. In the locking position, the cam locking pin **752** may generally be rotated along its axis between 50 and 130 degrees, preferably around 90 degrees (i.e., a "quarter-turn"). The locking width **760** prevents the distal end **756** of the cam locking pin **752** from fitting through the insert width **770** of the elongated undercut groove **768**. In some embodiments, cam locking pin **752** may be symmetrical and may have a flared end (e.g., distal end **756**) comprising a generally frustoconical surface, and the undercut groove **768** in the augment **764** (or, in some embodiments, an undercut groove in a mounting member) may have one or more enlarged openings to receive the flared end of the cam locking pin **752**. In such alternative embodiments, a locking screw (e.g., locking head screw **754** of FIG. **47**) may threadingly engage the cam locking pin **752** to apply a tensile force to the cam locking pin **752** against another implant such as a mounting member, augment, shell, or cage.

[0110] In the embodiments shown in FIGS. **51-54**, cleats may be provided proximate to a rim of an acetabular shell, cage, mounting member, or augment. For example, in some embodiments, one or more cleats **780** and **781** may extend or project from a superior aspect of a rim portion **782** of an acetabular shell **784** as shown. Cleats **780** and **781** may be used to secure soft tissues to the acetabular shell **784** or may serve as a means to attach secondary augments or any type of mounting member **786** to the acetabular shell **784**. In the particular instance shown in FIGS. **53** and **54**, a "quarter-turn" fastener connector arrangement is utilized. The quarter-turn fastener arrangement may comprise, for instance, a generally T-shaped male member **790** located on one or more regions of an acetabular shell, cage, or augment, and one or more complementary female members **792** located on more secondary augments or mounting members. The one or more secondary augments or mounting members engage the one or more male members **790** on the acetabular shell, cage, or augment in one degree of rotation, and then are rotated by a specified or variable number of degrees (e.g., 90 degrees) to lock the one or more secondary augments or mounting members to the one or more male members **790**. Of course, one of ordinary skill in the art would appreciate that the male and female members could be reversed to provide the same function. It should also be understood that other locking mechanisms may be used.

[0111] FIG. **55** further depicts one or more cleat portions **794** located at various portions of an acetabular shell or cage **796** (or, in some embodiments, an augment) configured for securing soft tissues. The one or more cleat portions **794** can

be arranged in any particular fashion around the acetabular shell **796**; however, it is preferred that the cleats **794** extend proximally from a rim portion or otherwise away from the acetabular shell **796** in order to provide clearance from liner-mating surfaces, cement mantle surfaces, bone contacting surfaces, and bony anatomy, for example. Cleat portions **794** may comprise suturing holes, roughened surfaces, clamps, hooks, or biologic coatings, or any other appropriate protrusions, or combinations thereof, to encourage fixation of the soft tissues to the implant (e.g., acetabular shell **796**). For example, as shown in the inset of FIG. **55**, sutures may be wrapped around cleat portion **794** and then secured to surrounding soft tissues.

[0112] FIGS. **56-60** illustrate embodiments wherein a mounting member **802** or an augment **804** may be attached peripherally to an acetabular shell or cage **806** via a recess **800** provided proximate a rim portion **808** of the acetabular shell or cage **806**. The recess **800** is sized to accept a protruding insertion portion **810** of the mounting member **802** or a protruding insertion portion **812** of the augment **804**, and the recess **800** may extend annularly circumferentially around the rim portion **808** to allow orbital placement of the mounting member **802** or augment **804** around a periphery of the shell or cage **806**. The mounting member **802** or augment **804** may be inserted into the acetabular shell or cage **806** before or after shell/cage impaction or cementing into a prepared acetabulum. One or more screw holes in the mounting member (e.g., screw holes **814**) or augment (e.g., screw holes **816**) rigidly secure the mounting member **802** or augment **804** to the bone and prevent orbital movement of the mounting member **802** or augment **804** around the shell or cage **806**. Screw holes **814** and **816** may include conventional holes, locking holes, or slots. The holes may be threaded, unthreaded, or partially threaded, and may be fixed or polyaxial. In some embodiments, screw holes **814** and **816** may include variable low-profile holes that allow for locking at a variety of angles. Once the mounting member **802** or augment **804** is positioned, the cantilever force pushes the rim **808** of the shell or cage **806** toward bone. The protruding insertion portion of the mounting member (e.g., portion **810**) or augment (e.g., portion **812**) provides a hold-down force to the shell or cage **806** after a screw is inserted through the mounting member **802** or augment **804** and into surrounding pelvic bone.

[0113] FIGS. **56** and **57** show an augment **804** being positioned with respect to an acetabular shell or cage **806**. FIGS. **58** and **59** illustrate a mounting member **802** being positioned with respect to an acetabular shell or cage **806**. The mounting member **802** is shown as having multiple securing holes **814** for use with fasteners. Securing holes **814** may be smooth, tapered, or threaded and may be used with any appropriate fastener, including but not limited to polyaxial screws. The securing holes **814** through the mounting member **802** (or securing holes **816** through the augment **804**) may be positioned at any appropriate angle, as shown, such as parallel to the member, oblique through the member, or otherwise as desired. While not shown, a honeycomb feature may be placed on outer portions of the mounting member **802** or augment **804** to provide spacing for a cement mantle between the mounting member **802** or augment **804** and surrounding bone. Moreover, porous structures, textured surfaces, biologic coatings, or orthopedic meshes may be integrally provided on, or incorporated between outer surfaces of the mounting members **802** or augments **804** and surrounding bone.

[0114] In the embodiments of FIGS. **58** and **59**, a recess **800** in the shell or cage **806** is defined by a proximally-extending lip **818** such that the mounting member **802** will sit on bone surrounding the acetabulum. In this way, the mounting members **802** will not interfere with the press-fit area between the shell **806** and prepared acetabulum adjacent the acetabular rim **808**. Moreover, because the connection is configured to allow mounting members **802** to sit on surrounding bone, the surrounding bone does not need to be countersunk or otherwise prepared to receive mounting members **802**.

[0115] FIG. **60** depicts an acetabular shell or cage **820** comprising an annular protrusion **822** along a rim portion **824** of the acetabular shell **820**. The annular protrusion **822** may extend partially around (as shown) or entirely around the circumference of the acetabular shell **820**, or one or more protrusions may be provided in any fashion around the acetabular shell **820**. The annular protrusion **822** may comprise an annular lip **826** defining an annular undercut groove **828** running circumferentially around the acetabular shell **820** proximate the rim portion **824**. The annular protrusion **822** may comprise one or more openings **830** for receiving sutures (e.g., for soft tissue or capsule re-attachment) or fasteners **832** such as set screws for contacting and frictionally engaging surfaces (e.g., divots) provided on protruding insertion portions **834** and **836** of mounting members **840** or augments **838** alike.

[0116] Fasteners **832** may be inserted into openings **830** located circumferentially laterally of the insertion portions **834** and **836** to serve as stops for preventing or limiting rotational movement of the attached mounting members **840** or augments **838**. The mounting members **840** or augments **838** may be secured down to surrounding bone after being inserted into the annular undercut groove **828** via long bone screws, thereby providing a hold-down force to the acetabular shell or cage **820**. The hold-down forces provided may complement the press fit, threaded fit, or cemented fixation between the acetabular shell or cage and surrounding prepared acetabular bone. In the instance shown, shell **820** is provided as a "hooded" shell similar to a cage, and may act as a buttress for a cemented or pressed-in liner to support various liner inclinations in varying degrees of acetabular or pelvic degradation, although it will be understood that these features may be provided on any other type of shell or cage.

[0117] In the embodiments shown in FIGS. **61-64**, one or more mounting members and/or augments may be integrally provided with orthopedic mesh to define one or more mesh mounts or void fillers. FIG. **61** shows a mounting member **380** having an orthopedic mesh **382**. In FIG. **62**, the orthopedic mesh portion **382** may be placed on an outer portion **384** of the shell **386** between bone, and a cement mantle can fill between the mesh **382**. The cement mantle rigidly connects the mounting member **380** (or, in some embodiments, an augment) to the shell **386** via the surgical mesh **382**. Rapid manufacturing techniques may be used to simultaneously create the mounting members or augments integrally with the orthopedic mesh portion. The mesh **382** may be honeycomb, diamond, or other weave pattern, or any combination thereof, and may come in multiple thicknesses. Mesh portion **382** may be oversized, customized for an individual patient, and/or standardized and trimmed by the surgeon to fit a particular patient's needs. Fasteners of all types may be inserted through one or more cells of the mesh **382**, as well as through the one or more mounting members or augments to further secure the implant to bony anatomy. For example, as shown in FIG. **61**,

a first screw **388** may be inserted through cell **390**, and a second screw **394** may be inserted through one of the plurality of screw holes **392** of mounting member **380**. Screw holes **392** may include conventional holes, locking holes, or slots. The holes may be threaded, unthreaded, or partially threaded, and may be fixed or polyaxial. In some embodiments, screw holes **392** may include variable low-profile holes that allow for locking at a variety of angles. Soft tissues may be reattached using the porosities of the mesh **382** as suture anchors, or simply as a bioscaffold. If desired, preformed trim lines may be provided by forming predetermined frangible portions in various areas of the mesh, in order to help configuration of the device for a particular patient. For example, as shown in FIG. **63**, mesh **400** includes a plurality of trim lines **402** that may be cut to separate the mounting members attached thereto, such as mounting members **404**. The separated mounting members **404** and the mesh **400** may then be placed into a patient's hip region **406** as shown in FIG. **64**.

[0118] FIGS. **65** and **66** illustrate some embodiments of a honeycomb design that may be provided on a mounting member or augment in order to control cement mantle thickness and spacing between said mounting member or augment and an adjacent acetabular shell, augment, bone, or other implant. For example, mounting member **410** of FIG. **65** includes honeycomb portion **412** provided on an attachment surface portion **414** of the mounting member **410**. The honeycomb feature **412** may be provided as any desired geometric shape. The mounting member **410** (or, in some embodiments, the augment) may comprise one or more securing holes **416** for receiving a surgical fastener **418** such as a polyaxial screw, cancellous screw, peg, or other securing device. The securing holes **416** may include conventional holes, locking holes, or slots. The holes may be threaded, unthreaded, or partially threaded, and may be fixed or polyaxial. In some embodiments, securing holes **416** may include variable low-profile holes that allow for locking at a variety of angles. The attachment portion **414** of the mounting member **410** may extend generally perpendicularly from another portion **415** of the mounting member **410**, and may comprise one or more concave curved surfaces **417** configured to abut an outer portion **422** of an acetabular shell **420**, or one or more convex surfaces (not shown) configured to abut an inner portion of a prepared acetabulum.

[0119] The foregoing is merely illustrative of the principles of the disclosure, and the systems, devices, and methods can be practiced by other than the described embodiments, which are presented for purposes of illustration and not of limitation. It is to be understood that the systems, devices, and methods disclosed herein, while shown for use in acetabular systems, may be applied to medical devices to be used in other surgical procedures including, but not limited to, spine arthroplasty, cranio-maxillofacial surgical procedures, knee arthroplasty, shoulder arthroplasty, as well as foot, ankle, hand, and extremities procedures.

[0120] Variations and modifications will occur to those of skill in the art after reviewing this disclosure. The disclosed features may be implemented, in any combination and subcombinations (including multiple dependent combinations and subcombinations), with one or more other features described herein. The various features described or illustrated above, including any components thereof, may be combined or integrated in other systems. Moreover, certain features may be omitted or not implemented.

[0121] Examples of changes, substitutions, and alterations are ascertainable by one skilled in the art and could be made without departing from the scope of the information disclosed herein. All references cited herein are incorporated by reference in their entirety and made part of this application.

What is claimed is:

1. An orthopedic implant system comprising:
an acetabular implant having a track that includes a plurality of slots and an exterior surface;
an augment having a protrusion that moves within the plurality of slots, the augment having a first cam surface that forms an interface with the exterior surface; and
wherein the protrusion has an adjustable fastener that, upon adjusting, fixes the augment with respect to the implant to impede further movement.

2. The orthopedic implant system of claim **1**, wherein the augment rotates about the exterior surface.

3. The orthopedic implant system of claim **1**, wherein the adjustable fastener is a tightening screw that extends through a through-hole in the augment.

4. The orthopedic implant system of claim **3**, wherein the tightening screw, upon tightening, expands the protrusion and thereby tightens the augment within the track.

5. The orthopedic implant system of claim **4**, wherein the protrusion is flared outwardly.

6. The orthopedic implant system of claim **3**, wherein the tightening screw has a head that fits within a slot and faces an interior portion of the implant.

7. The orthopedic implant system of claim **6**, wherein the slot has an interior opening that aligns with the head.

8. The orthopedic implant system of claim **7**, wherein the interior opening receives a tightening rod to tighten the screw.

9. The orthopedic implant system of claim **1**, wherein the track includes a dovetail joint that receives the protrusion.

10. The orthopedic implant system of claim **1**, wherein the track includes a straight portion and a curved portion.

11. The orthopedic implant system of claim **10**, wherein the track includes two straight slots and a curved portion.

12. The orthopedic implant system of claim **1**, wherein the track includes a J-shaped slot with a wall of the implant.

13. The orthopedic implant system of claim **1**, wherein the protrusion is part of an intermediate locking member that is integral to the augment.

14. The orthopedic implant system of claim **1**, wherein the first cam surface of the augment includes at least one trough that receives cement to bind the augment to the shell.

15. The orthopedic implant system of claim **14**, wherein the augment includes a plurality of projections that form a gap.

16. The orthopedic implant system of claim **15**, further comprising a flange attached to the augment.

17. A method of preparing an orthopedic implant, comprising the step of:
providing an implant having a curved external surface and an opening in the surface, the opening having at least two portions that join at a common region but are separated by an angle of less than 180°;
providing an augment having a first surface that interfaces with the curved external surface;
coupling the augment and implant by an intermediate locking member; and
tightening the intermediate locking member.

18. The method of claim **17**, including the step of securing the augment to the implant by disposing cement within a trough located on the first surface.

19. The method of claim **17**, further comprising the step of rotating the augment with respect to the implant about the curved external surface prior to tightening the intermediate locking member.

20. The method of claim **19**, further comprising the step of moving the intermediate locking member within the opening prior to tightening.

21. The method of claim **17**, further comprising the steps of applying a fastener to the implant, so that the fastener extends outwardly from the external surface, and positioning the augment about the external surface so that the extended fastener fits between two protrusions of the augment.

22. The method of claim **21**, wherein the intermediate locking member is tightened with respect to the augment by a screw.

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