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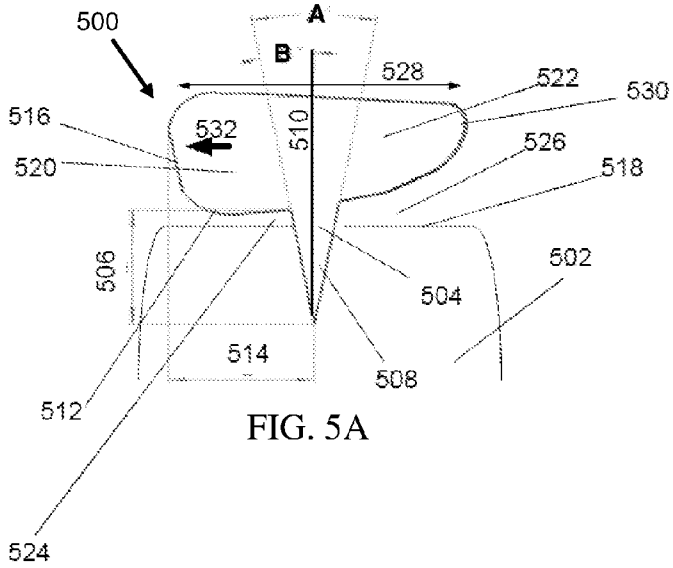

FIG. 5A

(57) Abstract: Prosthetic meniscus implant for placement in the knee joint, and implanting methods thereof. The medial meniscus implant includes: a body including a top surface configured to face a proximal direction towards the femoral condyle, a rigid bottom surface configured to face a distal direction towards the tibial plateau, at least a portion shaped to provide at least one meniscal function, the portion including at least a part of the top surface, and an anchoring section projecting distally from the bottom surface to fixate said implant to the tibia. In some embodiments, at least 60% of the anchoring section directly underlies, in the direction of the tibia, the portion of the implant which provides meniscal function. Also disclosed is a prosthetic meniscus kit including a template for positioning between a femoral condyle and a tibial plateau, and a prosthetic meniscus implant.

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MENISCUS IMPLANT

RELATED APPLICATION

This application claims the benefit of priority under 35 USC 119(e) of U.S. Provisional Patent Application No. 61/992,300, filed May 13, 2014, entitled "MENISCUS IMPLANT", the contents of which are incorporated herein by reference in their entirety.

FIELD AND BACKGROUND OF THE INVENTION

The present invention, in some embodiments thereof, relates to a prosthetic meniscus implant and, more particularly, but not exclusively, to a medial meniscus implant for placement in a knee joint, and implanting methods thereof.

U.S. Patent No. US 6,966,928 B2 to Fell et. al teaches "An implantable knee prosthesis for unicompartmental implantation into a knee joint includes a body having a substantially elliptical shape in plan and a pair of opposed faces. A peripheral edge extends between the faces and has first and second opposed sides and first and second opposed ends. At least one keel member extends from one of the faces. A first dimension D is defined by the first and second ends. A second dimension F is defined by the first and second sides. The dimension F is from about 0.25 to about 1.5 of the dimension D.".

WO Publication No. US 2013/0268074 A1 to Vowles teaches "Prosthetic knee menisci to be implanted in place of deteriorated native menisci to prevent damage to the articular cartilage of the femoral and tibial condyles and, thereby, to arrest the progressive development of osteoarthritis; said prosthetic menisci being made as a hollow form and inflated after implantation by injection of a settable polymer to shape them into congruence with the femoral and tibial condyles; being sized for the femoral and tibial condylar surfaces; having internal reinforcement for strength and durability; being made from materials having elastomeric characteristics similar to those of native menisci; having bearing surfaces treated chemically and/or physically to improve the efficiency of lubrication by synovial fluid and to enhance the wear characteristics of the bearing surfaces; and being restricted in translation within the intra-articular space by anchorage of their anterior and posterior horns and by the provision of secondary locating elements.".

In Clin. Orthop. 1960;18:86 , McKeever DC describes a tibial plateau prosthesis.

In Ann. rheum. Dis. (1974), 33, 1, a Macintosh metallic tibial plateau prostheses and arthroplasty procedure is described.

SUMMARY OF THE INVENTION

According to an aspect of some embodiments of the invention there is provided a prosthetic meniscus implant for placement in the knee joint, the implant comprising: a body comprising: a top surface configured to face a proximal direction towards the femoral condyle; a rigid bottom surface configured to face a distal direction towards the tibial plateau; at least a portion shaped to provide at least one meniscal function, the portion including at least a part of the top surface; and an anchoring section projecting distally from the bottom surface to fixate the implant to the tibia, wherein at least 60% of the anchoring section directly underlies, in the direction of the tibia, the portion providing meniscal function.

In some embodiments, a transverse section of the anchoring section defines a curved path between two points, a first point located in proximity to an anterior end of the implant and a second point located in proximity to a posterior end of the implant. In some embodiments, the curved path is substantially arc shaped, the path extending to surround a center point of the arc by at least 120 degrees.

In some embodiments, the implant comprises a first peg for anchoring to the tibia, the first peg configured at the anterior end of the implant, and a second peg for anchoring to the tibia, configured at the posterior end of the implant.

In some embodiments, the anchoring section tapers in the distal direction.

In some embodiments, the bottom surface at the portion providing meniscal function defines a contact area with the tibial plateau that is shaped and sized according to a contact area of a natural meniscus with the tibial plateau.

In some embodiments, the meniscal function comprises effectively increasing a contact area between the femoral condyle and the tibial plateau. Additionally or alternatively, the meniscal function comprises distributing load acting on the tibial plateau by the femoral condyle. Additionally or alternatively, the meniscal function comprises stabilizing the femoral condyle with respect to the tibial plateau. In some embodiments, stabilizing is provided by an inclination of the top surface at the portion, the inclination defining a concavity in which the relatively rounded femoral condyle is received.

In some embodiments, a length of the anchoring section in the distal direction ranges between 1 and 6 mm. In some embodiments, the top surface of the implant comprises a high quality surface finish.

In some embodiments, the bottom surface of the implant comprises a porous material in which bone tissue grows, increasing osseointegration of the implant with the bone.

In some embodiments, the implant comprises one or more openings for at least one of coupling the implant to a delivering tool, and injecting filler material to a lumen of the implant between the top and bottom surfaces.

In some embodiments, the anchoring section is continuous. Alternatively, the anchoring section is non continuous.

In some embodiments, the implant is shaped as a half ellipsoid, the meniscal providing portion extending along at least a portion of the curved periphery of the ellipsoid.

In some embodiments, the top surface of the implant is rigid, and the anchoring section is positioned below the bottom surface to receive force transferred from the rigid top surface through the body of the implant. In some embodiments, the force is compression force applied onto the top surface of the implant from the proximal, femoral direction.

In some embodiments, the body of the implant is rigid enough so that force is transferred by the body with less than 10% damping.

According to an aspect of some embodiments of the invention there is provided a medial meniscus implant for placement in the knee joint, the implant comprising: a rigid top surface configured to face a proximal directions towards the femoral condyle; a bottom surface configured to face a distal direction towards the tibial plateau, the bottom surface rigid enough to hold an anchoring section, the anchoring section extending distally from the bottom surface to fixate the implant to the tibia; wherein a geometry of the implant is adjustable.

In some embodiments, the geometry comprises a distance between the top and bottom surface, the distance being adjustable at one or more locations between an outer wall of the implant, facing a medial direction, and an inner wall of the implant, facing a lateral direction.

In some embodiments, the implant comprises one or more screws positioned within one or more respective holes formed in the implant, wherein the screw is advancable into the hole to modify the distance between the top and bottom surfaces. In some embodiments, the distance is adjusted by controlled injection of filler material into a lumen between the top and bottom surfaces.

In some embodiments, the lumen is divided into two or more compartments which are separately inflatable for selectively shaping the lumen.

In some embodiments, the implant comprises a channel extending between posterior and anterior ends of the implant, the channel sized to receive a tool. Optionally, filler material is injected through the channel.

In some embodiments, an outer wall of the implant facing a medial direction is expandable and compressible. In some embodiments, the outer wall is higher than the inner wall, forming an inclination of the top surface of the implant.

In some embodiments, the implant comprises a collapsed state and an expanded state, and in the expanded state of the implant the top surface is formed with topographic curvature.

According to an aspect of some embodiments there is provided a meniscus implant for placement in the knee joint, the implant comprising: a metal top surface configured to face a proximal direction towards the femur; a metal bottom surface configured to face a distal direction towards the tibia; a lumen between the top and bottom surfaces; and at least one opening defining access to the lumen, the opening providing for insertion of filler material into the lumen.

According to an aspect of some embodiments there is provided a prosthetic meniscus kit, the kit comprising: a template for positioning between a femoral condyle and a tibial plateau, the template adjustable in at least one of shape and size; and a prosthetic meniscus implant, wherein at least one of a shape, size and location of the implant in the joint are determined according to the template.

According to an aspect of some embodiments of the invention there is provided a method for implanting a meniscus implant in the knee joint, the method comprising: creating one or more ports in the knee; introducing, through the one or more ports, a meniscus implant having an anchoring section; extending the knee to apply compression force on the meniscus implant, causing the anchoring section to anchor into the tibia against sliding movement of the implant across the tibial plateau. In some embodiments, prior to introducing a meniscus implant, a gauge is inserted to the knee joint for at least one of determining one or more dimensions within the joint and for marking a location for the meniscus implant.

In some embodiments, the gauge is a template shaped according to the meniscus implant.

In some embodiments, the template comprises a recess shaped and sized according to an anchoring section of the meniscus implant, and the method further comprises pressing the template against the tibial plateau to produce a groove in which at least a portion of the anchoring section is received.

In some embodiments, prior to introducing of the implant, the method further comprises resurfacing one or more regions of the tibial plateau.

According to an aspect of some embodiments of the invention there is provided a method for implanting a meniscus implant in the knee joint, the method comprising: creating one or more ports in the knee; introducing, through the one or more ports, a template to be positioned between the

tibial plateau and the femoral condyle; determining, using the template, at least one of a location for positioning the meniscus implant, a size of the meniscus implant, and a shape of the meniscus implant; removing the template; selecting and implanting the meniscus implant in the knee joint in accordance with one or more parameters determined using the template.

In some embodiments, the method further comprises marking a location for positioning of the meniscus implant by compressing tissue on the tibial plateau using the template.

Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the invention are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of embodiments of the invention. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the invention may be practiced.

In the drawings:

FIG. 1 is an illustration of an exemplary knee joint (right knee);

FIG. 2 is a flowchart of an exemplary method for implanting a prosthetic medial meniscus, according to some embodiments of the invention;

FIG. 3 is an illustration of an exemplary crescent shaped medial meniscus implant positioned in a knee joint (right knee), according to some embodiments of the invention;

FIGs. 4A - 4B are views of the top surface (side) and the bottom surface (side), respectively, of an exemplary medial meniscus implant, according to some embodiments of the invention;

FIGs. 5A - 5B show two exemplary configurations, at a cross section, of an exemplary meniscus implant anchored to the tibia, according to some embodiments of the invention;

FIGs. 6A - 6F illustrate various exemplary configurations of an exemplary anchoring section of a meniscus implant, according to some embodiments of the invention;

FIG. 7 is an exemplary configuration of a medial meniscus implant, according to some embodiments of the invention;

FIGs. 8A - 8C illustrate an exemplary mechanism featuring a plurality of adjusting elements for shaping and/or sizing a meniscus implant, according to some embodiments of the invention;

FIGs. 9A - 9C illustrate an exemplary implant including a screw and/or wire for shaping and/or sizing the implant, according to some embodiments of the invention;

FIGs. 10A - 10B illustrate on exemplary mechanism for shaping the implant by injecting filler material, according to some embodiments of the invention;

FIGs. 11A - 11D show a back view of an exemplary meniscus implant before and after inflation (FIGs. 11A - 11B), and graphs indicating an exemplary distance of a top surface of the implant from the tibial plateau before, before, during and/or after inflation (FIGs. 11C - 11D), according to some embodiments of the invention;

FIG. 12 is a flowchart of an exemplary preparation method before implanting a meniscus implant, according to some embodiments of the invention;

FIGs. 13A - 13G are drawings of an exemplary method for implanting a meniscus implant in a knee joint (right knee), according to some embodiments of the invention;

FIGs. 14A and 14B are an exemplary groove template and an exemplary burring template, respectively, for resurfacing the tibial plateau, according to some embodiments of the invention;

FIGs. 15A - 15C illustrate an exemplary dummy implant (FIGs. 15A - 15B), and an exemplary dummy implant positioned in a knee joint (right knee) (FIG. 15C), according to some embodiments of the invention; and

FIGs. 16A - 16B are exemplary resurfacing patterns of the tibial plateau of a left knee, according to some embodiments of the invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

The present invention in some embodiments thereof relates to a prosthetic meniscus implant and, more particularly, but not exclusively, to a medial meniscus implant, and implanting methods thereof.

An aspect of some embodiments of the invention relates to a meniscus implant including at least a portion that is adapted to provide meniscal function, from which an anchoring section extends in a distal direction, towards the tibia.

In some embodiments, a meniscal function provided by the portion of the implant includes increasing an effective contact area between the femoral condyle and the tibial plateau. In some

embodiments, a meniscal function provided by the portion of the implant includes stabilizing the relatively rounded femoral condyle with respect to the relatively flat tibial plateau. In some embodiments, a meniscal function provided by the portion includes effectively elevating the tibial plateau. In some embodiments, a meniscal function provided by the portion includes distributing load.

In some cases, the meniscal function providing portion is configured to transfer forces in a proximal to distal direction, for example, transferring force applied by the femur to the anchoring section which enters the tibia. Additionally or alternatively, the meniscal function providing portion is configured to distribute loads applied by the femur circumferentially, such as towards the medial facing periphery of the joint.

In some embodiments, the portion that provides meniscal function is configured to occupy at least 55%, at least 60%, at least 70% of a volume originally occupied by the natural meniscus. In some embodiments, the contact area of the implant with the medial condyle varies, for example, it may change with joint movement such as during flexion or extension.

In some embodiments, a geometry of the meniscal function providing portion is selected to stabilize the joint. In some embodiments, the meniscal function providing portion is shaped to receive a ball-like structure of the femoral condyle. For example, in some embodiments, the meniscal function providing portion is C-shaped, receiving the condyle within an inner space defined by the C shape. In some embodiments, the implant includes horns, extending for example, along the edges of the joint, in the anterior and posterior directions. Optionally, the implant is crescent shaped. In some embodiments, a proximal to distal cross section of the meniscal function providing portion is wedge-shaped, including an inclination towards a center of a concavity in which the femoral condyle is received. At such a configuration, due to the inclination, force from the femur may act on the implant at an angle, for example, at an angle to a longitudinal axis of the joint. In some cases, the implant contacts the femoral condyle by at least partially surrounding the condyle, and force is transferred to the implant from the side walls of the codyle rather than from the distal tip of the femoral condyle.

In some embodiments, the whole implant is formed of the meniscal function providing portion and the anchoring section that extends from it. Alternatively, the implant includes one or more other portions, for example, a portion extending towards a center of the joint and overlying a larger surface area of the tibial plateau, for example, a surface area larger than an area which the meniscal function providing portion alone overlies.

In some embodiments, the implant is located between the femoral condyle and tibial plateau. Optionally, the implant is positioned a distance away from the tibial plateau rim, for example,

to position the anchoring section mainly in trabecular bone tissue. In some cases, an interface between the anchoring section and the outer cortex of the bone is minimized. By positioning the anchoring section away from the outer walls of the bone, damage to peripheral bone tissue may be reduced or prevented. A potential advantage of engaging trabecular bone may include improved osseointegration of the bone with the implant.

In some embodiments, a contour of an outer wall of the implant (facing a generally medial direction) substantially follows a curved contour of a medial segment of the tibial plateau rim.

In some embodiments, the anchoring section directly underlies the meniscal function providing portion. Optionally, the anchoring section extends, in a distal direction, from a bottom surface of the implant. In some embodiments, most of the anchoring section, such as 60%, 70%, 90% or intermediate, larger or smaller percentages of a transverse cross sectional area of the anchoring section are configured underneath the meniscal function providing portion.

In some embodiments, the anchoring section of the implant is a keel that extends to form a non-linear path, such as a curved path, between two points, for example, a first point located in proximity to an anterior end of the implant, and a second point located in proximity to a posterior end of the implant. In an example, the keel is shaped as an arc. Optionally, a radius of curvature of the keel is selected to match a radius of curvature and/or a contour of the curvature of at least a portion of the tibial plateau rim. A curved keel may better distribute forces such as shear forces, for example, shear forces acting between the tibial plateau and the implant, for example, in comparison to a straight keel. While forces acting on a straight keel may act substantially perpendicularly to the keel, forces acting on a curved keel such as an arc shaped keel may act in various angles and directions.

In some cases, for example, during gait, different forces act in various directions, and the curved keel may distribute these forces and reduce their local effect. In some cases, the curved keel distributes load, for example, distributing axial compression load applied by the femur in a transverse direction, such as in an anterior and/or posterior direction. A potential advantage of a curved keel may include reducing locations of higher stress.

The keel may be formed in various configurations. In some embodiments, one or more walls of the keel are perpendicular to the bottom surface of the implant. In some embodiments, the keel is continuous. Alternatively, the keel is non-continuous, for example, formed as a plurality of projections.

In some embodiments, the keel includes a bone engaging element. Optionally, a distal portion of the keel is configured to compact bone tissue. In some embodiments, the keel tapers in the distal direction, towards the tibia. In some cases, when the tapered keel is forced into the tibia

and advanced distally, bone material adjacent the keel is compressed by the widening profile of the walls of the keel. In some embodiments, a distal end of the keel is formed with a sharp edge, such as to penetrate bone tissue when being forced into the tibia.

In some embodiments, a length of the keel is selected to penetrate to a depth ranging between, for example, 0.5-10 mm, 1-3 mm, 6-9 mm or intermediate, larger or smaller depths into tibial bone tissue. Optionally, penetration is deep enough to reduce unwanted movement of the implant, for example, in a transverse direction with respect to the tibial plateau.

In some embodiments, the implant includes a rigid bottom surface. In some cases, the bottom surface is rigid enough to hold the anchoring section intact. In some embodiments, one or more additional portions of the implant, such as a top surface, are formed of a rigid material. Optionally, the rigid material includes, for example, a metal or a metal alloy, such as cobalt chrome. In an exemplary embodiment, the whole implant is formed of metal. Some potential advantages of an implant having at least a rigid bottom surface, for example, as compared to an implant mostly formed of a soft material, may include one or more of wear resistance, reduced dislocation relative to the joint, and/or improved distribution of stress.

In some embodiments, one or more portions of the implant such as the anchoring section and/or the bottom surface facing the tibia are coated by a porous coating, for example, a porous metallic coating. A potential advantage of a porous coating may include increased osseointegration of the implant with the tibial bone tissue, which may enhance the fixation strength of the implant to the tibia. In some cases, due to increased fixation strength provided by the porous coating, a shorter anchoring section may be used, e.g. an anchoring section that penetrates to a smaller depth within the tibial bone.

In some embodiments, one or more portions of the implant such as a top surface facing the femur are smooth, for example, polished with a high quality surface finish. A potential advantage of a smooth proximal surface may include reducing damage to the femoral cartilage, and/or reducing friction between the femur and the implant.

In some embodiments, the implant includes a first portion which is adapted to replace a meniscus, for example, as described hereinabove, and a second portion which is adapted to act as at least a portion of the tibial plateau, for example, reshaping the bone surface. Exemplary reshaping of the tibial plateau may include providing an implant with a planar portion which may effectively flatten the natural tibial plateau, or , alternatively, providing an implant with a curved surface portion which modifies a curvature of the natural tibial plateau. In an example, the implant is shaped as a half ellipsoid, overlying a relatively large area of the tibial plateau and extending further towards a

center of the joint, for example, in comparison to a crescent shaped implant. In some embodiments, the implant effectively elevates the tibial plateau, by being formed with a thickness.

An aspect of some embodiments of the invention relates to an adjustable meniscus implant including a rigid top surface facing the femur and a rigid bottom surface from which an anchoring section extends distally to fixate the implant to the tibia, In some embodiments, a geometry of the implant is adjustable, for example, lumen between the top and bottom surface is adjustable in shape and/or size. In some embodiments, the implant includes a first state in which the implant is reduced in size, for example, reduced in thickness, and a second state in which the implant is adjusted to occupy a larger space between the femoral condyle and the tibial plateau. In some cases, the implant is introduced into the knee joint in the first state, for example, arthroscopically, by using other minimally invasive technique, and/or by performing open surgery, and when positioned in the joint, the implant is transformed to the second state. Optionally, transforming the implant to the second state includes filling the lumen between the top and bottom surfaces with one or more filler materials such as PMMA.

In some embodiments, shaping the lumen includes modifying a thickness of the implant. Additionally or alternatively, shaping includes modifying a distance between, for example, anterior and posterior horns of the implant.

In some embodiments, shaping of the implant is obtained by inflation, for example, by injection of filler material. In some embodiments, the implant is divided into a plurality of inner compartments, and selective inflation of different portions of the implant can be performed. Additionally or alternatively to inflation, a lumen between the top and bottom surfaces is shaped using one or more adjusting elements, for example, one or more screws. In an exemplary embodiment, screws are arranged within respective holes along one or more of the implant's edges. Optionally, by advancing (e.g. by threading) or retracting a screw within its respective hole, a distance between the top and bottom surfaces of the implant is modified. Optionally, adjusting a distance between the top and bottom surfaces creates a slope, for example, if a back wall of the implant is extended to be higher than an inner wall, a slope is formed between the walls, decreasing in a radially inward direction towards the center of the joint.

In some embodiments, one or more openings are formed in the implant to provide access for adjusting the implant, and/or for injecting filler material, and/or for delivering or maneuvering the implant, for example, by attaching a tool such as a handle to an opening.

An aspect of some embodiments of the invention relates to a rigid prosthetic meniscus implant, including a distally projecting anchoring section positioned to receive force from a top

surface of the implant which is transferred by the implant. Optionally, the force is transferred through the rigid implant body with a damping less than, for example, 10%, 20%, 50%, or intermediate, larger or smaller percentages.

In some cases, for example, during extension of the knee, compression force and/or other forces, such as shear forces, act on the implant. In some cases, the forces include dynamic forces, for example, forces acting during movement of the knee joint. Additionally or alternatively, the forces are forces that naturally act on the knee joint, even when no movement of the joint is involved. In some cases, shear forces act to push the implant in a radially outward direction, for example, a medial direction, out of the joint, and the anchoring section resists those forces.

In some embodiments, for example, during insertion of the implant into the joint, compression force and/or other forces transferred by the implant to the anchoring section are strong enough to force the anchoring section into the tibia, penetrating the tibial plateau surface and/or deepening an existing anchoring into the bone. Additionally or alternatively, the keel is received within a pre-formed groove in the tibial plateau. Optionally, a distal portion of the keel is received in the groove, and compression force is applied to force a more proximal portion of the keel into the tibia.

An aspect of some embodiments of the invention relates to implanting a meniscus implant. In some embodiments, the implant is introduced to the knee joint, for example, arthroscopically, and the knee is extended to move the implant to a certain location and/or to cause an anchoring section of the implant to penetrate or further deepen an existing anchoring in the tibia. In some embodiments, the tibial and/or femoral condyles are reshaped to receive the implant, for example, one or more portions of the tibial plateau are resurfaced, such as by forming a groove in the bone for receiving an anchoring section of the implant. Optionally, a burr, a chisel and/or other tool suitable for resurfacing the bone is used for producing the groove.

In some embodiments, a contact surface between the implant and tibial plateau is enlarged, for example, by removing cartilage from the tibial plateau surface. Removal of cartilage may accelerate osseointegration of the implant with the bone.

In some embodiments, the anchoring section of the implant includes one or more elements, such as pegs, positioned for example, at the posterior and anterior ends of the implant. Optionally, the pegs secure the implant to the tibia. In some cases, the pegs are used in addition to the keel, for example, providing additional anchoring locations which reduce a risk of movement of the implant, such as transverse movement. Optionally, the pegs provide anchoring which is leveled with the implant, while the keel penetrates deeper into the tibia in a distal direction.

In some embodiments, a template is introduced to the joint, for example, before the meniscus implant. In some cases, the template is a dummy implant. Optionally, one or more parameters are determined with the aid of the dummy implant, for example, a size of the permanent implant, a shape of the permanent implant, a location for positioning the permanent implant. In some embodiments, various sizes and/or shapes of templates are provided, and are tested to select a permanent implant according to an anatomy and/or morphology of a patient. In some embodiments, the template is deformable, and can be shaped or reshaped in vivo.

In some embodiments, a marking is formed, for example, a marking in the tibial plateau tissue, for example, by applying compression force on the template, such as by extending the knee to cause the femur to apply compression on the template. The meniscus implant may then be positioned in the joint according to the produced marking.

In some embodiments, a groove template and/or a burring template are inserted to the knee, to prepare the bone surface of the tibia for implantation of the meniscus implant.

In some cases, immediate loading of the knee is performed following implantation, for example, immediately after, to assess knee function.

In some embodiments, a structure and/or materials of the implant are selected to comply with a dynamic morphology of the knee joint. For example, the structure and/or materials of the implant are selected to reduce friction between the femur and tibia. Additionally or alternatively, the structure and/or materials are selected to reduce damage to tissue such as the femoral cartilage. Additionally or alternatively, the structure and/or materials are selected to stabilize the knee joint. Additionally or alternatively, the structure and/or materials are selected to transfer loads acting within and/or on the knee joint.

It is noted that apparatuses and/or methods for example, as described herein may also be used with respect to a lateral meniscus of the knee. In some embodiments, an implant for example, as described herein may be used in a high tibial osteotomy procedure, for example, contributing to shifting weight from a damaged portion of the joint. Various embodiments may be suitable for use in anatomical locations other than the knee joint, for example, a shoulder joint.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not necessarily limited in its application to the details of construction and the arrangement of the components and/or methods set forth in the following description and/or illustrated in the drawings and/or the Examples. The invention is capable of other embodiments or of being practiced or carried out in various ways.

Referring now to the drawings, FIG. 1 illustrates an exemplary knee joint 100. The medial meniscus 102 and lateral meniscus 104 are two crescent-shaped pads of cartilaginous tissue that are located between the condyles 110 and 112 of the femur 106 and tibia 108. The menisci disperse the weight of the body, and reduce friction during movement. The menisci increase a contact area of the joint surface, and provide structural integrity to the knee when it undergoes tension and/or torsion, for example, during rolling, gliding, rotating, flexing and extending of the knee joint.

While the medial meniscus 102 is subjected mainly to rotational movement of the medial femoral condyle 110, the lateral meniscus 104 is subjected to combined rotation and translational anterior-posterior movement of the lateral femoral condyle 112, and is more mobile. The center of contact of lateral condyle 112 with lateral meniscus 104 shifts, while the center of contact of medial condyle 110 with medial meniscus 102 substantially remains in place. The condyles 110 and 112, and bone area between the condyles are at least partially coated by a layer of articular cartilage 116. In FIG. 1, the medial collateral ligament 118 and the lateral collateral ligament 120 are also shown, extending from femoral condyles 110 and 112 respectively to tibia 108.

Due to the rounded profile of the femoral condyles and the relatively flat surface of the tibial plateau 114, high pressure may form at the contact points of the condyles with the tibia. The menisci 104 and 102 act to deepen the tibial plateau 114 so that it better accommodates the femoral condyles. The menisci also provide shock absorption and lubrication for the joint.

Injuries to the meniscus may include tears, for example, acute tears that are a result of trauma or a sports injury, or chronic tears occurring as a result of wear. Some tears are treated with surgical repair, and some are treated symptomatically, such as with physical therapy and/or anti inflammatory medication.

A meniscectomy procedure is commonly performed for injured menisci, involving the repairing or removal, complete or in part, of the injured meniscus.

In some cases, a unicompartmental knee replacement is performed, involving the repairing of one side of the knee joint (e.g. medial or lateral side).

Implantation of a meniscus implant, according to some embodiments of the invention, can be performed to improve knee function even in cases in which contraindications for performing other procedures are present. For example, a patient diagnosed with sever degenerative changes mainly in the medial compartment but some degenerative changes in the lateral compartment may not be suitable for a unicompartmental knee replacement, but implantation of a meniscus implant for example, as described herein may improve the patient's knee joint condition. In addition, in some

cases, if implantation of a meniscus implant (such as a in a minimally invasive manner) fails, the procedure can be easily converted to a partial or total knee replacement.

FIG. 2 is a flowchart of an exemplary method for implanting a prosthetic medial meniscus, according to some embodiments of the invention.

In some cases, a decision is made, for example, by a physician, to implant a prosthetic medial meniscus in a knee joint (200) of a patient. In some cases, a condition of the natural medial meniscus is assessed, for example, by imaging, and a decision is made based on diagnosis of degenerative indications in the meniscus, such as a tear in the meniscus. In some cases, the decision to implant a medial meniscus involves assessing a condition of a lateral meniscus. For example, in some cases, if the lateral meniscus is torn or otherwise damaged, a total knee replacement might be considered. In some cases, a severely damaged medial meniscus and/or severe degenerative changes in the knee joint are indications for implanting a medial meniscus.

In some embodiments, one or more ports are created in the knee (202). Optionally, a port is created under the knee cap. In some cases, a first incision is created for insertion of an arthroscope into the knee, and a second, optionally larger incision is created for insertion of the meniscus implant. Optionally, the joint interior is examined using the arthroscope. In some cases, reminisce of the natural meniscus are removed, for example, using a shaving tool. Optionally, loose portions of cartilage are removed.

In an example, a first antero-lateral port is formed in the knee. Optionally, the knee is inspected using an arthroscope. In some cases, an additional antero-medial port is formed. Optionally, resection of remaining medial meniscus tissue and/or preparation of the tibia plateau for example, as described herein are performed through the antero-medial port.

In some embodiments, for example, as further described herein, a gauge is used to determine implant parameters (204). In some embodiments, the gauge is a dummy implant which is introduced to a location of the medial meniscus (204). Various one or more parameters of the implant may be assessed using the dummy, for example, a size, shape, and/or a location for positioning the implant. Additionally or alternatively, the gauge is any tool suitable for assessing one or more dimensions joint related dimensions, such as a size of the tibial plateau area onto which the implant is attached.

In some embodiments, one or more portions of the tibial plateau are resurfaced, for example, by forming a groove in which at least a portion of an anchoring section of the implant is received. Optionally, the groove is produced by using the dummy implant, for example, as further described herein. Optionally, the groove is shaped and/or sized according to the anchoring section of

the implant. In some embodiments, resurfacing includes reducing a thickness of cartilage on the tibial plateau. Optionally, at one or more areas of the tibial plateau, the cartilage is fully removed. A potential advantage of removing the cartilage may include increasing osseointegration.

In some embodiments, a medial meniscus implant having an anchoring section configured to face the tibia, for fixating the implant to the tibia, is introduced to the joint, for example, through one or more of the ports (206). In some cases, the implant is introduced through the antero-medial port. Optionally, the port is enlarged prior to insertion of the implant, for example, enlarged from a size of 0.5 cm to a size of 1 cm, from a size of 0.2 cm to a size of 1.5 cm, from a size of 1 cm – 2.5 cm, or intermediate, larger or smaller sizes. In some embodiments, the implant is inserted and/or positioned in place with the aid of a handle and/or other tool suitable for maneuvering the implant within the knee joint. In some embodiments, insertion and/or positioning of the implant are assisted by an arthroscope, for example, being passed through the antero-lateral port.

In some embodiments, for example, as further described herein, the implant includes a rigid bottom surface, facing the tibial plateau. Optionally, the implant includes a rigid top surface, facing the femoral condyle. Optionally, the whole implant is formed of a rigid material, such as cobalt chrome.

In some embodiments, adhesive material such as bone cement is applied, for example, to a bottom surface of the implant. Optionally, application of bone cement provides a primary fixation of the implant to the bone.

In some embodiments, once the implant is located in the knee joint, the patient's knee is extended, for example, with the aid of a physician, to force at least a portion of the anchoring section into the tibia (208). Optionally, extension of the knee applies force on the implant, such as compression force applied for example, on the top surface of the implant. The compression force is then transferred through the body of the implant, due to at least a part of the implant being formed of a rigid material. Optionally, compression force transferred from the top surface is received by the anchoring section with less than, for example, 10%, 20%, 5%, 30% or intermediate, larger or smaller percentages damping. A potential advantage of a rigid implant may include the ability to transfer most of the force applied by the femur on the top surface of the implant to the anchoring section that extends from the bottom surface of the implant.

It is noted that compression force acting on the implant may reach up to, for example, 900 N (for example, when the patient is in a standing position), 700N , 500N or intermediate, larger or smaller magnitudes.

In some embodiments, the anchoring section is pushed to a certain depth into the tibia, for example, pushed 10%, 50%, 85%, 100% or intermediate, larger or smaller percentages of the height of the anchoring section into the tibia. Optionally, the anchoring section penetrates the tibial plateau. Additionally or alternatively, the anchoring section is received within a groove in the tibial plateau, such as a preformed groove shaped and/or size to receive the anchoring section.

Additionally or alternatively to extending the knee, a balloon is inserted arthroscopically and inflated at a location suitable for applying force to the implant, for example, in order to move the implant to a certain location and/or to apply force onto the anchoring section. For example, the balloon is inflated between the femoral condyle and the implant. In some embodiments, the balloon includes one or more markers to indicate the extent of inflation. Optionally, the extent of inflation is correlated with the advancement of the anchoring section in the distal direction.

In some embodiments, further adjustments to a positioning of the implant are made, for example, using the handle, for example, before the implant is fully anchored to the tibia. Optionally, once a desired position of the implant is obtained, the handle is removed. Optionally, the one or more ports in the knee are closed.

In some cases, following the implantation procedure, for example, at least 2, 3, 4, 5 hours after the implantation, the joint with the implanted meniscus can withstand full weight bearing, enabling the patient to stand and/or walk.

In some cases, if degenerative changes occur in the knee joint, for example, if the lateral meniscus is torn, a partial or total knee replacement procedure can be performed. Optionally, the meniscus implant is removed. Alternatively, the meniscus implant is incorporated in the prosthetic knee joint. In some cases, a femoral component which articulates with the meniscus implant is provided, and implanted in the knee joint along with the meniscus implant.

FIG. 3 is an illustration of an exemplary crescent shaped medial meniscus implant 300 positioned in a knee joint, according to some embodiments of the invention.

In some embodiments, implant 300 is inserted to a location between the tibia 302 and femoral condyle 304. Condyle 304 may be at least partially covered by layer of articular cartilage, which may come in contact with the implant, for example, with a top surface of the implant.

In some embodiments, a bottom surface of implant 300 contacts the tibial plateau 306. In some embodiments, implant 300 is positioned a distance (indicated by the double headed arrow) 308 away from a rim of the tibia, for example, a radial distance ranging between 1-10 mm, such as 2 mm, 5 mm, 9 mm or intermediate, longer or shorter distances. Optionally, distance 308 is selected to be large enough to keep the implant away from the medial bone cortex 310. Additionally or

alternatively, distance 308 is selected to be large enough so that an anchoring section (for example, as shown in FIGs. 6A - 6F) of implant 300 may be inserted mostly into trabecular bone tissue, (found in the interior portion of the bone), as opposed to anchoring to the cortical bone tissue on the external layer of the bone. A potential advantage of anchoring the implant to trabecular bone tissue may include increasing osseointegration with the bone.

In some embodiments, implant 300 occupies at a least a portion of the joint space which was previously occupied by a natural medial meniscus. In some embodiments, the implant does not overlie a central area 312 between the tibial plateau 306 and condyle 304, but rather extends inwardly in a radial direction to a certain distance. In an example, a width (indicated by the double headed arrow) 314 of implant 300, measured between a radially outward back wall 316 and radially inward wall 318 of the implant, ranges between, for example, 2-4 cm, 1-3 cm, 3-5 cm, or intermediate, larger or smaller ranges. Optionally, width 314 decreases in the direction of posterior horn 320 of the implant and/or in the direction of the anterior horn of the implant (hidden in this figure by condyle 304).

In some embodiments, condyle 304, for example a cartilage layer covering the convex condyle surface, occasionally contacts implant 300. A distance (indicated by the double headed arrow) 332 between the implant and a condyle portion directly above the implant may dynamically change, for example, during gait and even during standing, as the leg muscles function to maintain a positioning of the bones with respect to each other. Optionally, distance 332 varies between outer back wall 316 and inner wall 318.

In some cases, bone tissue may grow over time to cover one or more portions of implant 300, for example, covering one or more portions of the implant's outer walls.

In some embodiments, an inner radius 328 of implant 300, extending to inner wall 318, ranges between, for example, 10-20 mm, such as 12 mm, 15 mm, 18 mm or intermediate, larger or smaller radius. In some embodiments, an outer radius 330 extending to outer wall 316 ranges between, for example, 20-30 mm, such as 22 mm, 25 mm, 27 mm or intermediate, larger or smaller radius.. Optionally, the inner and/or outer radii vary between different portions of the implant.

Alternatively, in some embodiments, implant 300 is increased in width and extends to overlie central area 312, thereby contacting a larger surface area of tibial plateau 306. In an example, the implant features a half-ellipsoid or a table spoon profile.

In some embodiments, a top surface 322 of the implant is formed with a slope, for example, at an angle α ranging between, for example, 2.5-5 degrees, 3-8 degrees, 2-10 degrees, or intermediate, larger or smaller ranges. In some cases, due to the inclined surface of the implant (e.g.

top surface 322), force 334 from the femoral condyle is received at an angle, for example, at an angle with respect to the joint axis of extension. Optionally, the implant distributes the force, for example, distributing the force circumferentially, such as in a radially outward direction.

In some embodiments, back wall 316 of implant 300 is high enough to increase joint space on the medial side, for example, keeping condyle 304 a distance away from tibial plateau 306. Optionally, a height (indicated by the double headed arrow) 326 of back wall 316 ranges between, for example, 3-10 mm, such as 6 mm, 7 mm, 9 mm or intermediate, larger or smaller height.

In some embodiments, back wall 316 is high enough to cause the transferring of at least a portion of the load on the joint, such as compression load, to a lateral side of the joint. Optionally, height 326 is selected to effectively reduce load on medial meniscus implant 300 by transferring the load towards the lateral side of the knee joint, for example, in cases in which a healthy natural lateral meniscus exists.

FIGs. 4A - 4B are views of the top surface (side) (FIG. 4A) and the bottom surface (side) (FIG. 4B) of an exemplary medial meniscus implant, according to some embodiments of the invention.

In some embodiments, implant 400 includes a bottom surface 402 from which a keel 404 extends distally to fixate the implant to the tibia. In some embodiments, bottom surface 402 is at least partially rigid, for example, rigid at 60%, 80 %, 95% or intermediate, larger or smaller percentages of the surface. In some embodiments, keel 404 is at least partially rigid, for example, rigid at 60%, 80%, 95% or intermediate, larger or smaller percentages of the keel's volume.

In some embodiments, a top surface 406 of implant 400 is at least partially rigid, for example, rigid at 60%, 80%, 95% or intermediate, larger or smaller percentages of the surface.

In some embodiments, a young's modulus of a material from which bottom surface 402 and/or keel 404 and/or top surface 406 are made of ranges between, for example, 200-300 GPa, such as 220 GPa, 250 GPa, 280 GPa or intermediate, larger or smaller values. In an example, one or more portions of the implant are formed of a cobalt chrome alloy, having a Young's modulus of, for example, 258 GPa. Additionally or alternatively, one or more portions of the implant are formed of silicon, having a Young's modulus ranging between, for example, 130-185 GPa.

In some embodiments, keel 404 is formed with a higher stiffness than other portions of the implant, for example, a higher stiffness than top surface 406, for example, 10%, 30%, 70% or intermediate, larger or smaller percentages higher. In some embodiments, bottom surface 402 and/or keel 404 and/or top surface 406 are formed of a metal or metal alloy such as cobalt chrome or Co-Cr-Mo, Co-Ni-Cr-Mo alloys. Additionally or alternatively, one or more portions of the implant

are formed of a polymer such as PEEK, carbon PEEK, Ultra-high-molecular-weight polyethylene, or other polymers.

In some embodiments, a body of implant 400, being a lumen between the top and bottom surfaces, is filled with a rigid material, for example, metal. In an example, the whole implant (for example, including the top and bottom surfaces, body and keel) is formed of a single piece of metal. A potential advantage a metal implant includes increased wear resistance, for example, in comparison to a polymer implant.

In some embodiments, most of implant 400 such as 70%, 80%, 90%, 100% of the implant is formed of a rigid material. In some cases, due to the rigidity of the implant, force such as compression can be transferred by the implant's body with little or no damping, for example, less than 20%, 10%, 5% or intermediate, larger or smaller percentages damping. In some cases, the force is transferred by the implant's body to keel 404, causing it to anchor into the tibia or deepen an existing anchoring within the tibia.

A potential advantage of an implant which is mostly or completely rigid may include reducing a risk of the implant being deformed in shape and/or worn by the forces acting on the knee joint.

A potential advantage of an implant having a rigid keel may include reducing a risk of the implant moving from a desired position in the knee joint.

In some embodiments, bottom surface 402 is a rugged surface, for example, including one or more protrusions 408 and/or other surface texture. In some embodiments, bottom surface 402 includes a porous texture. Optionally, the surface is coated with a porous coating, for example, including ceramic and/or metallic particles. In an example, the surface is coated with hydroxylapatite. A potential advantage of a rugged surface may include increasing a contact area between the tibial plateau and the implant, which may enhance osseointegration with the bone, for example, by growth of bone tissue within the pores.

In some embodiments, bottom surface 402 is coated by a layer of elastic material, for example, formed of elastomeric material and/or a collagen based substance. Optionally, the elastic layer effectively increases the contact surface area between the tibial plateau and the implant. In some embodiments, keel 404 extends distally from bottom surface 402 through the elastic layer.

In some embodiments, top surface 406 is smooth, for example, formed with a high surface finish. Optionally, top surface 406 is smooth enough to reduce damage to the condylar cartilage.

While referring to keel 404, in some embodiments, keel 404 extends to form a curved path between two points 428 and 430. Optionally, the first point 428 is located in proximity to an anterior end 422 of the implant. Optionally, the second point 430 is closer to a posterior end 424 of the

implant. In some embodiments, one of the points is closer to an implant end than the other point is closer to the opposite end, for example, as shown in FIG. 4B (point 430 is farther away from end 424 than point 428 is away from end 422). An exemplary distance (indicated by the double headed arrow) 432 between a point such as point 428 and a posterior or anterior end of the implant which is closer to that point (in this example, anterior end 422) ranges between, for example, 1-10 mm, such as 1 mm, 3 mm, 7 mm or intermediate, longer or shorter distances.

In some embodiments, the curved keel 404 features a radius of curvature 420 ranging between, for example, 5-30 mm, such as 6 mm, 10 mm, 25 mm or intermediate, larger or smaller radius. Optionally, the radius of curvature varies at different portion of the keel. Optionally, a central angle Θ defining the keel ranges between, for example, 30- 270 degrees, such as 60, 140, 250 degrees or intermediate, larger or smaller angles.

In some embodiments, a curved path of keel 404 partially surrounds a central point 434 defined by the implant, for example, encircling central point 434 by more than 100 degrees, more than 120 degrees, more than 160 degrees, more than 190 degrees, or intermediate, larger or smaller angles. Optionally, central point 434 is located in the middle of length 410, which extends across the anterior and posterior ends of the implant. Additionally or alternatively, for example, in cases in which the curved path of keel 404 is an arc, central point 434 is the center of a circle 436 which the arc is a part of.

In some embodiments, a width (indicated by the double headed arrow) 418 of keel 404 ranges between, for example, 1.5-2mm, 0.5-3 mm, 1-4 mm or intermediate, larger or smaller ranges. Optionally, keel 404 tapers in a distal direction, for example, as shown in figures hereinbelow.

In some embodiments, most of keel 404 such as 60%, 75%, 80% of the keel extends along an anterior half of length 410. Optionally, keel 404 is not centered with respect to length 410, for example, being closer to the anterior end of the implant 422.

In some embodiments, keel 404 is closer to radially outward facing back wall 412 of the implant (facing a medial direction) than to radially inward wall 414 (facing a lateral direction), for example, located at a distance (indicated by the double headed arrow) 416 smaller than 8 mm, smaller than 5 mm, smaller than 3 mm or intermediate, larger or smaller distances from back wall 412. Optionally, distance 416 is selected to be large enough to keep the keel away from the periphery of the tibial plateau.

A potential advantage of a keel positioned offset from a center of the implant, for example, with respect to an anterior-posterior axis and/or with respect to a transverse and/or longitudinal axis

of the implant may include a better distribution of the stress, reducing a stress rising effect of the keel.

In some embodiments, implant 400 is inflatable. Optionally, the implant's body, for example, a lumen between the top and bottom surfaces, is filled with a filler material such as "Bionate® PCU" biomedical polymer, silicon rubber, polyurethane, and/or TPU. Optionally, the filler material includes metal and/or polymer, such as PMMA. Additionally or alternatively, implant 400 is inflated with fluid. In some cases, a composition of the filler material is selected to increase the shock absorbance capabilities of the implant.

In some embodiments, one or more portions of the implant, such as back wall 412 are adjustable, for example, adjustable in height. Optionally, back wall 412 and/or inner wall 414 are formed of an elastic material, such as "Bionate® PCU" biomedical polymer, silicon rubber, polyurethane, and/or TPU, that is stretched when implant 400 is inflated. Additionally or alternatively, for example, as further shown herein, wall 414 and/or wall 412 are formed with a plurality of ribs, which can be expanded or compressed, having an accordion like configuration. In some embodiments, inflation of one of the walls 414 or 412 produces a slope at the top surface. In an example, back wall 412 is increased in height more than inner wall 412, shaping an implant with a thickness that decreases in the radially inward direction.

In some embodiments, implant 400 includes one or more openings 426. Optionally, filler material is injected into the implant's body through opening 426. Additionally or alternatively, maneuvering of implant 400 is performed using opening 426, for example, by attaching a handle to the opening. In some embodiments, opening 426 is formed in an anterior horn of the implant. Additionally or alternatively, opening 426 is formed in a posterior horn of the implant. In some embodiments, opening 426 extends to form a channel within the implant's body. Optionally, the channel extends a certain distance within the implant's body. In an example, the channel extends between the posterior and anterior ends of the implant. Additionally or alternatively, a channel extends along a transverse axis of the implant.

In some embodiments, when referring to a transverse cross section of the implant, anterior end 422 and/or posterior end 424 feature a blunt rounded profile, for example, as shown in this figure. Alternatively, for example, in cases in which the implant is crescent shaped, anterior end 422 and/or posterior end 424 define a horn which is the intersecting point between the inner and outer arcs of the implant, which are observed at a cross section of the inner wall and the back wall respectively.

FIGs. 5A - 5B show two exemplary configurations, at a cross section, of an exemplary meniscus implant 500 anchored to the tibia 502, according to some embodiments of the invention.

In some embodiments, for example, as shown in FIG. 5A, keel 504 extends distally from implant 500, penetrating a distance into tibia 502. Optionally, a length (indicated by the double headed arrow) 506 of keel 504 ranges between, for example, 1-6 mm, such as 2 mm, 4mm, 5 mm, intermediate, larger or smaller lengths. In some embodiments, keel 504 tapers in the distal direction, optionally including a sharp distal tip 508. Alternatively, distal tip 508 is blunt. In some embodiments, a tapering angle A ranges between, for example, 10-80 degrees. Optionally, keel 504 tapers symmetrically with respect to a central longitudinal axis 510 of the keel, having a tapering angle B at a first medial side of distal tip 508 that is equal A/2. Alternatively, the keel is asymmetrical, having an angle B that is equal to, for example, A/4, A/3, A/5. In some cases, the relationship between the angles affects the way forces are distributed by the keel. For example, if angle B is smaller than remaining angle (A minus B) there may be increased compaction of bone by the keel at the lateral side of distal tip 508 as compared to the medial side of distal tip 508. Optionally, this reduces the risk of damaging tibial bone closer to the exterior, medial facing portion of the bone. In some embodiments, angle B is small enough to increase a resistance against a force 532 which may act in a radially outward direction, and may cause the implant to move in a medial and proximal direction which may pull the keel out of the tibia.

A potential advantage of a keel tapering in the distal direction may include facilitating penetration of the keel into the tibia. Another potential advantage may include accelerating osseointegration due to the compaction of bone tissue by the keel.

Alternatively, keel 504 tapers in an opposite direction, narrowing towards a proximal end of the keel which is attached to bottom surface 512.

Alternatively, keel 504 does not taper, having a constant cross section profile, for example, a rectangular cross section profile.

In some embodiments, keel 504 is positioned such that the central axis 510 of the keel is located a distance (indicated by the double headed arrow) 514 from a back wall 516 of implant 500. Optionally, distance 514 ranges between, for example, 10%, 30%, 50%, 80%, 90% or intermediate, larger or smaller percentages of width (indicated by the double headed arrow) 528, which extends between back wall 516 (which faces a medial direction) and inner wall 530 (which faces a lateral direction).

In some embodiments, one or more walls of keel 504, such as wall 510, may be substantially perpendicular to bottom surface 512.

In some embodiments, implant 500 is positioned on the tibial plateau 518 such that bottom surface 512 fully contacts the bone surface. Alternatively, one or more portions of the implant such as back portion 520 and/or inner portion 522 (for example, on opposite sides of the keel) are slightly elevated from the tibial plateau 518, for example, as shown in this figure. In some cases, gaps 524 and 526 (corresponding with the back and inner portions) are reduced following implantation, for example, as bone tissue grows and fills the gaps. Over time, gaps 524 and 526 may be completely filled with bone tissue.

In some embodiments, implant 500 is strongly attached to the tibia, such as by keel 504, so that even during articulation of the joint, no movement of at least the bottom surface of the implant with respect to the tibial plateau is made possible. A potential advantage of reducing movement may include reducing pain, such as during articulation of the knee joint.

In some embodiments, for example, as shown in FIG. 5B, implant 500 includes an extension 534, extending from example in a distal direction at a location of inner wall 530. In some embodiments, extension 534 is tapered, such as for penetrating through tibial plateau 518. In some embodiments, extension 534 is formed as a continuation of inclined top surface 536. In some embodiments, a continuous extension 534 occupies a space that may form between bottom surface 512 and tibial plateau 518, thereby potentially reducing a risk of tissue such as condylar cartilage tissue being caught between the implant and the tibia, for example, during articulation of the knee. Another potential advantage may include increasing a contact area between bottom surface 512 and tibial plateau 518.

FIGs. 6A - 6F illustrate various exemplary configurations of an exemplary anchoring section of a meniscus implant, according to some embodiments of the invention.

FIG. 6A shows a distal facing side of the meniscus implant 600, from which an arc shaped keel 602 projects distally.

In some embodiments, implant 600 includes one more pegs 604, for example, extending distally from the implant, at the anterior and/or posterior horns 606 and 608, respectively. Alternatively, one or more pegs are located at other locations, for example, closer to keel 602. In some embodiments, pegs 604 provide additional anchoring of the implant to the tibial plateau, for example, in addition to keel 602. Alternatively, the implant includes a set of pegs which anchor to the tibia, for example, instead of keel 602. When configured at horns 606 and/or 608, pegs 604 may anchor to one or more portions of the tibial plateau which are naturally elevated relative to the tibial plateau portion in which keel 602 is received. Optionally, by anchoring to the elevated portions, pegs 604 increase a contact area between the bottom surface of the implant and the tibia.

FIG. 6B shows a cross section of implant 600 at a location of exemplary peg 604, along line d-d' (indicated by the double headed arrow). In some embodiments, peg 604 is shaped as a sharp projection. Alternatively, peg 604 is shaped as a rod, a cone, or other configuration suitable for engaging the bone tissue. Optionally, a length of peg 604 is selected to provide an anchoring which is deep enough to maintain fixation of the implant, for example, at the anterior and/or posterior ends of the implant.

FIGs. 6C and 6D are cross sections of implant 600 showing exemplary keel configurations. In some embodiments, for example, as shown in FIG. 6C, keel 602 is formed with straight edges 610. Additionally or alternatively, for example, as shown in FIG. 6D, keel 602 is formed with beveled edges 610. In both configurations shown, keel 602 is continuous.

Alternatively, for example, as shown in FIG. 6E, keel 602 is non-continuous, for example, formed as a plurality of projections 612, such as 2, 4, 6, 10, 20 projections or intermediate, larger or smaller number of projections. Optionally, the projections differ in size, for example, in length, and/or shape. In some embodiments, the plurality of projections are arranged to form an arc shape. Various embodiments may include projections of different shape profiles, for example, having a trapezoidal profile, such as shown herein, a rectangular profile, a triangular profile, or others. Optionally, a distance (indicated by the double headed arrow) 614 between the projections ranges between, for example, 0.1-3 mm, such as 0.5 mm, 1.5 mm, 2.7 mm or intermediate, larger or smaller distances.

FIG. 6F shows an anchoring section 616 formed of a plurality of segments, for example, 2, 3, 5, 8, 10 segments or intermediate, larger or smaller number. Optionally, the segments are arranged with respect to each other to partially encircle a theoretical center point 618 of the implant. In the example shown herein, three segments are arranged in a substantially trapezoidal outline. In some embodiments, a segment is a straight line. Alternatively, a segment is curved.

FIG. 7 shows an exemplary meniscus implant 700 featuring a half ellipsoid shape. In some embodiments, a keel 702 is configured to project from a bottom surface of the implant.

In some embodiments, a maximal width (indicated by the double headed arrow) 704 of the half ellipsoid implant 700 is large enough so that the implant engages a surface area of at least 30 %, at least 25%, at least 40% or intermediate, larger or smaller percentages of the tibial plateau. Optionally, most of the implant is positioned on a medial half of the tibial plateau. In a configuration for example, as described herein, implant 700 may provide both a meniscal function, for example, by an implant portion 710 closer to a curved edge 706 of the half-ellipsoid, facing a medial direction, and a tibial plateau reshaping function, for example, by an implant portion 712 (on an opposite side of the dashed line 714) closer to the straight edge 708 of the half ellipsoid, facing a lateral direction.

Portion 710 may be located closer to the rim of the tibial plateau, while portion 712 may be closer to the center of the knee joint.

A potential advantage of an implant covering a relatively large surface area of the tibial plateau may include reducing the risk of damaging the femoral condyle cartilage, for example, by reducing a number of locations in which loose cartilage portions may get trapped under the implant, potentially causing a tear in the cartilage.

In some embodiments, most of the anchoring section such as 60%, 70%, 90%, 95% or intermediate, larger or smaller percentages of a transverse cross section area of keel 702 (indicated by the line texturing) is configured under meniscal portion 710. Optionally, in some embodiments, the remaining portion of the keel is configured under portion 712 of the implant. In an example, as shown in this figure, the whole cross section area of the keel is configured under meniscal portion 710.

In some embodiments, the anchoring section is formed of a plurality of structural elements, for example, including a set of distally extending projections, a keel and one or more pegs, and/or any other structural elements suitable for anchoring into the tibia or combination thereof. Optionally, the structural elements are positioned under meniscal portion 710. Alternatively, the structural elements are positioned under central portion 712. Alternatively, the structural elements are distributed under both portions 712 and 710.

FIGs. 8A - 8C illustrate an exemplary mechanism including a plurality of adjusting elements for shaping and/or sizing a meniscus implant, according to some embodiments of the invention.

In some embodiments, implant 800 includes one more adjusting elements, adapted for changing a shape and/or size of the implant, for example, during the implantation procedure. In some embodiments, an adjusting element is a screw 802.

In an exemplary mechanism, a thickness of the implant, determined by one or more distances between top surface 804 and bottom surface 806, is adjusted by tapping one or more screws 802 into holes 808 in the implant. In some embodiments, a plurality of holes 808 adapted to receive screws 802 are peripherally arranged along back wall 810 of the implant. Optionally, screws 802 and holes 808 are formed with matching male and female threads. In some embodiments, a hole 808 tapers in a radially inwards direction, for example, as shown in FIG. 8B, and tapping of screw 802 increases an angle γ between top surface 804 and bottom surface 806, thereby increasing a thickness of the implant along at least a portion of the implant, for example, along back wall 810. In some embodiments, a distance between top surface 804 and bottom surface 806 decreases in a radially inwards direction, forming a slope. In some embodiments, the size of angle γ

is a function of the extent in which screw 802 is threaded within hole 808. For example, advancing screw 802 deeper within hole 808 enlarges angle γ.

Additionally or alternatively, in some embodiments, one or more screws and respective holes are arranged along inner wall 812. Optionally, threading of screws at inner wall 812 increases a thickness of the implant at a portion close to inner wall 812.

In some embodiments, for example, as shown in FIG. 8C, back wall 810 is formed with a slit 824, for example, extending between the anterior and posterior ends of the implant. Optionally, slit 824 allows for increasing and/or decreasing a height of back wall 810, to change a height of at least a portion of top surface 804. In some embodiments, a thickness of slit 824 is increased by threading one or more screws 802 into their respective holes 808. In some embodiments, one or more elastic elements, such as springs, may be positioned within slit 824, extending between proximal and distal portions of back wall 810 on both sides of the slit. Optionally, the elastic elements restrict the expansion of slit 824, thereby limiting a height of back wall 810.

In some embodiments, a working channel 814 passing within the implant's body interconnects between the plurality of holes 808. Optionally, access to working channel 814 is provided through opening 816 and/or opening 818, for example, configured in proximity to the anterior 820 and posterior 822 horns respectively. In some embodiments, a lumen of working channel 814 is large enough to enable passing a tool through, for example, a wire such as a nitinol wire. Optionally, the wire is used for securing the implant to the bone.

In some embodiments, screws 802 are arranged to distort a shape of implant, for example, by moving the anterior horn 820 and posterior horn 822 closer or further apart from each other.

Additionally or alternatively, adjusting elements different than screws can be used, for example, other fixation devices such as pins, clips or the like.

FIGs. 9A - 9C illustrate an exemplary meniscus implant 920 including a single hole and screw for shaping and/or sizing the implant, according to some embodiments of the invention. Optionally, screw 900 and matching hole 902 are located, for example, at a center point of back wall 904. As shown in the cross section of FIG. 9B, hole 902 may intersect with working channel 906.

FIG. 9C shows an example in which a wire 908 is passed through the implant, for example, passed within a circumferential slot 914 extending along back wall 904, and is advanced and/or rotated to change a height of back wall 904. In some embodiments, wire 908 includes one or more projections 910 which are suitable for pushing against matching projections 912 fitted within slot 914, for example, upon rotation of the wire. Additionally or alternatively, wire 908 is advanced within slot 914 to increase a height of back wall 904 by gradually forcing projections 912 in a proximal direction.

In some embodiments, a pin or screw 916 is coupled to an end of wire 908. Optionally, screw 916 is threaded to cause rotation and/or advancement of wire 908. In some embodiments, the implant is rigid enough so that other than the adjusted portion, such as the back wall of the implant, the implant does not deform in response to rotation and/or advancement of the wire.

FIGs. 10A - 10B illustrate on exemplary mechanism for shaping an exemplary meniscus implant 1000 by injecting filler material, according to some embodiments of the invention. In some embodiments, for example, as shown at the cross section along line AA' (FIG. 10A) shown in FIG. 10B, a lumen between top surface 1002 and bottom surface 1004 of the implant is filled with a filler material 1008, such as PMMA, silicon based glue or elastomer, implant grade epoxy. In some embodiments, the material is injected through one or more openings 1006.

In some embodiments, the injected filler material 1008 changes a shape and/or size of the implant, for example, inflating the implant so that top surface 1002 and/or bottom surface 1004 are pushed further apart from each other.

In some embodiments, the implant is formed with one or more compartments 1010 that receive the filler material. Optionally, the compartments are separated, for example, by an internal wall (indicated by the dashed lines) 1012 or other barrier, so that a portion of the implant is inflated by the material, while another portion is not inflated or is inflated to a reduced size. Optionally, by controlling the extent of inflation at different portions of the implant, the implant is adjusted to fit a morphology of the joint. In some embodiments, a curvature of top surface 1002 is set by inflating only some compartments, such as compartment 1014.

In some embodiments, an amount and/or type of filler material used for inflating the implant are selected according to one or more parameters such as a desired size of the implant, wear resistance of the filler material, shock absorbance abilities of the material, and/or other parameters. In some cases, factors such as the patient's age, the patient's medical history, the patient's exercise habits, and/or other parameters are taken into consideration when selecting a type and/or amount of filler material for the implant.

FIGs. 11A - 11D show a back view of an exemplary meniscus implant before and after inflation (FIGs. 11A - 11B), and graphs indicating an exemplary distance of a top surface of the implant from the tibial plateau before, before, during and/or after inflation (FIGs. 11C - 11D), according to some embodiments of the invention.

In some embodiments, one or more walls of the meniscus implant such as back wall 1100 are formed with a geometry suitable for expanding and contracting the wall, for example, for

adjusting a thickness of the implant. In some embodiments, back wall 1100 is defined by a plurality of ribs 1102 folded in an accordion like configuration.

In some embodiments, a height 1104 of wall 1100 is adjusted, for example, increased, by inflating the implant. For example, height 1104 may range between 2-4 mm, such as 2 mm, 3 mm, 3.7 mm or intermediate, larger or smaller height in a non-inflated state, for example, as shown in FIG. 11A, and 4- 10 mm, such as 5 mm, 7 mm, 9 mm or intermediate, larger or smaller height in an inflated state, for example, as shown in FIG. 11B. Optionally, inflation is achieved by injecting filler material and/or by using adjustment elements for example, as described hereinabove. Optionally, during inflation, ribs 1102 move further apart from each other, increasing height 1104.

Additionally or alternatively, back wall 1100 is formed of an elastic material such as silicon, and/or Bionate ® PCU medical polymer that can be stretched by inflation of the implant.

The graphs shown in FIGs. 11C - 11D show exemplary distances of a top surface 1106 of the implant from the tibial plateau at various stages of the inflation process, with respect to the back wall and inner wall of the implant, between which the top surface extends. It is noted that the tibial plateau is not necessarily planar, and may feature an irregular topography, but is referred to as planar for clarification purposes.

In the example of FIG. 11C, at the initiation of the inflation process, marked as stage 1, top surface 1106 is substantially parallel to the tibial plateau, and is located at a relatively short distance from the tibial plateau. Optionally, in this collapsed configuration, the implant occupies a small volume due to its reduced height. At stage 2, for example, at the end of the inflation process, a distance of top surface 1106 from the tibial plateau is largest at the back wall end of the surface, and smallest at the inner wall end of the surface, forming a slope. An exemplary distance of top surface 1106 at the collapsed state may range between, for example, 2-4 mm, and at the inflated configuration between, for example, 4-8 mm.

In the example of FIG. 11D, at the initiation of the inflation process, marked as stage 1, top surface 1106 is substantially parallel to the tibial plateau, and is located at a relatively short distance from the tibial plateau. In stage 2, only some portions of top surface 1106 are lifted, forming a curvy topography of the surface, for example, featuring convex and/or concave curvature. A curvy layout of the top surface may be obtained, for example, by selectively injecting filler material into one or more compartments defined within the implant's body, and/or by adjusting a shape of the implant using only a portion of the adjusting elements, for example, threading only some of the screws into their matching holes to raise at least a portion of the top surface.

FIG. 12 is a flowchart of an exemplary preparation method before implanting a meniscus implant, according to some embodiments of the invention.

In some embodiments, one or more ports are created in the knee (1200). Optionally, a port is created for introducing a gauge (1202) into the knee joint. In some cases, the implant is later introduced through the gauge's port. Alternatively, an additional port is created for insertion of the implant.

In some embodiments, the gauge is used for determining one or more dimensions in the joint (1204), for example, a size of a tibial plateau surface area (e.g. a diameter), a space between the femoral condyle and the tibia, a shape and/or size of the femoral condyle, an radius of curvature of a periphery of the tibia, and/or other shapes and/or dimensions according to which the meniscus implant is selected.

In some embodiments, the gauge is a dummy implant, for example, as further described herein. Alternatively, the gauge is any tool suitable for assessing the one or more dimensions, for example, using a tool including a scale with distance markings that can be viewed, for example, with the aid of an arthroscope. In some embodiments, a depth gauge is used, including for example, a wire formed with markings that is introduced to the knee joint, for estimating various dimensions such as a substantial diameter of the tibial plateau. Additionally or alternatively, in some embodiments, one or more dimensions are assessed by imaging the knee joint, for example, using CT or MRI. Additionally or alternatively, a template having a shape of the meniscus is introduced to the knee joint. Optionally, the template is flat enough to be introduced via a small, optionally transverse port in the knee.

In some embodiments, a groove is formed in the tibial plateau. Optionally, the groove is shaped and/or sized to receive an anchoring section of the implant, for example, shaped as a crescent. In some embodiments, the groove is produced by compressing a dummy implant against the tibial plateau. Optionally, the knee is extended to apply compression force on the dummy implant, to form the groove. Additionally or alternatively, a burr is used to carve the groove.

FIGs. 13A - 13G are a set of drawings of an exemplary method for implanting a meniscus implant, according to some embodiments of the invention.

FIGs. 13A and 13B show a meniscus template 1300 introduced to the joint, for example, using a handle 1302. In some embodiments, the template includes a recess 1304. Optionally, recess 1304 is shaped according to a shape of the anchoring section of the implant.

In some embodiments, template 1300 is positioned at a location in which the meniscus implant is intended to be positioned. Optionally, during positioning, template 1300 is held at a slightly

elevated position from the tibial plateau 1308, to enable moving the template freely. In some embodiments, when the location is set, template 1300 is temporarily anchored to the tibia, for example, by passing a kirschner wire through one or more holes 1306 in the template. Optionally, holes 1306 are configured on an extra-articular extension 1318 of the template 1300, and template 1300 is attached to bone surface outside the joint.

In some cases, if the template does not fit, the template is removed and one or more different sized templates are introduced to the knee joint, until the template matches the joint dimensions.

In some embodiments, by pressing template 1300 onto tibial plateau 1308, a groove 1310 is formed, for example, as shown in FIG. 13C. Optionally, the produced groove matches a shape of recess 1304 of the template. Optionally, template 1300 stamps the surface of the tibia when it is compressed against it, for example, by the femur applying force onto the template during extending of the knee, as the femur and tibia are aligned with respect to each other. Additionally or alternatively, force is applied to template 1300 by a tool such as an inflated balloon. Optionally, extending of the knee moves template 1300 to a position in which it better imitates a position of a natural meniscus.

In some embodiments, template 1300 is removed, and meniscus implant 1312 is introduced to the joint, for example, as shown in FIG. 13D. Alternatively, the implant is inserted over template 1300, for example, seated above template, and then the template is removed. Additionally or alternatively, a dummy implant is inserted before permanent or semi permanent implant 1312 is introduced.

In some embodiments, implant 1312 is delivered and/or maneuvered using a handle 1314, for example, attached to the posterior or anterior horn of the implant.

In some embodiments, at least a portion of an anchoring section 1316 of implant 1312 is received within groove 1310. Optionally, 5%, 10%, 30%, 70% or intermediate, larger or smaller percentages of a height of a keel shaped anchoring section 1316 are received within the groove.

Optionally, during positioning of the implant, one or more wires and/or screws and/or other elements suitable for temporarily fixating the implant to the bone are used.

In some embodiments, once the implant is attached to the tibial plateau 1308, handle 1314 is removed, for example, as shown in FIG. 13F.

In some embodiments, for example, as shown in FIG. 13G, the knee is extended to align the tibia 1318 with respect to the femur 1320. In some cases, during and/or following extending of the knee, compression force 1324 is applied by femoral condyle 1322 onto implant 1314. In some cases,

the force is applied onto top surface 1326 of the implant, and is transferred by the implant's body toward the anchoring section 1316. Optionally, the force is strong enough to push the keel 1316 into the tibia 1318 or further deepen an anchoring of the keel in the tibia.

In some cases, extending of the knee moves the implant to a location of the natural meniscus, for example, moving the implant towards a center of the joint, moving the implant in an external direction, moving the implant in an anterior direction, moving the implant in a posterior direction and/or any other directions.

FIGs. 14A - 14B show an exemplary burring template (FIG. 14A) and an exemplary groove template (FIG. 14B), according to some embodiments of the invention.

In some embodiments, a burring template 1400 is introduced to the knee joint, for example, before insertion of the implant. Optionally, the tibial plateau area surrounded by burring template 1400 is treated, for example, by removing soft tissue from the surface and/or by exposing subchondral bone tissue. Optionally, the removed tissue is washed out of the joint by an irrigation system or the like.

In some embodiments, a shape of burring template 1400 matches a contour of the meniscus implant, for example, shaped as a crescent. Alternatively, other shapes could be used, for example, a half ellipsoid. Optionally, burring template 1400 defines a surface area on the tibial plateau that is larger than the implant itself, so that surface portions adjacent the implant would be treated as well.

In some embodiments, a groove template 1402 is introduced to the knee joint. Optionally, groove template 1402 includes one or more recesses 1404 for producing a groove in the tibial plateau, for example, in which an anchoring such as an arc shaped keel can be received. Additionally or alternatively, template 1402 includes one or more recesses 1406 for producing a dent in the tibial plateau, for example, in which a peg can be received. In an example, two recesses having a circular profile are configured at the posterior and anterior horns of the implant.

FIGs. 15A - 15C illustrate an exemplary dummy meniscus implant 1500, according to some embodiments of the invention. FIGs. 15A and 15B show exemplary dummy implants, and FIG. 15C shows an exemplary dummy implant positioned inside a knee joint at a location of a medial meniscus, according to some embodiments of the invention.

In some embodiments, dummy implant 1500 is introduced to the knee joint before the meniscus implant. In some embodiments, dummy implant 1500 is configured for providing one or more markings for assessing a desired positioning of the meniscus implant. Additionally or alternatively, dummy implant 1500 is used for determining one or more dimensions of the meniscus

implant. In some cases, a plurality of dummy implants are inserted to the knee joint, one after the other, to identify the most suitable size and/or shape of the implant to be used.

In some embodiments, dummy implant 1500 is reduced in thickness relative to the meniscus implant, for example, having a thickness (indicated by the double headed arrow) 1502 ranging between 0.2-5 mm. Optionally, the dummy implant is insertable into the knee joint via a small, for example, transverse cut in the medial part of the knee.

In some embodiments, dummy implant 1500 is formed, at least in part, of a rigid, resilient material, for example, metal such as stainless steel, and/or polymers such as Acetal or PEEK. Additionally or alternatively, dummy implant 1500 is formed of more elastic materials, such as foam or elastomeric material.

In some embodiments, for example, as shown in FIG. 15A, dummy implant 1500 includes two layers: a rigid bottom layer 1504, for example, formed of metal, and a softer top layer 1506, for example, formed of foam. Alternatively, the bottom layer is soft, and the top layer is rigid.

In some cases, for example, when pressing the dummy implant against the tibial plateau 1510, (for example, as shown in FIG. 15C) bottom layer 1504 produces one or markings on the bone surface. Optionally, the markings indicate a location for positioning the meniscus implant, for example, after removal of the dummy implant from the knee. In some embodiments, top layer 1506 is formed of a material that is soft enough to reduce or prevent damage to the condylar cartilage.

In some embodiments, for example, as shown in FIG. 15B, dummy implant 1500 includes one or more bulges 1508, for example, protruding in a distal direction from a bottom surface of the implant. Optionally, the bulges stamp the tibial bone surface, marking a location for the meniscus implant, for example, producing a crescent shaped marking.

In some embodiments, dummy implant 1500 is deformable. Optionally, the dummy implant is shaped or reshaped, for example, inside the knee joint, to fit the anatomy of the joint. Optionally, the meniscus implant is shaped according to the dimensions of the adjusted dummy implant, for example, by using a mold.

FIGs. 16A - 16B are exemplary resurfacing patterns of a tibial plateau, according to some embodiments of the invention.

In some embodiments, for example, prior to implantation of the meniscus implant, the tibial plateau 1600 is treated. Optionally, treating includes resurfacing the bone.

In some embodiments, a crescent shaped pattern 1602, for example, as shown in FIG. 16A, is produced in the bone surface. Alternatively, a different pattern is produced in the bone surface, for example, a half ellipsoid 1604, such as shown in FIG. 16B. In some embodiments, the resurfacing is

performed at a bone region on which a natural meniscus was attached. Additionally or alternatively, the treated bone region is wider and extends towards a center of the joint. Additionally or alternatively, the treated bone region may include at least 60%, 70%, 90% or intermediate, larger or smaller percentage of the surface area of the tibial plateau.

In some embodiments, the resurfaced pattern is characterized by rounded edges and/or corners 1606. A potential advantage of rounded edges may include reducing erosion, such as erosion to the femur cartilage coming in contact with the tibial plateau. Another potential advantage may include reducing buckling of the bone by forming a continuous contact surface, for example, as opposed to local contact points which may cause stress risers and may reduce the stability of the implant.

In some embodiments, a depth of the recesses produced in the tibia is large enough to accommodate a large enough portion of the implant sufficient for keeping the implant in place. Optionally, deep recesses reduce the need of applying bone cement to the implant, such as to a bottom surface of the implant.

The terms "comprises", "comprising", "includes", "including", “having” and their conjugates mean "including but not limited to".

The term "consisting of" means "including and limited to".

The term "consisting essentially of" means that the composition, method or structure may include additional ingredients, steps and/or parts, but only if the additional ingredients, steps and/or parts do not materially alter the basic and novel characteristics of the claimed composition, method or structure.

As used herein, the singular form "a", "an" and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a compound" or "at least one compound" may include a plurality of compounds, including mixtures thereof.

Throughout this application, various embodiments of this invention may be presented in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the invention. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed subranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

Whenever a numerical range is indicated herein, it is meant to include any cited numeral (fractional or integral) within the indicated range. The phrases “ranging/ranges between” a first indicate number and a second indicate number and “ranging/ranges from” a first indicate number “to” a second indicate number are used herein interchangeably and are meant to include the first and second indicated numbers and all the fractional and integral numerals therebetween.

As used herein the term "method" refers to manners, means, techniques and procedures for accomplishing a given task including, but not limited to, those manners, means, techniques and procedures either known to, or readily developed from known manners, means, techniques and procedures by practitioners of the chemical, pharmacological, biological, biochemical and medical arts.

As used herein, the term "treating" includes abrogating, substantially inhibiting, slowing or reversing the progression of a condition, substantially ameliorating clinical or aesthetical symptoms of a condition or substantially preventing the appearance of clinical or aesthetical symptoms of a condition.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

WHAT IS CLAIMED IS:

1. A prosthetic meniscus implant for placement in the knee joint, the implant comprising:

a body comprising:

a top surface configured to face a proximal direction towards the femoral condyle;

a rigid bottom surface configured to face a distal direction towards the tibial plateau;

at least a portion shaped to provide at least one meniscal function, said portion including at least a part of said top surface; and

an anchoring section projecting distally from said bottom surface to fixate the implant to the tibia, wherein at least 60% of said anchoring section directly underlies, in the direction of the tibia, said portion providing meniscal function.

2. The implant according to claim 1, wherein a transverse section of said anchoring section defines a curved path between two points, a first point located in proximity to an anterior end of the implant and a second point located in proximity to a posterior end of the implant.

3. The implant according to claim 2, wherein said curved path is substantially arc shaped, said path extending to surround a center point of said arc by at least 120 degrees.

4. The implant according to claim 2, comprising a first peg for anchoring to the tibia, said first peg configured at said anterior end of the implant, and a second peg for anchoring to the tibia, configured at said posterior end of the implant.

5. The implant according to claim 1, wherein said anchoring section tapers in said distal direction.

6. The implant according to claim 1, wherein said bottom surface at said portion providing meniscal function defines a contact area with said tibial plateau that is shaped and sized according to a contact area of a natural meniscus with the tibial plateau.

7. The implant according to claim 1, wherein said meniscal function comprises effectively increasing a contact area between said femoral condyle and the tibial plateau.

8. The implant according to claim 1, wherein said meniscal function comprises distributing load acting on said tibial plateau by said femoral condyle.

9. The implant according to claim 1, wherein said meniscal function comprises stabilizing said femoral condyle with respect to said tibial plateau.

10. The implant according to claim 9, wherein said stabilizing is provided by an inclination of said top surface at said portion, said inclination defining a concavity in which the relatively rounded femoral condyle is received.

11. The implant according to claim 1, wherein a length of said anchoring section in said distal direction ranges between 1 and 6 mm.

12. The implant according to claim 1, wherein said top surface of the implant comprises a high quality surface finish.

13. The implant according to claim 1, wherein said bottom surface thereof comprises a porous material in which bone tissue grows, increasing osseointegration of the implant with said bone.

14. The implant according to claim 1, comprising one or more openings for at least one of coupling the implant to a delivering tool, and injecting filler material to a lumen of the implant between said top and bottom surfaces.

15. The implant according to claim 1, wherein said anchoring section is continuous.

16. The implant according to claim 1, wherein said anchoring section is non continuous.

17. The implant according to claim 1, shaped as a half ellipsoid, said meniscal providing portion extending along at least a portion of the curved periphery of the ellipsoid.

18. The implant according to claim 1, wherein said top surface thereof is rigid, and wherein said anchoring section is positioned below said bottom surface to receive force transferred from said rigid top surface through said body of the implant.

19. The implant according to claim 18, wherein said force is compression force applied onto said top surface of the implant from the proximal, femoral direction.

20. The implant according to claim 18, wherein said body thereof is rigid enough so that force is transferred by said body with less than 10% damping.

21. A medial meniscus implant for placement in the knee joint, the implant comprising:
a rigid top surface configured to face a proximal directions towards the femoral condyle; and
a bottom surface configured to face a distal direction towards the tibial plateau, said bottom surface rigid enough to hold an anchoring section, said anchoring section extending distally from said bottom surface to fixate the implant to the tibia;
wherein a geometry of the implant is adjustable.

22. The implant according to claim 21, wherein said geometry comprises a distance between said top and bottom surface, said distance adjustable at one or more locations between an outer wall of the implant, facing a medial direction, and an inner wall of the implant, facing a lateral direction.

23. The implant according to claim 22, comprising one or more screws positioned within one or more respective holes formed in the implant, wherein said screw is advancable into said hole to modify said distance between said top and bottom surfaces.

24. The implant according to claim 22, wherein said distance is adjusted by controlled injection of filler material into a lumen between said top and bottom surfaces.

25. The implant according to claim 24, wherein said lumen is divided into two or more compartments which are separately inflatable for selectively shaping said lumen.

26. The implant according to claim 21, comprising a channel extending between posterior and anterior ends of the implant, said channel sized to receive a tool.

27. The implant according to claims 24 and 26, wherein said filler material is injected through said channel.

28. The implant according to claim 22, wherein said outer wall of the implant facing a medial direction is expandable and compressible.

29. The implant according to claim 28, wherein said outer wall is higher than said inner wall, forming an inclination of said top surface of the implant.

30. The implant according to claim 21, comprising a collapsed state and an expanded state, and wherein in said expanded state of the implant said top surface is formed with topographic curvature.

31. A meniscus implant for placement in the knee joint, the implant comprising:
a metal top surface configured to face a proximal direction towards the femur;
a metal bottom surface configured to face a distal direction towards the tibia;
a lumen between said top and bottom surfaces; and
at least one opening defining access to said lumen, said opening providing for insertion of filler material into said lumen.

32. A prosthetic meniscus kit, the kit comprising:
a template for positioning between a femoral condyle and a tibial plateau, said template adjustable in at least one of shape and size; and
a prosthetic meniscus implant, wherein at least one of a shape, size and location of said implant in said joint are determined according to said template.

33. A method for implanting a meniscus implant in the knee joint, the method comprising:
creating one or more ports in the knee;

introducing, through said one or more ports, a meniscus implant having an anchoring section; and

extending the knee to apply compression force on said meniscus implant, causing said anchoring section to anchor into the tibia against sliding movement of said implant across said tibial plateau.

34. The method according to claim 33, wherein prior to introducing said meniscus implant, a gauge is inserted to the knee joint for at least one of determining one or more dimensions within the joint and for marking a location for said meniscus implant.

35. The method according to claim 34, wherein said gauge is a template shaped according to said meniscus implant.

36. The method according to claim 35, wherein said template comprises a recess shaped and sized according to an anchoring section of said meniscus implant, and wherein said method further comprises pressing said template against said tibial plateau to produce a groove in which at least a portion of said anchoring section is received.

37. The method according to claim 33, wherein prior to said introducing of said implant said method further comprises resurfacing one or more regions of said tibial plateau.

38. A method for implanting a meniscus implant in the knee joint, the method comprising:

creating one or more ports in the knee;

introducing, through said one or more ports, a template to be positioned between the tibial plateau and the femoral condyle;

determining, using said template, at least one of a location for positioning said meniscus implant, a size of said meniscus implant, and a shape of said meniscus implant;

removing said template; and

selecting and implanting said meniscus implant in the knee joint in accordance with one or more parameters determined using said template.

39. The method according to claim 38, wherein said method further comprises marking a location for positioning of said meniscus implant by compressing tissue on said tibial plateau using said template.

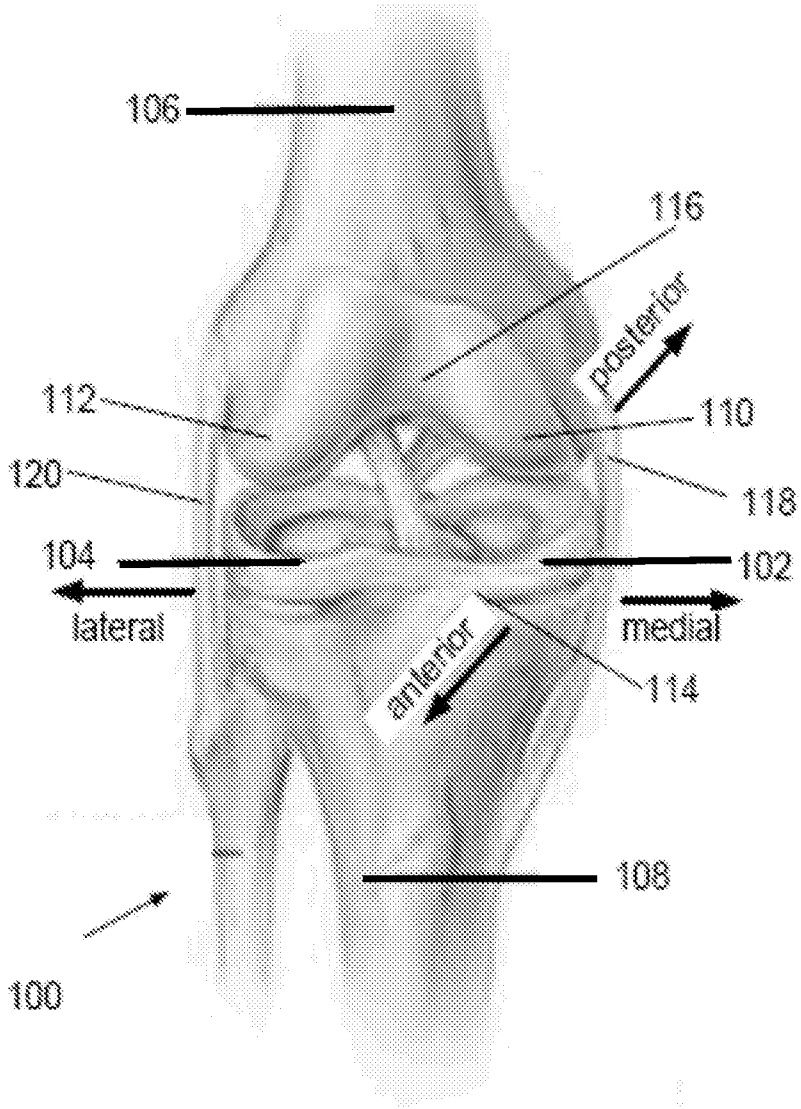

106
116
posterior
112
110
120
118
104
102
lateral
medial
anterior
114
108
100

FIG. 1

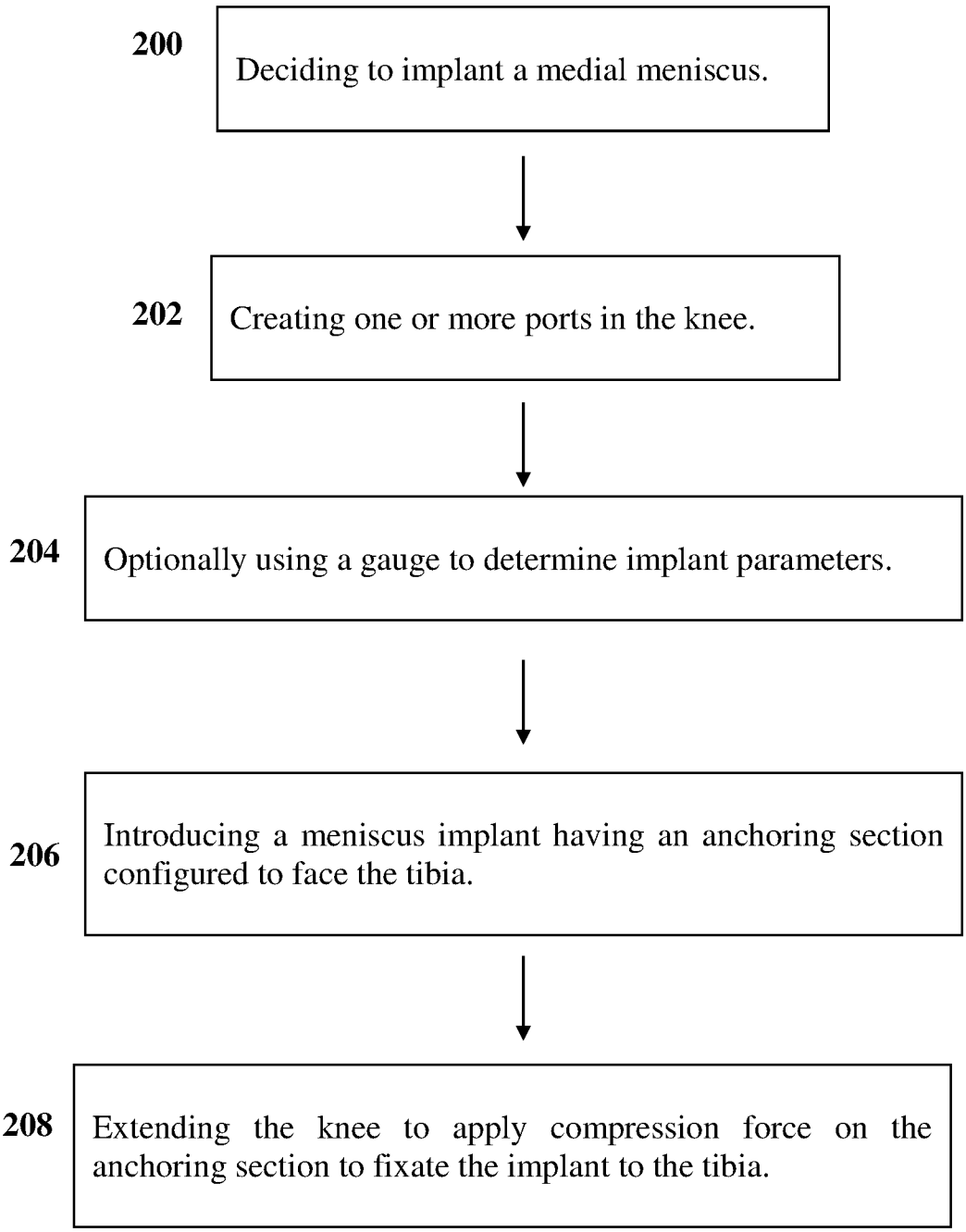

200
Deciding to implant a medial meniscus.
202
Creating one or more ports in the knee.
204
Optionally using a gauge to determine implant parameters.
206
Introducing a meniscus implant having an anchoring section configured to face the tibia.
208
Extending the knee to apply compression force on the anchoring section to fixate the implant to the tibia.

FIG. 2

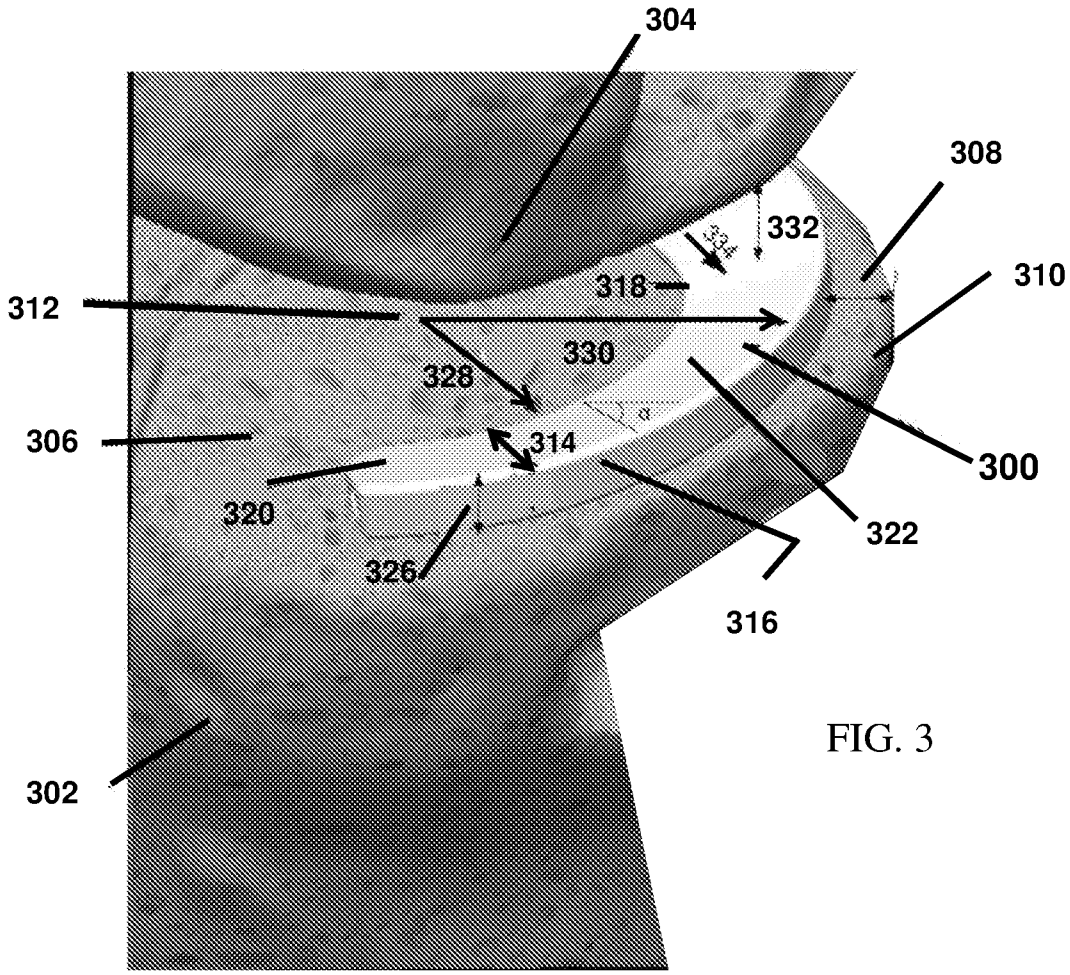


FIG. 3

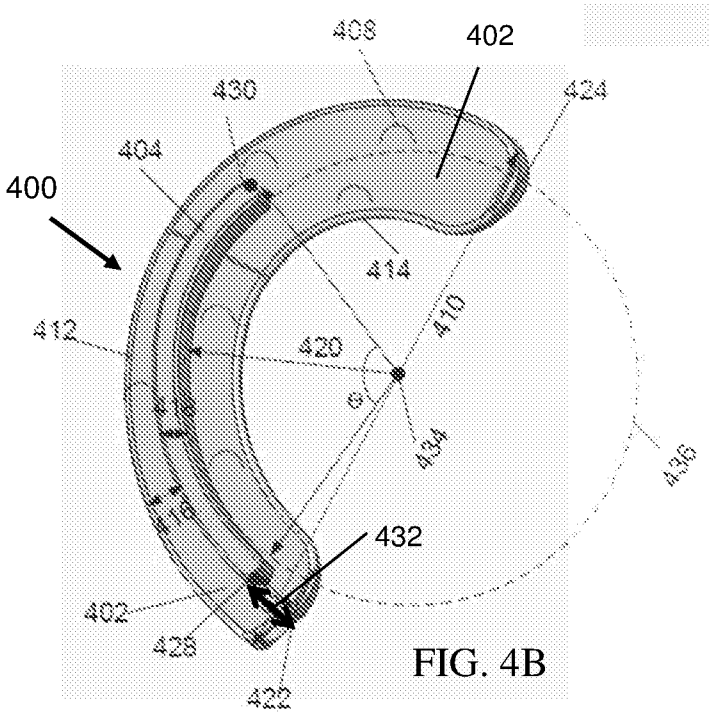


FIG. 4B

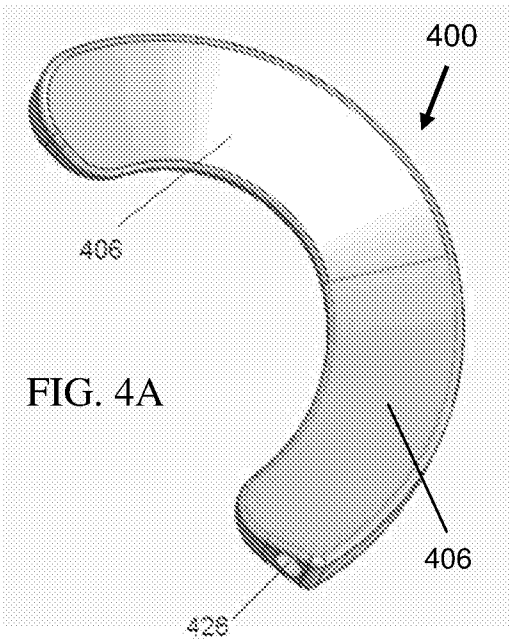


FIG. 4A

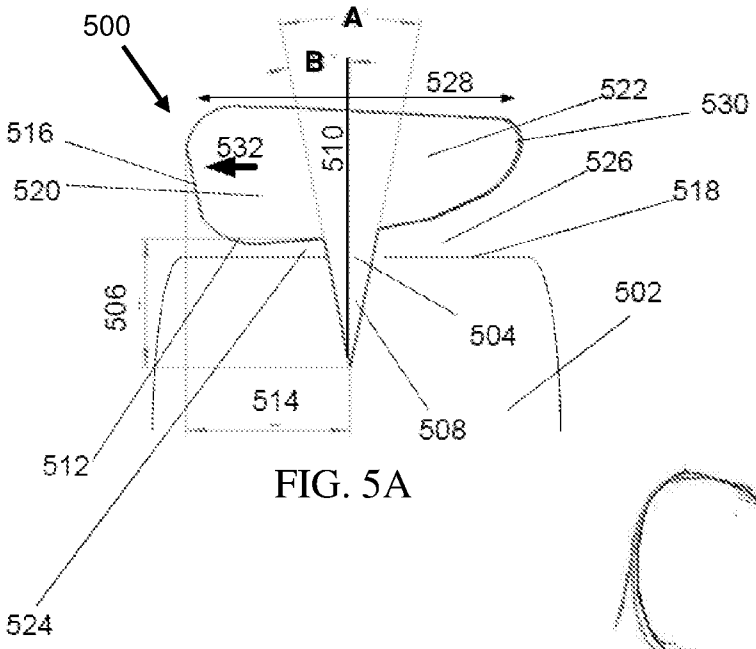
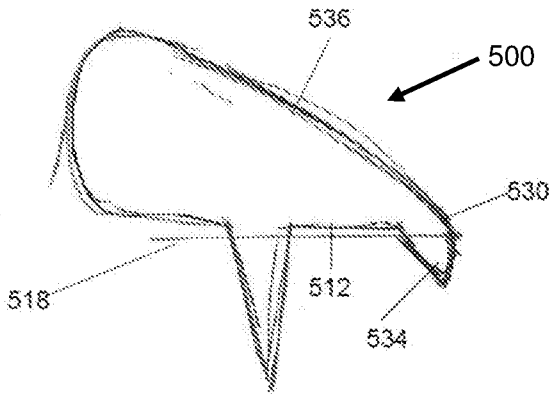


FIG. 5A

FIG. 5B



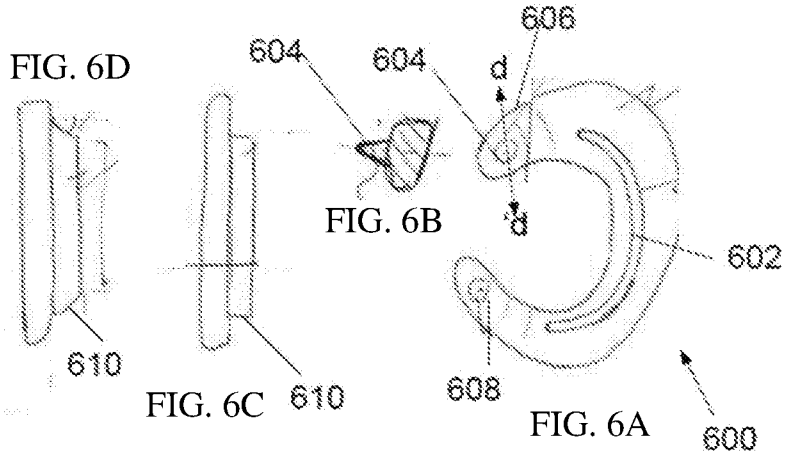


FIG. 6D

FIG. 6B

FIG. 6C

FIG. 6A

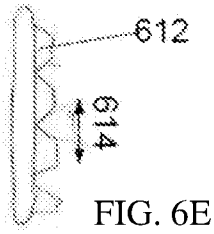


FIG. 6E

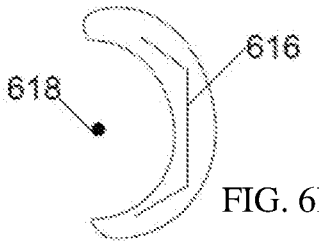
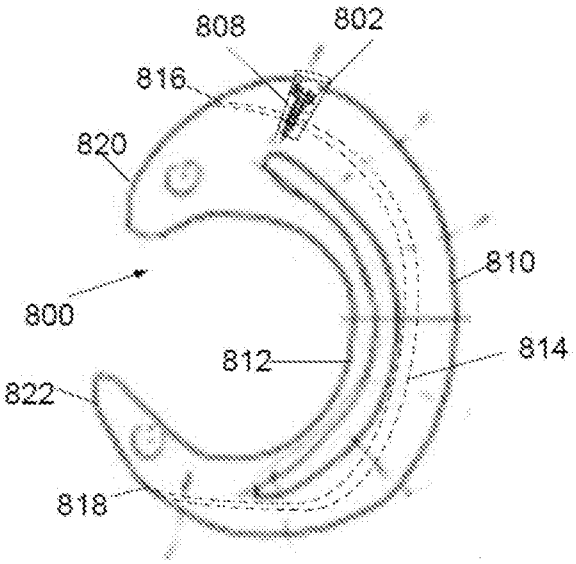


FIG. 6F

FIG. 8A



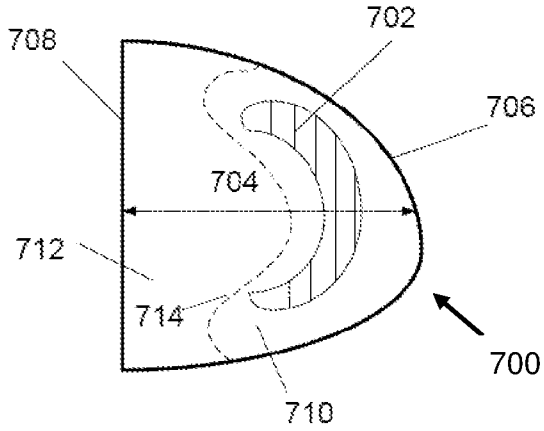


FIG. 7

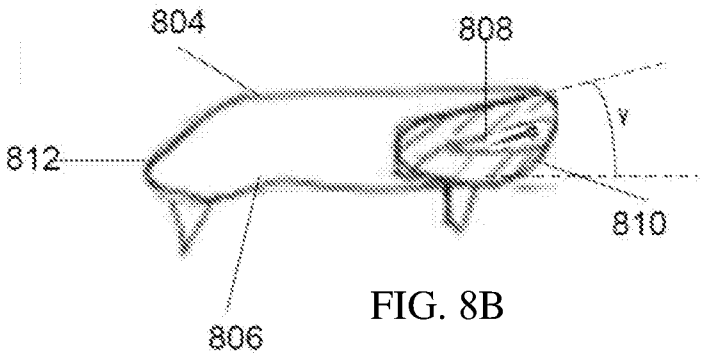


FIG. 8B

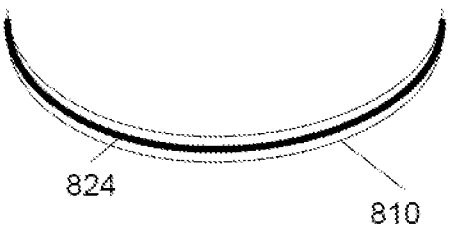


FIG. 8C

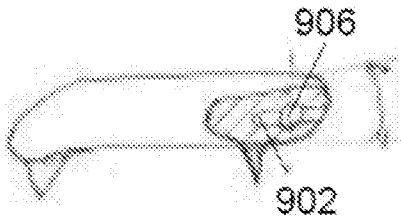


FIG. 9B

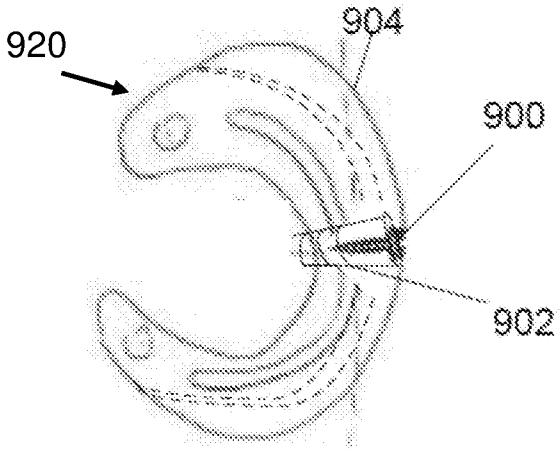


FIG. 9A

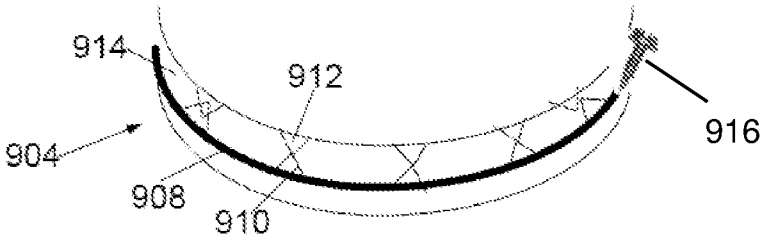


FIG. 9C

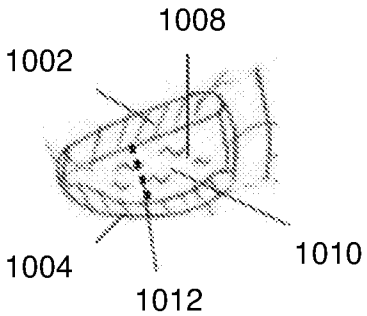


FIG. 10B

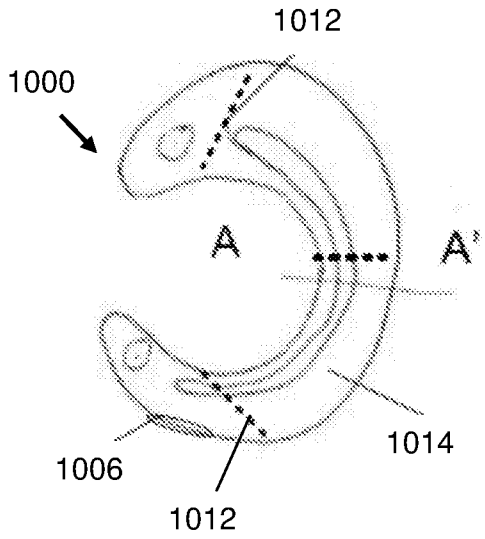


FIG. 10A

FIG. 11A

FIG. 11B

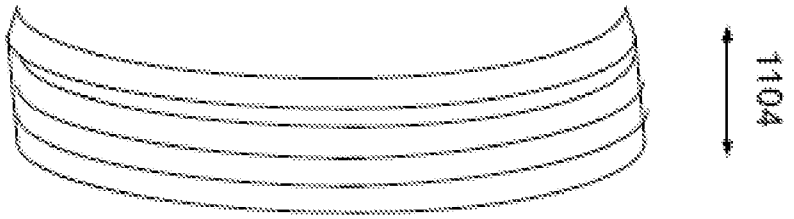


FIG. 11C

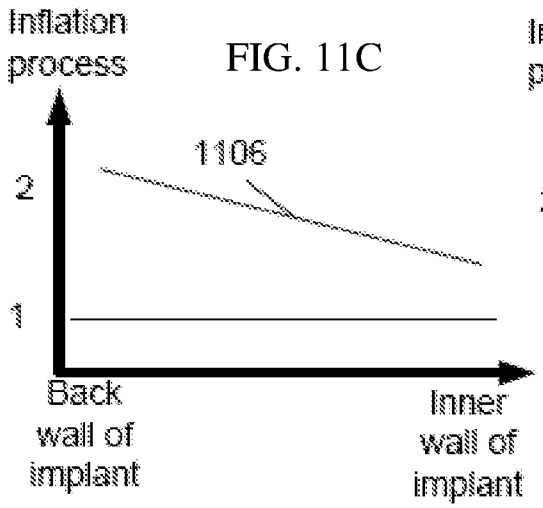
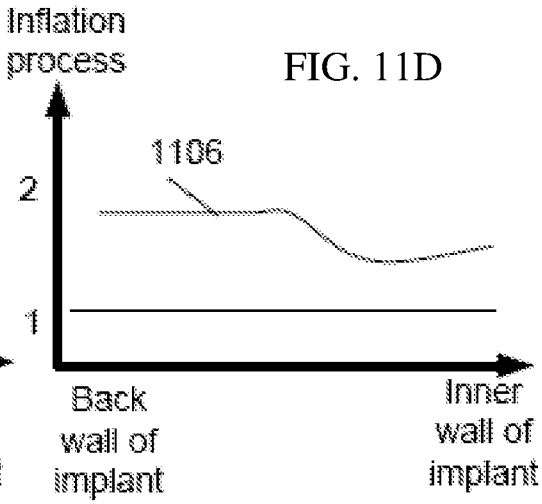


FIG. 11D



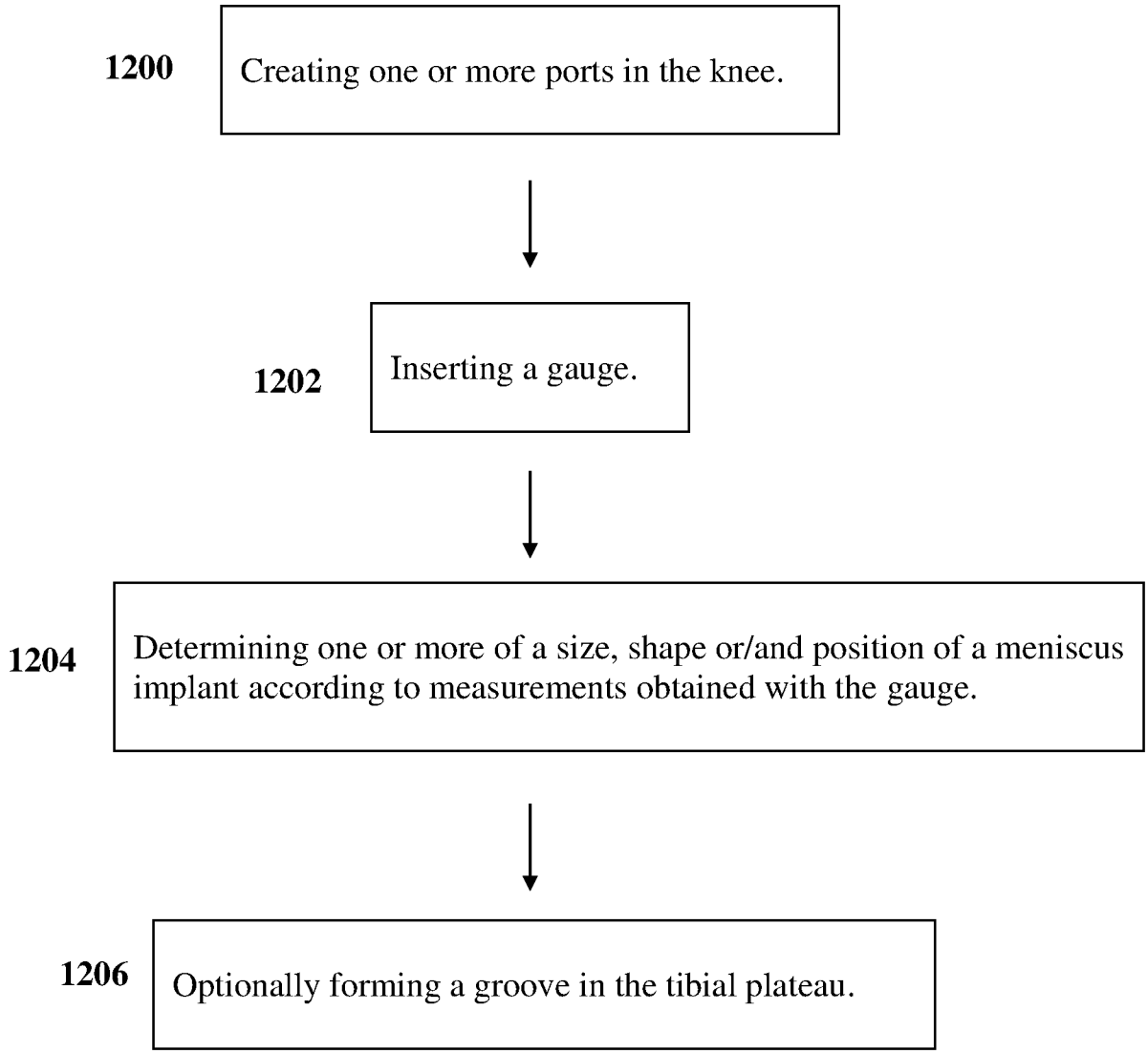

1200
Creating one or more ports in the knee.
1202
Inserting a gauge.
1204
Determining one or more of a size, shape or/and position of a meniscus implant according to measurements obtained with the gauge.
1206
Optionally forming a groove in the tibial plateau.

FIG. 12

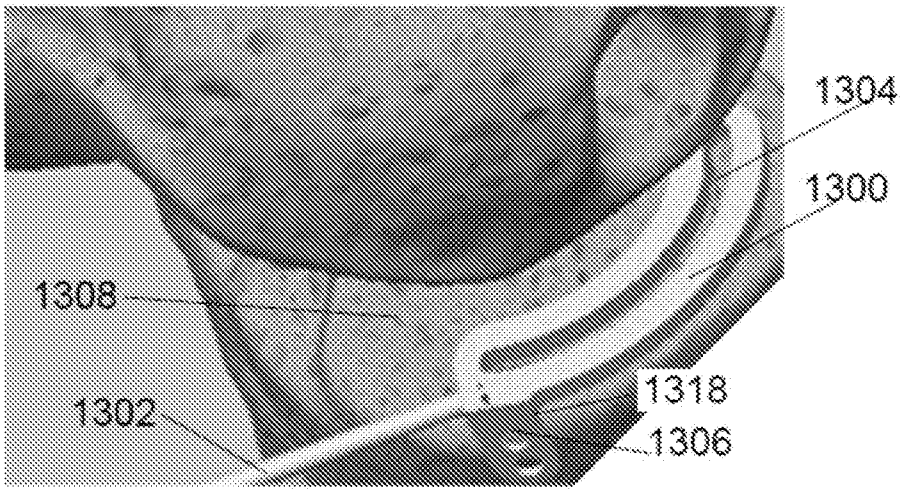


FIG. 13A

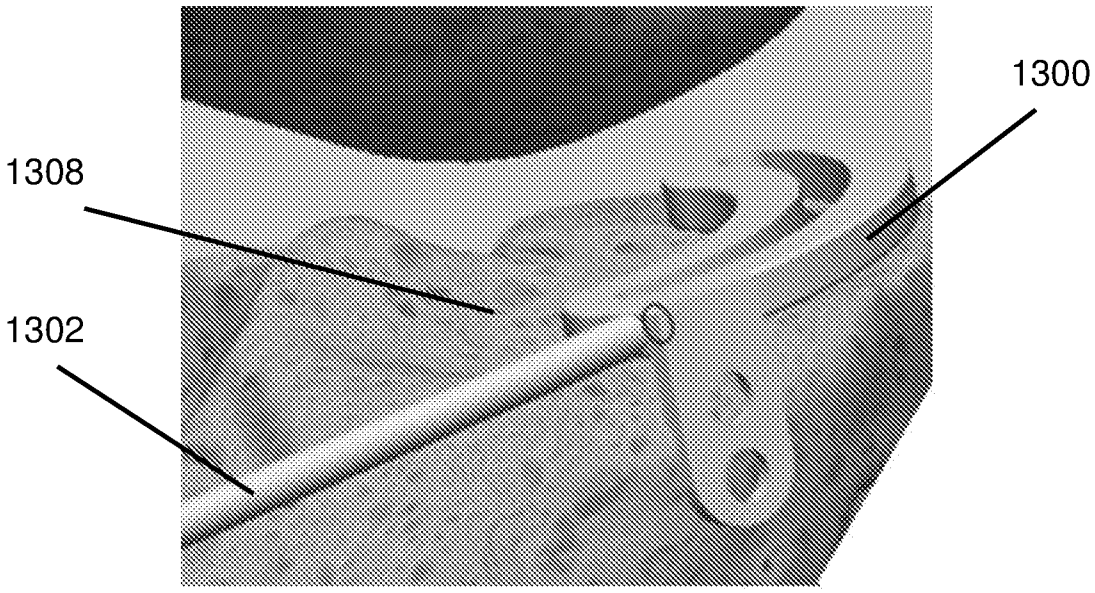


FIG. 13B

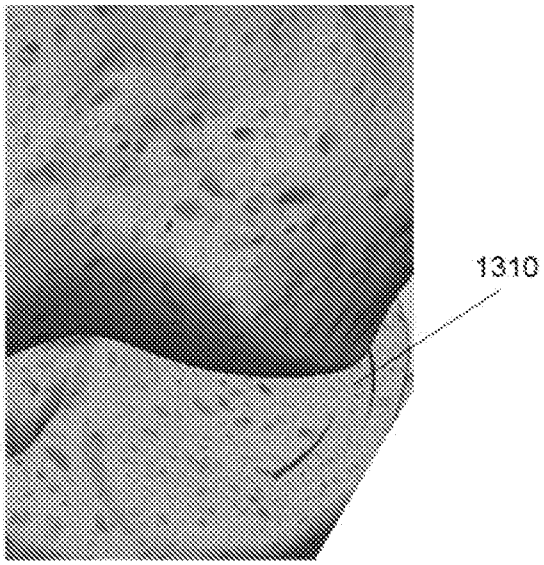


FIG. 13C

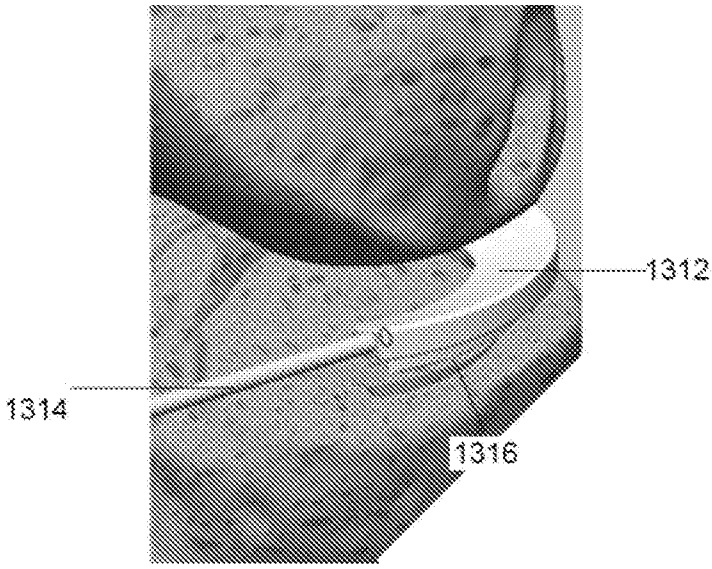


FIG. 13D

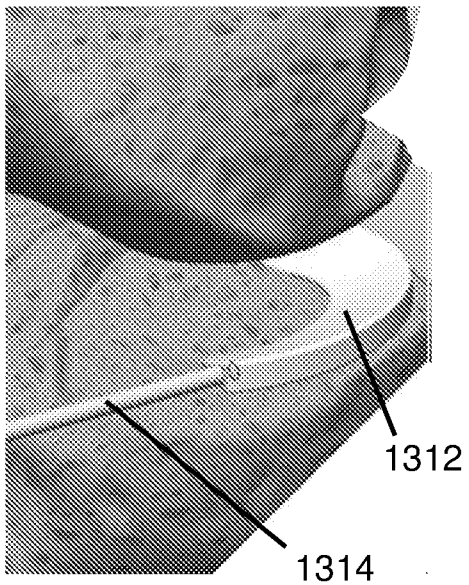


FIG. 13E

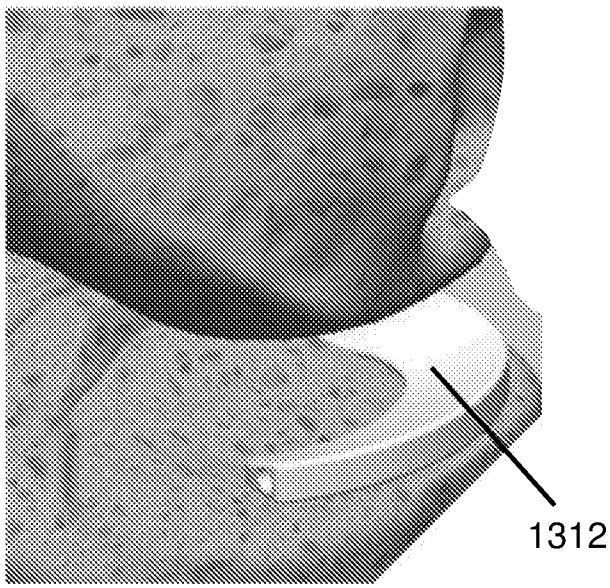
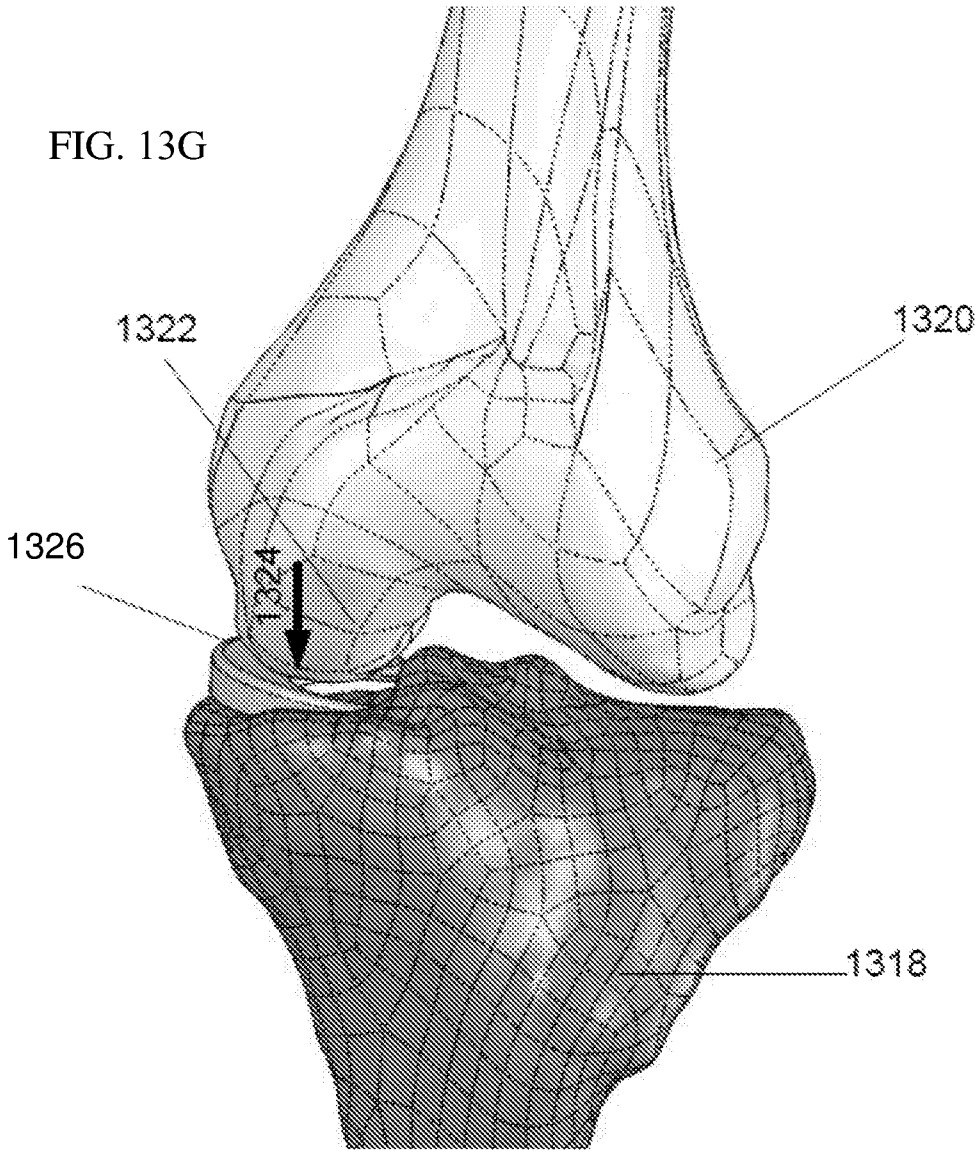


FIG. 13F

FIG. 13G



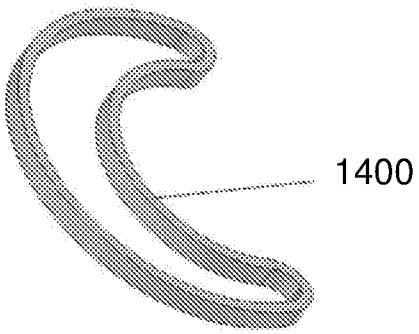


FIG. 14A

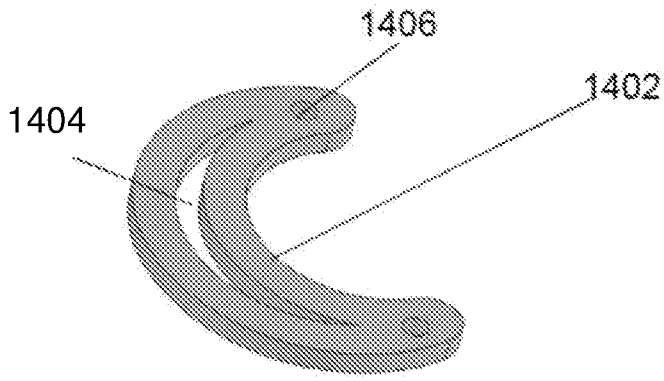


FIG. 14B

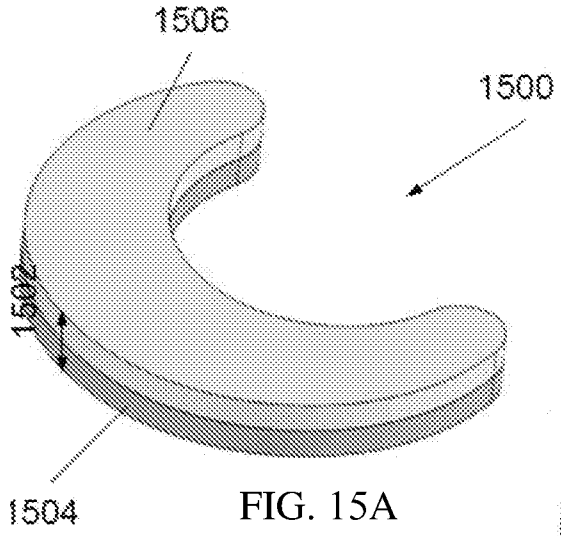


FIG. 15A

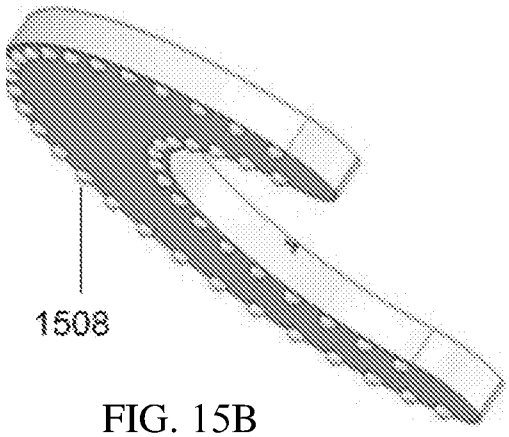


FIG. 15B

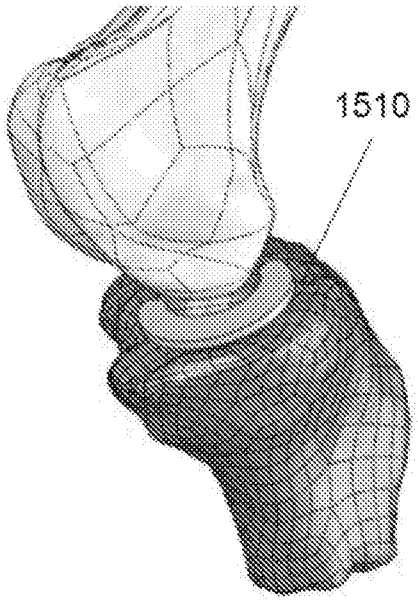


FIG. 15C

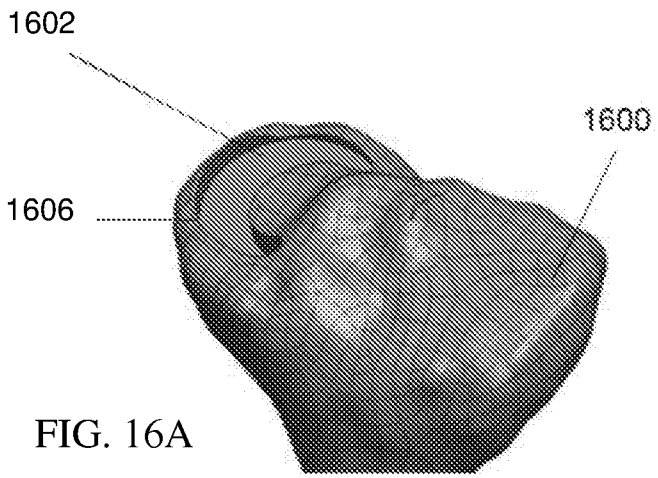


FIG. 16A

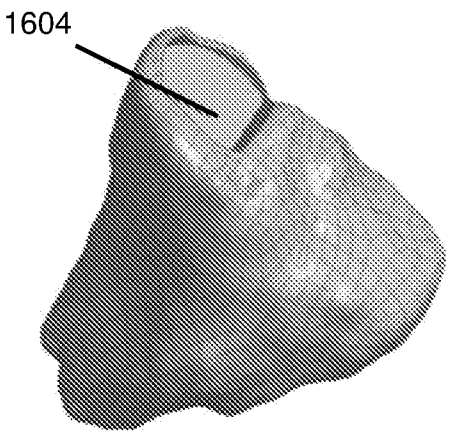


FIG. 16B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2015/053487

A. CLASSIFICATION OF SUBJECT MATTER
IPC (2015.01) A61F 2/30, A61F 2/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC (2015.01) A61F

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Databases consulted: THOMSON INNOVATION, Esp@cenet, Google Patents
Search terms used: meniscus, meniscal, knee, implant, prosthesis, anchor, rigid, stiff, hard, inflation

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013312897 A1 VOWLES et al. 28 Nov 2013 (2013/11/28) para.[0026], [0027], [0056], [0058], [0064]-[0066], [0069], [0071], [0072], [0074]; fig. 11-20	1-39

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
15 Oct 2015	19 Oct 2015

Name and mailing address of the ISA:	Authorized officer
Israel Patent Office Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel Facsimile No. 972-2-5651616	COHEN Meytal Telephone No. 972-2-5657820

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2015/053487

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
US 2013312897 A1	28 Nov 2013	US 2013312897 A1	28 Nov 2013
		AU 2012214106 A1	26 Sep 2013
		EP 2672928 A1	18 Dec 2013
		WO 2012106763 A1	16 Aug 2012