



(51) International Patent Classification:

A61F 2/38 (2006.01) A61B 17/16 (2006.01)
A61F 2/30 (2006.01)

(21) International Application Number:

PCT/EP2017/060496

(22) International Filing Date:

03 May 2017 (03.05.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1607859.4 05 May 2016 (05.05.2016) GB

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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,

DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR,
KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR,
TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: CANINE PROSTHETIC ELBOW JOINT

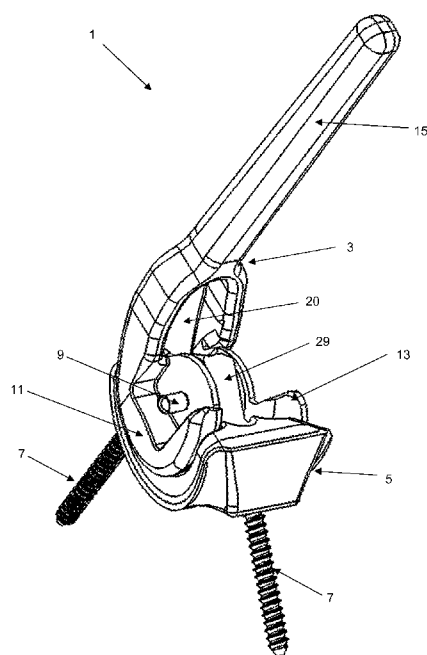


FIGURE 1

(57) Abstract: The present invention provides a prosthetic elbow joint (1) for attaching to a humerus and an ulna of a dog, the joint having a humeral component (3) for mounting between the medial and lateral condyles of the humerus, comprising a first articular surface; and an ulnar component (5) for mounting in the trochlear notch of the ulna, comprising a second articular surface; wherein the humeral and ulnar components are hinged together by an axle (9), such that the first and second articular surfaces are movable relative to one another about the axle.



CANINE PROSTHETIC ELBOW JOINTTECHNICAL FIELD

This invention relates to replacement canine elbow joints.

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BACKGROUND OF THE INVENTION

Various degenerative conditions, such as osteoarthritis and dysplasia, can affect the function of the elbow. Surgical treatment either to repair or replace the joint is necessary to avoid the joint becoming useless.

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Replacement elbow joints for dogs have already been proposed.

European Patent Application Publication No. 2120797 discloses a prosthetic elbow joint for a dog having a humeral component and ulnar component having curved outer surfaces which are mutually co-operable to permit relative movement. The humeral component is mountable on a trochlear bone portion of the dog's humerus which joins its medial condyle to its lateral condyle. The ulnar component includes screws to attach to both the radius and ulna.

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US Patent Application Publication No. 2004-220675 discloses a prosthetic elbow joint for a dog in which a humeral component having an elongate stem and spiral grooved cylindrical head is engaged with a corresponding spiral ridge on an ulnar component that is attached to the ulna. This document suggests that the grooved and ridged nature of the replacement joint provides desirable lateral stability for the joint.

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US Patent Application Publication No. 2005-043806 proposes a less invasive canine elbow replacement technique. Here, the humeral component comprises a stem that is insertable between the medial and lateral condyles of the humerus into the medullary canal. To permit this, a trochlear portion of bone between the medial and lateral condyles is cut out. To fix the humeral component in place, a transcondylar screw is located between the medial and lateral columns of the humerus. The ulnar component defines a U-shaped cavity for cooperating with the humeral component. This component is attached to the ulna by using a jig to cut a squared portion at the proximal end of the ulna, where it is fixed using a pin down the ulna's canal and an anconeal screw.

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In all of the above examples, the humeral component and ulnar components are held in engagement with one another by the surrounding ligaments and muscles, and have curved

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outer surfaces which allow relative rotational movement of the components. However, the above joints have a tendency to dislocate as a result of the humeral and ulnar components tilting open laterally. This problem is exacerbated by the need to operate on soft tissues around the joint when installing the prosthesis. In addition, once such a dislocation occurs, it can increase the chances of a subsequent dislocation occurring. Thus, there remains a need for a canine elbow prosthesis with a reduced tendency to dislocate.

SUMMARY OF THE INVENTION

To address the above problems in the prior art, a first aspect of the invention provides a prosthetic elbow joint for attaching to a humerus and an ulna of a dog, the joint having a humeral component for mounting between the medial and lateral condyles of the humerus, comprising a first articular surface; and an ulnar component for mounting in the trochlear notch of the ulna, comprising a second articular surface;

wherein the humeral and ulnar components are hingedly connected by an axle (e.g. a pin), such that the first and second articular surfaces are movable relative to one another about the axle.

Advantageously, such an arrangement allows the humeral and ulnar components to rotate relative to one another whilst restricting the possibility of dislocation caused by the components pulling or twisting apart.

The axle may be separate from the humeral component and ulnar component. In other words, the joint may comprise said humeral component, said ulnar component, and an axle (e.g. a pin) hingedly connecting said components. Advantageously, this allows the humeral component and ulnar component to be fitted to the humerus and ulna respectively, and subsequently hingedly linked together via the axle. This allows the prosthesis to be installed with relatively less deformation of the joint than would be required for a prosthesis where the humeral and ulnar are installed as a pre-linked unit. Advantageously, this can limit the amount of damage to soft tissues around the joint when installing the prosthesis, reducing the risk of post-operative complications.

Alternatively, the axle may be a constituent part of (e.g. integral with) the humeral component or ulnar component. For example, one component (e.g. the humeral component) may have an integral bar and the other component a complementary closure (e.g. clip) which locks onto the bar, to permit rotation about the bar. This allows the components to be fitted to the relevant bones separately, and then locked together.

Preferably, the ulnar and humeral components each incorporate a through hole which, in use, is aligned to form an axle channel for accommodating the axle. To fit the axle, the hole in the humeral component is aligned with the hole in the ulnar component to create a
5 channel, allowing the axle to be pushed into position. For example, the prosthesis may be installed by reaming/drilling/boring a hole across (e.g. perpendicular/transverse to) the bone axis between the lateral and medial condyles of the humerus, positioning the humeral and ulnar components such that the holes of the components align with the hole in the bone to form an axle channel, and inserting the axle into position in the axle channel through the
10 hole in the bone. As explained above, connecting the humeral and ulnar components *in situ* in this way limits the amount of deformation that is required to fit the prosthesis. In addition, aligning the components of the prosthesis with a hole in the bone allows accurate positioning of the prosthesis.

15 In such embodiments, the axle may protrude on one or both side of the axle channel formed by the holes of the humeral and ulnar components. For example, the axle may protrude 1 mm or more, 2 mm or more, 3 mm or more, 4 or more or 5 mm or more beyond the axle channel. The maximum distance the axle may protrude may be, for example, 10 mm, 8 mm, or 6 mm. For example, the axle may protrude from 2-8 mm or 3-5 mm. Advantageously, the
20 protruding portions of the axle can sit within the hole in the bone, further helping to secure the prosthesis to the humerus. In this way, the humeral and ulnar components may be fixed to the humerus and ulna respectively, and the axle inserted into position through a transcondylar hole such that it protrudes either side of the axle to support the joint in position. The additional support provided by the protruding axle means that the humeral and
25 ulnar components can be made relatively less bulky, thereby reducing the amount of trochlea bone that needs to be removed to fit the device.

Preferably, the axle is a pin having a locking mechanism for locking the pin in position after insertion into the humeral and ulnar component. For example, the axle may be a pin having
30 a locking element which engages the humeral and/or ulnar component after insertion to lock the pin in position. The locking element may be a relatively wider (larger diameter) portion of the axle (e.g. a collar/flange) which prevents removal of the axle through the axle channel. Alternatively, or additionally, said locking element may be or comprise a screw thread provided on the axle which screws into a corresponding screw thread provided on the ulnar
35 or humeral component. The screw thread on the axle screws into only one of the ulnar or humeral component (not both) so as not to interfere with relative movement of the ulnar and

humeral components. The screw thread on the ulnar or humeral component may be provided on the inner surface of the through hole in said component.

Suitably, the axle is a snap fit pin. For example, the axle may be a pin having one or more deformable lugs or lips at one or both ends which snap into place when pushed into position. Advantageously, linking the humeral and ulnar component via a snap-fit mechanism provides a simple way of connecting the components. For example, the axle may comprise a central shaft having a collar at one or both ends, wherein the collar(s) are wider than the central shaft, and at least one of the collars has one or more deformable lugs or lips.

Alternatively, the axle may be a screw-fit pin.

The axle may be removable. Advantageously, this allows the humeral and ulnar components to be disconnected, allowing repair or replacement of the components separately without having to remove the prosthesis as a single unit.

Where the axle has one or more portions with relatively larger diameters which serve as locking elements for holding the axle in position, the maximum diameter of the one or more portions of the axle may be only marginally larger than the diameter of the above-mentioned axle channel created by the humeral and ulnar components. For example, the ratio of the maximum diameter of the relatively larger diameter portion of the axle to the axle channel diameter may be greater than 1 to 1.05, greater than 1 to 1.1, greater than 1 to 1.15, greater than 1 to 1.2, or greater than 1 to 1.25. Advantageously, this allows the axle to be pushed into position through the bone without having to create an excessively wide transcondylar hole, and hence reduces the amount of bone which must be removed to fit the joint prosthesis.

For example, when the axle comprises a central shaft having a relatively wider collar at one or both ends, the maximum diameter of the collar(s) may be greater than 1 to 1.05, greater than 1 to 1.1, greater than 1 to 1.15, greater than 1 to 1.2, or greater than 1 to 1.25 of the diameter of the axle channel.

The humeral component may comprise one or more interlocking features (e.g. plates) which interlock with complementary interlocking features on the ulnar component. The axle may be mounted through such interlocking features to form a hinge.

For example, one of the components (e.g. the humeral component) may comprise one or more arms spaced by a gap, and the other component (e.g. ulnar component) may comprise

one or more knuckles which are positioned in the gap between said arms. In such instances, the one or more arms may be interdigitated with the one or more knuckles. Positioning the one or more knuckles between the one or more arms helps to prevent or resist relative twisting of the components.

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Preferably, the humeral component comprises a medial arm and a lateral arm, spaced by a gap, and the ulnar component may comprise a knuckle which is positioned in the gap between the medial and lateral arms in use. The knuckle may be an upstanding ridge or plate having a hole through which the axle extends in use. The knuckle may be fixed
10 relative to the ulnar component, instead of being separately rotatable relative to the ulnar component. The humeral component may comprise only two arms (said medial arm and lateral arm). The ulnar component may comprise only one knuckle.

The axle is mountable through the medial arm, knuckle and lateral arm so as to hingedly link
15 the humeral and ulnar components. Accordingly, the arms and knuckle include holes for accommodating the axle. Advantageously, sandwiching the knuckle of the ulnar component between two arms on the humeral component helps to resist relative twisting motion of the components, and reduces strain placed upon the axle. Note that the terms "medial arm" and "lateral arm" are used as labels to refer to portions of the humeral component which are
20 relatively closer to the medial condyle and lateral condyle of the humerus respectively in use, but are not intended to refer to a particular orientation of the prosthesis (since the determination of whether an arm is "medial" or "lateral" will depend on whether the left or right elbow is being replaced).

25 The medial arm and lateral arm may each take the form of a plate (i.e. plate-like structure), with the plates spaced apart so as to create a gap for accommodating the knuckle. For example, the humeral component may be a fork, having a central stem linking two plate-shaped prongs (the medial and lateral arms), spaced so as to accommodate a complementary knuckle on the ulnar component. The knuckle of the ulnar component may
30 itself be a central "plate" on the ulnar component.

Preferably, the knuckle of the ulnar component abuts both the medial and lateral arms of the humeral component, in use. For example, the average gap between the knuckle and medial/lateral arms may be less than 1 mm, less than 0.7 mm, less than 0.5 mm, less than
35 0.3 mm, or less than 0.2 mm. Preferably, the average gap is 0.1 mm or less on either side of the knuckle. Advantageously, this limits possible lateral and twisting movement of the ulnar component relative to the humeral component.

Preferably, the knuckle comprises or consists of a low-friction material, to facilitate relative movement of the humeral and ulnar components. Preferably, the knuckle is made from polyether ether ketone (PEEK), since such materials are both low-friction and

- 5 structurally/mechanically robust, allowing the knuckle to be sufficiently robust to structurally link the humeral and ulnar components whilst facilitating relative rotation of the components.

The ulnar component may comprise:

- 10 a knuckle element, having a ridge positioned between the medial arm and lateral arm of the humeral component, and the second articular surface; and
a mounting element, for mounting the knuckle element in the trochlear notch of the ulna.

Preferably, the joint comprises:

- 15 (i) a humeral component for mounting between the medial and lateral condyles of the humerus comprising a medial arm and a lateral arm providing humeral articular surfaces;
(ii) an ulnar component for mounting in the trochlear notch of the ulna, comprising:
20 a knuckle element, having a ridge positioned between the medial plate and lateral plate of the humeral component, and an ulnar articular surface; and
a mounting element, for mounting the knuckle element in the trochlear notch of the ulna;
(iii) an axle (e.g. pin), hingedly connecting the humeral component and ulnar component via the medial arm, lateral arm and knuckle element so as to permit relative rotational
25 movement of the humeral and ulnar articular surfaces.

The knuckle element may incorporate a low-friction material which abuts the medial and lateral arms of the humeral component in use. For example, preferably the knuckle element is made from (e.g. consists of) a low-friction material. In such instances, the knuckle
30 element acts as a bearing. Advantageously, fixing the humeral component to the ulnar component via a low-friction knuckle element facilitates relative rotations of the humeral and ulnar components. In addition, such an arrangement avoids the need for additional bearings between the humeral and ulnar components, which helps to reduce the weight and thickness of the joint. The low-friction material may be a ceramic material, a metal material, or a
35 polymer material, such as polyether ether ketone (PEEK) since such materials are both low-friction and structurally/mechanically robust.

The medial arm and/or lateral arm of the humeral component may comprise a hooked portion for gripping a trochlear bone portion. For example, the arms may be/include plates which have a groove/recess in their outer faces capable of hooking onto a portion of the trochlear bone. In such embodiments, the prosthesis may be installed by cutting a central gap in the trochlear bone between the medial and lateral condyles (optionally all the way to the trochlear foramen) whilst retaining peripheral trochlear bone portions (i.e. removing some, but not all, of the trochlear bone portion). The humeral and ulnar components can then be positioned within the gap between the condyles, such that the hooked recesses of the medial and lateral arms grip the remaining trochlear bone. Advantageously, this aids positioning of the prosthesis relative to the bone, and allows the prosthetic joint to make use of the intrinsic strength of the bone to hold the prosthesis in place and absorb forces on the joint. Furthermore, the approach means that less of the trochlea needs to be removed than is required for some existing canine elbow prosthesis, which can make the surgery less invasive. The peripheral trochlear bone portions may be prepared (e.g. shaped using a cutting tool) to conform with the shape of the hooked portion. For example, the hooked portion may define a rectangular (box-like) recess. The peripheral trochlear bone portion(s) may be squared off using a cutting tool before the humeral component is mounted thereon. The humeral portion may be cemented to the peripheral trochlear bone portion. The first articular surface may be formed on an opposite surface of the humeral component from the hooked portion.

Preferably, the humeral component includes a stem that is insertable in the intramedullary canal of the humerus. The stem may be cemented in place. The stem can provide axial stability of the humeral component. For example, the humeral component may take the form of a forked structure, comprising a stem that is insertable in the intramedullary canal of the humerus, linking two opposing prongs (the medial and lateral arms) with optionally recessed outer surfaces for gripping a peripheral trochlear portion in use.

The stem may be perpendicular to the axle when the axle and stem are viewed front-on (that is, viewed perpendicular to the axis of rotation about which the humeral and ulnar component rotate, instead of viewed axially along either the axle or stem). In this way the stem travels in a plane when rotated around the axle. Alternatively, the stem may be tilted. In other words, the stem may be angled away from perpendicular when the axle and stem are viewed front-on. In this way, the stem is angled towards the axis of rotation so that it sweeps through a partial cone when rotated around the axle. For example, the stem may be angled at least 1°, at least 2°, at least 3°, or at least 4°, relative to a direction perpendicular to the axle when the axle and stem are viewed front-on, up to a maximum of, for example,

15° or 10°. Preferably, the stem is tilted at an angle of between 2° to 7°, more preferably 3° to 6°, most preferably 5°. When installed, this results in the axis of rotation being tilted towards body midline by a corresponding amount. Advantageously, this reflects the natural geometry of the canine elbow joint, and thus allows the stem to be more comfortably
5 accommodated in the intramedullary canal of the humerus.

The stem may be an integral part of the humeral component. Alternatively, the stem may be a separate part which is attached (preferably removably attached) to a main body of the humeral component (which provides the first articular surface of the humeral component).

10 For example, the stem may be connected to the main body of the humeral component by a screw. Having the stem as a separate part is particularly advantageous when the stem is tilted, because the user can choose the appropriately angled stem to attach to the main body of the humeral component, without requiring modification of the main body of the humeral component. This simplifies manufacture, because it is only necessary to make a single type
15 of main body for the humeral component, which can be used with multiple different types of stem. For example, a stem adopting an angle of +5° may be chosen for the left elbow, and a stem adopting an angle of -5° may be chosen for the right elbow, both of which may be attached to the same type of main body. Preferably, the same stem may be installed in multiple ways on the main body, for example so as to adopt either a positive or negative
20 angle. For example, the same stem may be installed in one of two ways, e.g. to adopt an angle of +5° or an angle of -5°. Advantageously, this allows a single type of main body and stem to be adaptable for use with both left and right hand elbows. In addition, this arrangement can facilitate replacement of the main body of the humeral component at a later point, if required.

25 Preferably, the humeral component includes an opening arranged to align with the supratrochlear foramen when the humeral component is mounted on the humerus such that a passageway through the humerus is maintained. The canine humerus is naturally formed with a through hole in the form of the supratrochlear foramen. This hole receives the
30 anconeal process of the ulna during articulation of a normal elbow joint. Thus, to preserve freedom of movement and to minimise the amount of bone removal, it is desirable to maintain this through hole in the prosthetic joint.

Preferably, the first and second articular surfaces are curved surfaces which are mutually co-
35 operable to permit relative rotation between them. For example, the articular surfaces may be co-operable cylindrical surfaces. The first articular surface may have a convex shape, and the second articular surface may have a concave shape adapted to receive the convex

shape. Preferably, one of the articular surfaces is the surface of a low-friction knuckle element, as described above. Alternatively, a separate bearing may be provided between the curved surfaces of the first and second articular surfaces so that relative movement is smooth. The bearing may be made from a low-friction biocompatible material, such as polyether ether ketone (PEEK). The skilled reader understands that each of the humeral and ulnar components may comprise more than one articular surface. For example, when the humeral component comprises medial and lateral arms, each of the arms may bear an articular surface which is cooperable with corresponding articular surfaces arranged on each side of the knuckle of the ulnar component. The articular surfaces arranged on each side of the knuckle of the ulnar component preferably slope away from the knuckle (i.e. from the central ridge down towards the edges of the ulnar component), since this mimics the natural articular shape and results in the knuckle being thicker towards the centreline which helps strengthen the base of the ridge.

Suitably, the articular surface(s) of the humeral component contacts the articular surface(s) of the ulnar component in use. Advantageously, the provision of articular surfaces helps to stabilise the prosthesis. In particular, the articular surfaces help to spread the load of compressive forces applied to the joint. In the absence of the cooperating articular surfaces such compressive forces would be borne solely by the axle, requiring the axle to be made relatively more robust. Similarly, the articular surfaces help to limit lateral movement or relative twisting of the humeral and ulnar components, limiting the need for the axle to fulfil this purpose. Taken together, this means that the axle can be made relatively small, facilitating its insertion through the condyles without requiring removal of large amounts of bone.

Preferably, the ulnar component has a curved fixing surface arranged to contact the ulna within the trochlear notch of the ulna. The trochlear notch is a curved portion of bone that engages the trochlea in a normal elbow joint. The present invention aims to preserve the curvature of bone in this region of the ulna in the prosthetic joint. There are two advantages to this. Firstly, preserving the curvature of the bone can permit less bone to be removed. Secondly, the curvature of bone can provide greater structural support for the second articular surface (on the ulnar component). Many known prosthetic elbow joints propose radical reconfiguration of the proximal end of the ulna. Often, the anconeal process is completely removed and the trochlear notch reshaped as an L-shaped ledge. This requires an invasive process which may compromise clinical outcome.

To minimise re-shaping of the trochlear notch, the curved fixing surface preferably closely matches the curve of the trochlear notch. In particular, the curved fixing surface may define an arc of at least 160°, at least 170° or at least 180°. In this way, the curved fixing surface omits projections which would necessitate removal of regions of the trochlear notch in order to be accommodated.

In addition to the curved fixing surface, the ulnar component may have a flange projecting from the end of the curved fixing surface to provide additional stability to the ulnar component. This flange may overlay or abut a portion of the coronoid process in use.

Preferably, the ulnar component includes a plurality of fasteners for attaching its curved fixing surface within the trochlear notch. For example, the ulnar component may include one or more bone screws. The ulnar component may also include one or more pegs or dowels extending from the curved fixing surface, which help to site the ulnar component in a corresponding hole in the trochlear notch before being screwed into position, and further help to stabilise and fix the ulnar component.

Preferably, the ulnar component has said curved fixing surface and a flange projecting from the end of the curved fixing surface, with fasteners provided on both the curved fixing surface and flange. Advantageously, this provides particularly robust fixing of the ulnar component to the ulna, with the flange providing additional fixation to the lower part of the prosthesis, which is subjected to large amounts of force during use.

The trochlear notch may be prepared to receive the ulnar component. For example, the second articular surface on the ulnar component may be arranged to take the place of the natural surface of the trochlear notch. Thus, the trochlear notch may be deepened, i.e. a curved layer of bone may be removed, to receive the curved fixing surface of the ulnar component such that the curve of the second articular surface lies substantially in the position of the natural trochlear notch.

Preferably, the ulnar component may therefore comprise a curved plate having a central knuckle, with articular surfaces formed on a concave inner surface and the curved fixing surface on the convex outer surface.

Preferably, the ulnar component is mounted to the ulna only (and not to the radius) so as to allow relative motion of the ulna and radius (in particular, pronation and supination).

In a particularly preferred embodiment, the joint comprises:

- (i) a humeral component for mounting on a trochlear bone portion of the humerus comprising a medial plate and a lateral plate providing humeral articular surfaces;
- (ii) an ulnar component for mounting in the trochlear notch of the ulna, comprising:
 - 5 a knuckle element, having a ridge positioned between the medial plate and lateral plate of the humeral component, and an ulnar articular surface; and
 - a mounting element, for mounting the knuckle element in the trochlear notch of the ulna;
- (iii) an axle, hingedly connecting the humeral component and ulnar component via the
10 medial plate, lateral plate and knuckle element so as to permit relative rotational movement of the humeral and ulnar articular surfaces;

wherein the medial plate and lateral plate each include a groove in their outer faces for gripping onto a trochlear bone portion. This embodiment may have any of the preferred and optional features above. For example, the medial plate, lateral plate and knuckle element
15 may each incorporate a through hole which is aligned to form an axle channel, wherein the axle is accommodated within the axle channel and protrudes on both sides of the axle channel. In addition, the humeral articular surfaces may have a convex shape, and the ulnar articular surface may have a concave shape adapted to receive the convex shape.

Advantageously, joint prosthesis incorporating grooved outer faces and an axle which
20 protrudes on both sides of the axle channel provides can be securely fitted with minimal removal of bone. In particular, the humeral and ulnar components can be made relatively less bulky due to the support provided by the axle when accommodated in a transcondylar hole in the humerus, and the grooved portions mean that the trochlea of the humerus does not need to be completely removed.

25 The humeral and ulnar components discussed above may be independent aspects of the invention.

A kit of parts for constructing a joint as described above may also be an independent aspect
30 of the invention.

Another independent aspect of the invention may be a method of installing a joint as described above. This may comprise the steps of creating a transcondylar hole through the humerus, fitting the humeral and ulnar components to the humerus and ulna respectively,
35 aligning throughholes in the humeral and ulnar components so as to form an axle channel aligned with the transcondylar hole, and linking the humeral and ulnar components by inserting the axle into the axle channel via the transcondylar hole. The step of fitting the

humeral component may comprise cutting a trochlear bone portion such that peripheral portions of the trochlear bone are retained, and inserting the peripheral bone portions into a hook (e.g. groove) on the humeral component.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention are now described with reference to the accompanying drawings, in which:

- Fig. 1 shows a perspective view of a canine elbow joint prosthesis according to a first embodiment of the invention;
- Fig. 2 shows a side view of the canine elbow joint prosthesis of Fig. 1;
- Fig. 3 shows a back view of the canine elbow joint prosthesis of Fig. 1;
- Fig. 4 shows the ulnar component of the prosthesis of Fig. 1 in greater detail;
- Fig. 5 shows the humeral component of the prosthesis of Fig. 1 in greater detail;
- Fig. 6 shows the pin of the prosthesis of Fig. 1 in greater detail;
- Fig. 7 shows an exploded view of the components of the prosthesis of Fig. 1;
- Figs. 8A and 8B show a canine humerus before and after preparation for installation of the prosthesis of Fig. 1;
- Fig 9 shows a perspective view of a humeral cutting jig for preparing a humerus for the prosthesis of Fig. 1;
- Fig 10 shows a side view of an applicator, for inserting the axle between the humeral and ulnar components of the prosthesis;
- Figs. 11 and 12 show perspective views of a canine elbow joint prosthesis according to a second embodiment of the invention;
- Fig. 13 shows the ulnar component of the prosthesis of Fig. 11 in greater detail;
- Fig. 14 is a side view of the mounting plate of the ulnar component of Fig. 11 positioned in the trochlear notch of a canine ulna;
- Fig. 15 shows a front view of the humeral component of the prosthesis of Fig. 11;
- Fig. 16 shows a perspective view of the humeral component of the prosthesis of Fig. 11; and
- Fig. 17 shows the underside of the humeral component of the prosthesis of Fig. 11, showing the two-part construction.

DETAILED DESCRIPTION; FURTHER OPTIONS AND PREFERENCES

- In addition to the prosthetic canine elbow joint of the invention, the discussion below describes apparatus for preparing a distal end of a humerus to receive the humeral component of a prosthetic elbow joint, the apparatus including a reamer shaft that is insertable into the medullary canal of the humerus, and jig that is securably mountable on

the shaft at the distal end of the humerus, wherein the jig is configured to (i) guide a cutting tool to cut the trochlear bone of the humerus which joins its medial condyle to its lateral condyle into a predetermined shape suitable for receiving the humeral component, and (ii) cut a hole through the condyles of the humerus to allow a pin/axle to be inserted through the hole into position so as link the humeral and ulnar components. The reamer shaft can be adapted to clear a passageway in the medullary canal of the humerus. When the reamer is subsequently removed, this passageway may be used by a stem on the humeral component. The apparatus can include a cross handle that is reversibly attachable to the reamer shaft. The cross handle can be used to rotate the reamer shaft to clear the passageway.

The reamer shaft can define an axis substantially along the humerus. By fixing the jig with respect to this axis, the trochlear bone can be shaped in a way that causes the humeral component to adopt a predetermined orientation with respect to the humerus. Preparation of the humerus in this way can therefore be used to control the location and direction of relative movement within the prosthetic joint.

The jig may include a plurality of guide slots for orienting a cutting blade, the guide slots being arranged to permit movement of the cutting blade along the surfaces of the predetermined shape. The jig may also include guide holes for orienting a drilling/boring/reaming device to create holes in predetermined positions on the bone. For example, the jig may include:

- a guide hole, for creating a hole through the humerus in a transcondyle direction, for introducing the axle which links the humeral and ulnar components;

- a pair of side plane slots that are spaced apart from each other and extend substantially parallel from each other in a plane normal to the transcondyle direction to remove at least a portion of the trochlea;

- and optionally, in instances where a portion of the trochlear bone is retained:

- an upper plane slot and a lower plane slot which are spaced apart and each extend substantially in a plane parallel to both a transcondyle direction and the direction of the reamer shaft; and/or

- a distal plane slot that extends substantially normal to the direction of the reamer shaft. In instances where the jig incorporates the side plane slots, upper plane slot, lower plane slot and distal plane slots the predetermined shape of the bone after cutting may be cuboidal. The planes defined by the upper plane slot and lower plane slot may diverge slightly, i.e. to give the shape of bone after cutting a trapezoidal cross-section. The corresponding internal faces of the hooked portion (when present) converge in a similar

manner to achieve a wedge-like fit between the bone portion and the hook. Suitably, the apparatus is arranged to remove a central transcondyle portion of trochlear bone located at the distal end of the supratrochlear foramen whilst still retaining peripheral portions of the trochlear bone to serve as ledges for receiving a hooked portion of the humeral component.

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As explained above, the humeral component may include a hooked portion that is adapted to grip a prepared trochlear bone portion. By creating a cuboidal (i.e. squared-off edged) bone portion to fit snugly in a corresponding recess (hook) in the humeral component, the orientation of the humeral component with respect to the humerus can be more accurately controlled. Previous arrangements have typically relied on the skill and eye of the surgeon for alignment accuracy.

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Also discussed below is apparatus for preparing a proximal end of an ulna to receive the ulnar component of a prosthetic elbow joint, the apparatus including a cutting tool having a curved cutting edge arranged to cut an arc in bone when the cutting tool is moved in a cutting direction, and an elongate guide element located in the transcondylar humeral guide hole with the guide element being coaxially inserted into the cutting tool and protruding therefrom in the cutting direction. The apparatus is therefore adapted to deepen the trochlear notch and articular fovea by removing a curved portion of bone therefrom.

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The cutting edge is arranged to oscillate along this curve to effect cutting. The cutting tool may oscillate about a rotation axis. The rotation axis may be along the same direction as the cutting direction.

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The curved edge may lie on a circle. Preferably, the centre of the circle is defined by the elongate guide element. This can allow the curvature of the arc that is cut in the bone by the apparatus to be related to the position of the original trochlear notch.

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Thus, the cutting tool may comprise a cutting blade in the form of a partial cylindrical sleeve having a U-shaped cross-section, the curved cutting edge being at one end of the sleeve and a driving element being attached to the other end of the sleeve, the driving element being drivable to effect oscillation of the cutting edge. The driving element may be an engagement bit (key) that is receivable in the chuck of an oscillating power tool. The guide element may be a rod. The cutting edge may be movable relative to the guide element to effect cutting. The guide element may be removable.

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Also briefly discussed below are methods of implanting the humeral and ulnar components of a prosthetic canine elbow joint. For example, a method of implanting a humeral component of a prosthetic canine elbow joint at a distal end of a humerus may include: inserting a reamer shaft into the medullary canal of the humerus; securely mounting a jig on the reamer shaft at the proximal end of the humerus; guiding a drill with the jig to drill a hole through the bone in a transcondyle direction; guiding a cutting tool with the jig to cut a slot between the medial and lateral condyles of the humerus and optionally forming the peripheral trochlear bone portion to have a predetermined shape; removing the jig and reamer shaft; and mounting the humeral component on the trochlear bone portion of the humerus. Mounting the humeral component may include inserting a stem of the humeral component into the medullary canal. To create the peripheral trochlear bone portion(s) having a predetermined shape, the method may include moving a cutting edge through: an upper plane and a lower plane which are spaced apart and extend in planes substantially parallel to both a transcondyle direction and the direction of the reamer shaft; a pair of side planes that are spaced apart from each other and extend substantially parallel with each other in planes normal to the transcondyle direction; and a distal plane that extends substantially normal to the direction of the reamer shaft, whereby the predetermined shape of the trochlear bone portion is cuboidal.

Furthermore, a method of implanting an ulnar component of a prosthetic canine elbow joint on a proximal end of an ulna may include: moving a curved cutting edge in a medial-lateral direction through the ulna underneath the trochlear notch to remove a layer of bone from the trochlear notch and articular fovea to thereby create a larger arcuate groove; and mounting the ulnar component in the arcuate groove. Preferably, the method includes moving the curved cutting edge in a cutting direction defined by an elongate guide element which is located inside the transcondylar humeral hole.

Turning now to the drawings, Fig. 1 shows a canine elbow joint prosthesis 1 according to a first embodiment of the present invention comprising a humeral component 3 that is attachable to the humerus and an ulnar component 5 attachable to the ulna using bone screws 7. The humeral component 3 and ulnar component 5 are linked by pin 9, which allows relative rotation of the components whilst preventing lateral and axial movement of the joint.

The humeral component 3, shown in greater detail in Fig. 5, takes the form of a fork having a medial axle-mounting plate 11 and lateral axle-mounting plate 13 connected via a central stem 15. The central stem can be cemented into a cavity reamed into the intramedullary

canal of the humerus. The medial and lateral axle-mounting plates are spaced from one another, and include aligned holes 17 and 19 for accommodating pin 9. The outer faces of the axle-mounting plates include a hook-shaped groove 18, for accommodating a portion of the trochlea bone (see feature 104 in Fig. 8B).

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The canine humerus 100, shown in Fig. 8A, typically includes a supratrochlear foramen 102 extending through the humerus. The supratrochlear foramen 102 provides space for the anconeal process of the ulna during articulation of the joint. To provide freedom of movement of the prosthetic joint of the invention, it is therefore desirable to maintain this space. The humeral component 3 therefore has an opening 20 arranged to lie over the supratrochlear foramen 102 when implanted and sized to permit the anconeal process of the ulna to pass therethrough during articulation of the joint.

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The ulnar component, shown in greater detail in Figs. 4 and 7, consists of a curved mounting plate 21 and a knuckle 23. The knuckle 23 is correctly positioned on the mounting plate 21 using position guides 25, and is held in contact with the mounting plate 21 by bone screws 27 which penetrate screw holes in the mounting plate and knuckle. The knuckle 23 incorporates an upstanding plate region 29 having a through hole 31, which forms a central crest/ridge along the centre of the knuckle. The upstanding plate region 29 fits between the medial and lateral axle-mounting plates 11 and 13 of the humeral component, such that the holes 17 and 19 of the humeral component align with hole 31 of the knuckle to form an axle channel which accommodates pin 9.

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The pin 9, shown in greater detail in Fig. 6, is a cylinder incorporating a central shaft 33, flanked by integral collars 35 and 37. The axle includes crosswise cuts to allow collar 35 to be reversibly inserted into the axle channel. Specifically, the crosswise cuts allow collar 35 to be pinched such that it can be inserted through one face of the axle channel until it protrudes out of the other face of the channel, at which point pressure can be released to allow the collar to expand and lock the axle within the channel.

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Fig. 7 shows an exploded view of the prosthesis shown in Figs. 1 to 3, showing mounting plate 21, knuckle 23 and bone screws 7 of the ulnar component in greater detail.

Fig. 9 shows a cutting jig 200 for preparing the distal end of a humerus for the humeral component of a prosthetic elbow joint. The jig 200 comprises an L-shaped block with a top plate 202, a back plate 204, and a side arm 206. The back plate 204 is adapted to be

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mounted on the elongate body of a reamer (not shown). For this purpose the back plate 204 has a through hole 207 for receiving the reamer body.

The purpose of the jig 200 is as a guide for shaping the trochlear bone portion of the humerus to receive the prosthesis 1.

The top plate 202 has three slots 208 through it. These slots form a U shaped channel which runs in a direction that is substantially normal to the bone axis (reamer body) direction. A cutting blade moving in these slots would flatten the distal facing end of the humerus.

The back plate 204 has a pair of slots 210 through it. These slots are substantially parallel to the bone axis (reamer body) direction and transverse to the transcondylar direction. A cutting blade moving in these planes removes a portion of the trochlea between the lateral and medial condyles of the humerus to produce a gap/slit for accommodating the arms of the humeral component and knuckle of the ulnar component.

In the embodiment shown, the jig 200 is configured so that peripheral portions 104 of the trochlea bone are retained, as shown in Fig. 8B, to serve as a ledge for the hooked portions 18 of the prosthesis. The back plate 204 also includes additional slots arranged to guide a cutting tool (not shown) to shape the peripheral trochlear bone portions into a block-like (e.g. cuboidal) shape, so as to conform with the shape of the hooked portions 18 of the prosthesis. For example, back plate 204 has a pair of transverse slots 212, 214 and a pair of upright slots 216. The transverse slots 212, 214 are substantially parallel with each other and lie in transverse planes that are substantially parallel to both the bone axis direction and a transcondylar direction (i.e. a direction between equivalent points on the medial and lateral condyles). A cutting blade moving in these planes would cut the faces of the squared-off trochlear bone portion that contact the top and bottom surfaces of the hook in the humeral component.

The lower transverse slot 214 is wide enough to flatten the lower part of the distal end of the humerus. This can be achieved because the lower part of the humerus naturally curves upwards as it extends away from the distal end. This is not the case for the upper part. The upright slots 216 are therefore provided at each end of the upper transverse slot 212 to permit the layer of bone located above the upper transverse cut to be removed. The upright slots 216 lie in parallel planes that are normal to the transverse planes and parallel to the bone axis direction. A cutting blade moving in these planes would cut parallel to the axis of the humerus to form side walls for the trochlear bone portion. Referring to Fig. 8A, the top

part of the trochlear bone portion falls downward into the supratrochlear foramen. Thus, this provides a natural point at which the cut will complete to free a top cut-off portion of bone. Where there is no supratrochlear foramen, the top plate may contain a further pair of slots towards its proximal end.

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The side arm 206 includes a guide hole 218 to allow accurate drilling through the humerus in a transcondylar direction, through the lateral condyle and out through the medial condyle (or vice versa). The jig 200 is arranged such that the resulting hole is aligned with the position of the through holes 17, 19 and 31 of the prosthesis when correctly installed, allowing the pin 9 to be pushed into position through the hole in the bone. Advantageously, the collars 35 and 37 of pin 9 protrude within the hole in the bone, further helping to stabilise the prosthesis relative to the bone.

To prepare the humerus, the surgeon first osteotomises the lateral epicondyle of the humerus and removes the tip of the anconeal process. The joint can then be dislocated to allow the reamer to be inserted and advanced into the intramedullary canal. After reaming, the cross-bar is removed and the jig is slid onto the reamer body until it touches the bone, and is secured in place.

After securing the jig via bone pins inserted through plate 202 (not shown), an oscillating saw blade is inserted through the guide slots to cut the bone. After cutting, the jig and reamer are removed, leaving a prepared surface to which the humeral component can be fixed, optionally using bone cement.

After the humeral and ulnar components are fixed in position, the components may then be hingedly fixed by inserting pin 9 into position. To do this, the surgeon may use a pin applicator 300, as shown in Figure 10. This applicator 300 has a shaft 302 terminating in a threaded tip (not shown) onto which the collar 37 of pin 9 may be screwed, to allow the pin 9 to be pushed into position through the hole through the humerus created by jig 200. Once in position, the threaded connection is unscrewed so as to release pin 9, allowing the applicator to be withdrawn from the bone.

Figs. 11 to 17 show a canine elbow joint prosthesis 401 according to a second embodiment of the present invention, including a humeral component 403 and ulnar component 405 hingedly connected through an axle 409.

The ulnar component, shown in detail in Fig. 13, is of a similar construction to that of the first embodiment, incorporating a curved mounting plate 421, and a knuckle 423 having an upstanding plate region 429 with a throughhole 431 for receiving axle 409. However, the component includes additional fasteners compared to the first embodiment to more robustly secure the ulnar component within the trochlear notch of the ulna. Specifically, in addition to the bone screws 407 which are provided in the first embodiment, the curved mounting plate 421 includes a solid peg 443 for inserting into a corresponding hole formed in the trochlear notch, and a flange 439 which serves as a fixing point for additional bone screws 441. The solid peg 443 also helps to facilitate correct siting of the ulnar component during installation. In addition to the extra fasteners, a further distinction from the first embodiment is that the mounting plate 421 does not include the box-like structure present at the front of the mounting plate 21, and has a more rounded profile. This reduces the amount of ulna that needs to be removed to accommodate the ulnar component.

The position of the mounting plate of the ulnar component when installed on the ulna is shown in greater detail in Fig. 14. A curved cut is created in the bone by removing a portion of the trochlear notch and a layer of the coronoid process. The mounting plate 421 is then accommodated within the curved cut, with flange 439 abutting the remaining coronoid process 500.

The humeral component, shown in detail in Figs. 15 to 17, is again similar to that of the first embodiment, but instead is a two-part construction having (i) a main body 447 incorporating linked medial axle-mounting plate 411 and lateral axle-mounting plate 413, and (ii) stem 415, attached through bolt 449 (shown in Fig. 17). The stem 415 is tilted at an angle α away from perpendicular so as to lean towards the axis of rotation, to reflect the geometry of the canine elbow. In this case, the angle α is -5° . However, the stem can be reversed so as to adopt an angle of $+5^\circ$, for use on the opposite elbow.

The ulnar component 405 and humeral component 403 are linked through axle 409. In this case, the axle 409 is a pin having a tapered end 435 for insertion through the axle channel and a relatively wider collar end 437. The collar end 437 incorporates a male screw thread in front of the collar which screws into a corresponding female screw thread provided in the throughhole of the humeral component (not shown). In this case, both the medial axle-mounting plate 411 and lateral axle-mounting plate 413 incorporate such a screw thread, to allow the axle to be inserted in either direction. To install the axle 409 the user pushes the tapered end 435 through the holes in the ulnar and humeral components, and screws the axle into position via screwdriver socket 445 until the collar 437 prevents further tightening.

CLAIMS

1. A prosthetic elbow joint for attaching to a humerus and an ulna of a dog, the joint having:
- 5 a humeral component for mounting between the medial and lateral condyles of the humerus, comprising a first articular surface; and
- an ulnar component for mounting in the trochlear notch of the ulna, comprising a second articular surface;
- wherein the humeral and ulnar components are hingedly connected by an axle, such
- 10 that the first and second articular surfaces are movable relative to one another about the axle.
2. A prosthetic elbow joint according to claim 1, wherein the ulnar and humeral components each incorporate a through hole which is aligned to form an axle channel,
- 15 wherein the axle is accommodated within the axle channel.
3. A prosthetic elbow joint according to claim 2, wherein the axle protrudes on both sides of said axle channel.
4. A prosthetic elbow joint according to any one of claims 1 to 3, wherein the axle is a snap-fit pin.
- 20 5. A prosthetic elbow joint according to any one of claim 1 to 3, wherein the axle is a screw-fit pin.
- 25 6. A prosthetic elbow joint according to any one of claims 1 to 5, wherein the humeral component comprises a medial arm and a lateral arm spaced by a gap, and the ulnar component comprises a knuckle which is positioned in the gap between the medial and lateral arms.
- 30 7. A prosthetic elbow joint according to claim 6, wherein the axle is mounted through the medial arm, knuckle and lateral arm so as to hingedly connect the humeral and ulnar components.
- 35 8. A prosthetic elbow joint according to claim 6 or 7, wherein the knuckle is made from polyether ether ketone.

9. A prosthetic elbow joint according to any one of claims 6 to 8, wherein the ulnar component comprises:

a knuckle element, having a ridge positioned between the medial arm and lateral arm of the humeral component, and the second articular surface; and

5 a mounting element, for mounting the knuckle element in the trochlear notch of the ulna.

10. A prosthetic elbow joint according to claim 9, wherein the knuckle element is made from polyether ether ketone.

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11. A prosthetic elbow joint according to any one of claims 6 to 10, wherein the medial arm and/or lateral arm comprises a hooked portion for gripping a trochlear bone portion.

12. A prosthetic elbow joint according to claim 11, wherein the hooked portion is a
15 groove in the outer face of said arm capable of gripping onto a portion of the trochlear bone.

13. A prosthetic elbow joint according to any one of the previous claims, including a stem that is insertable in the intramedullary canal of the humerus.

20 14. A prosthetic elbow joint according to any one of the previous claims, wherein the first and second articular surfaces are curved surfaces which are mutually co-operable to permit relative rotation between them.

15. A kit of parts comprising a humeral component, ulnar component and axle as
25 described in any one of claims 1 to 14.

16. A humeral component for a prosthetic elbow joint according to any one of claims 1 to 13.

30 17. An ulnar component for a prosthetic elbow joint according to any one of claims 1 to 13.

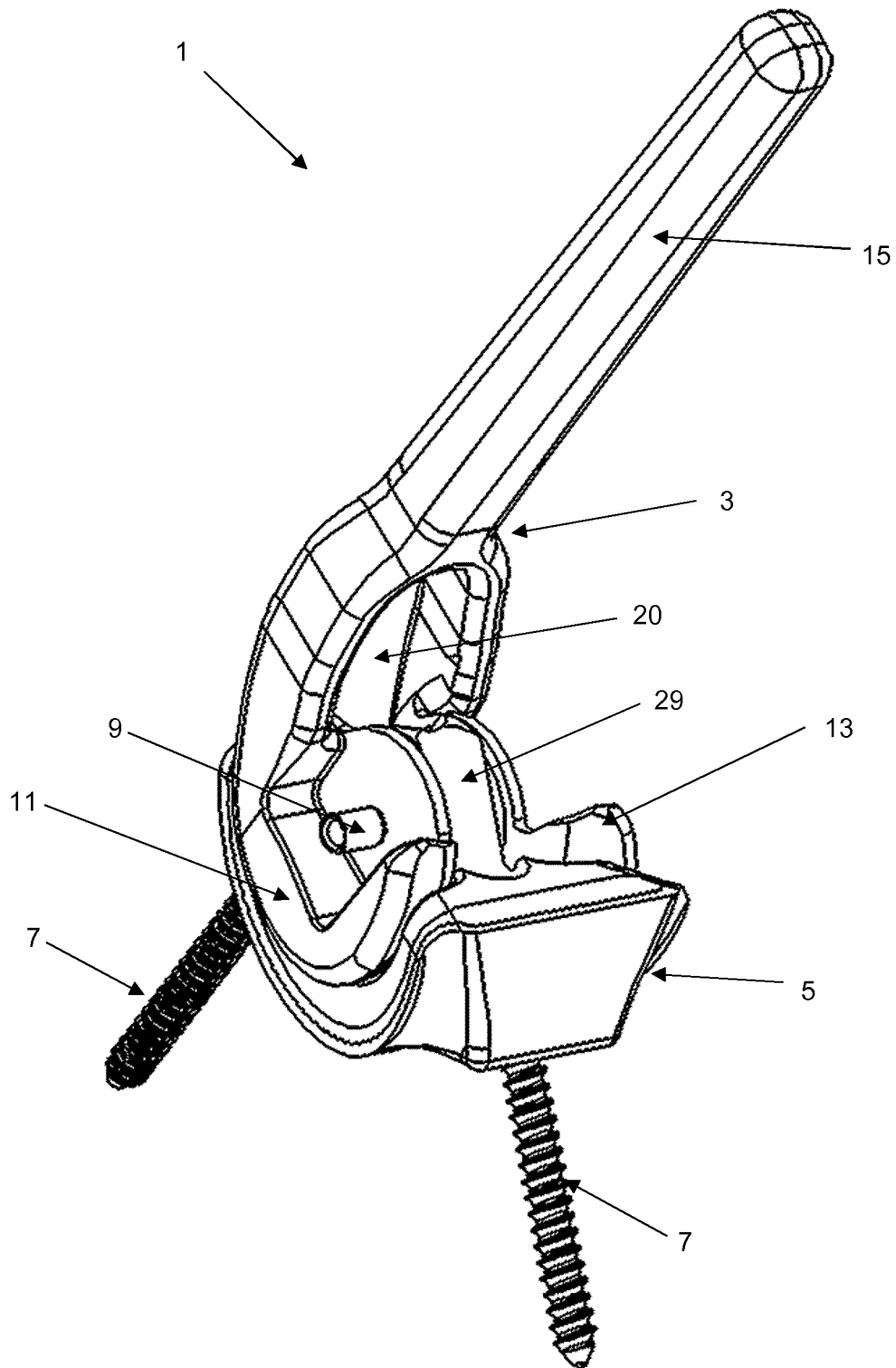


FIGURE 1

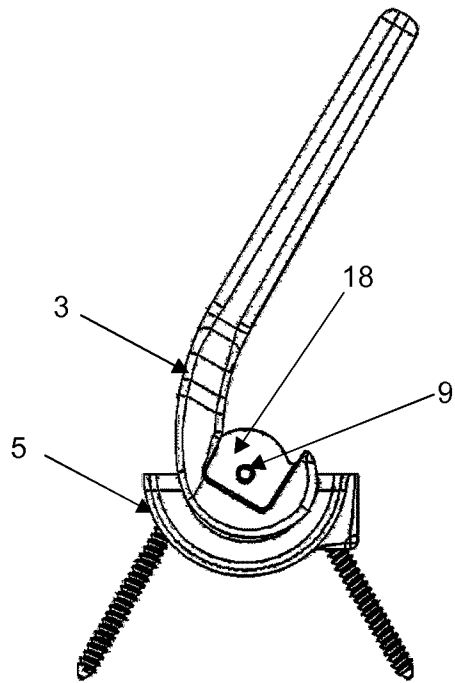


FIGURE 2

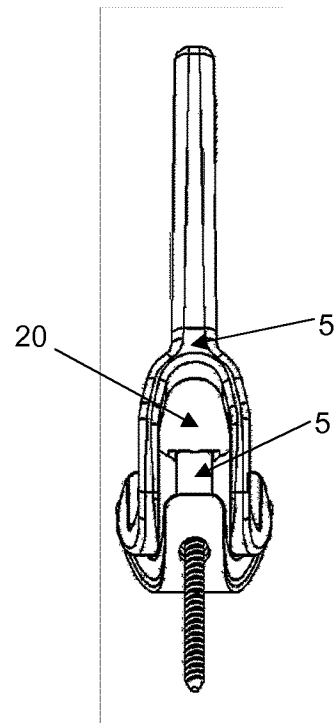


FIGURE 3

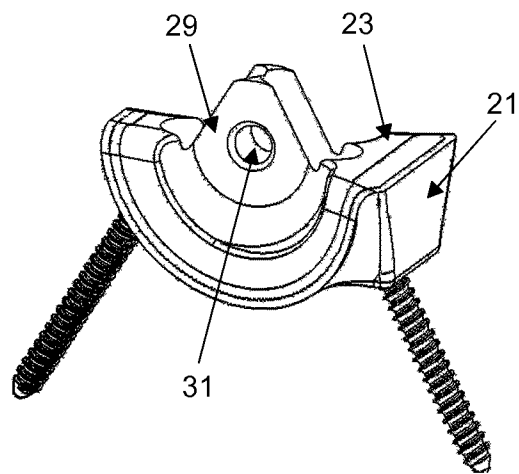


FIGURE 4

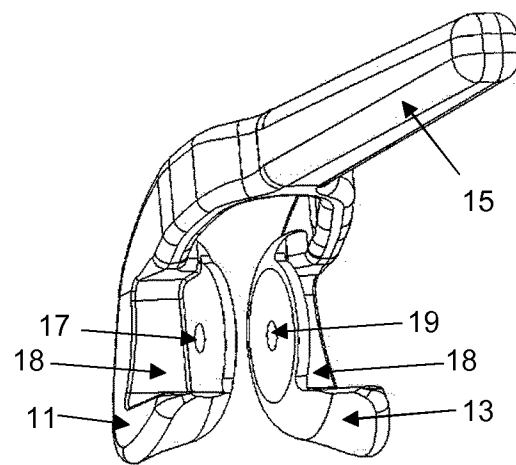


FIGURE 5

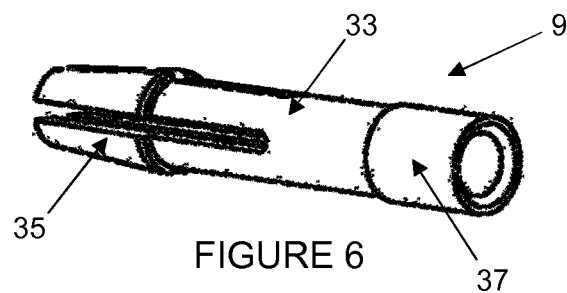


FIGURE 6

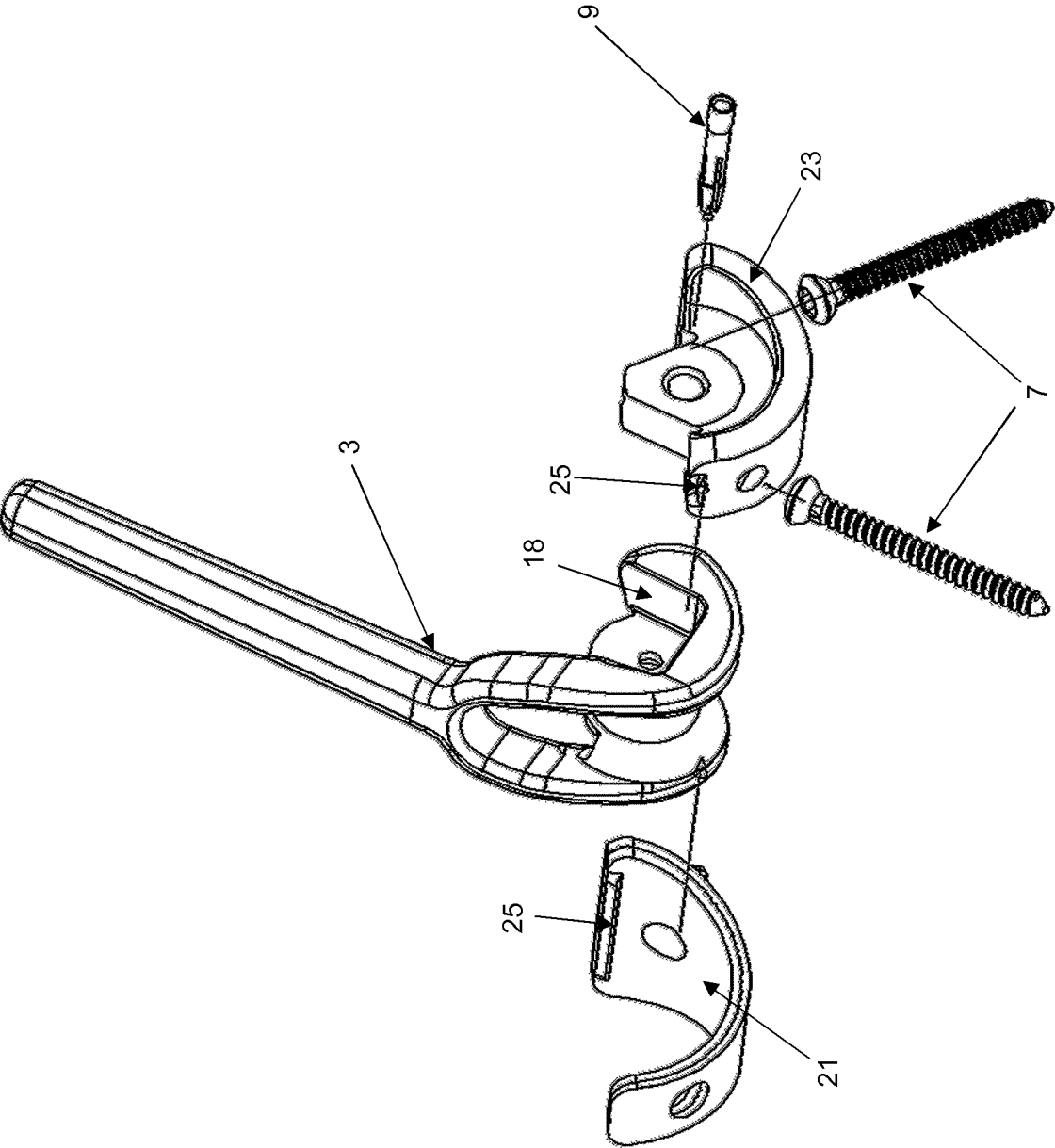


FIGURE 7

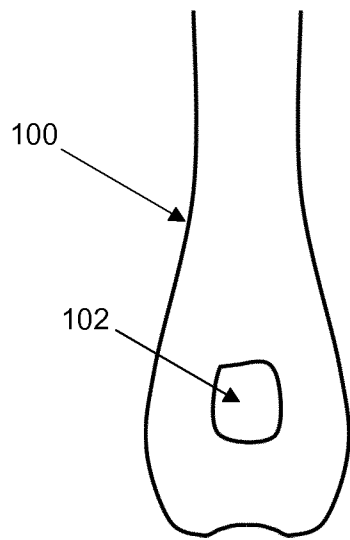


FIGURE 8A

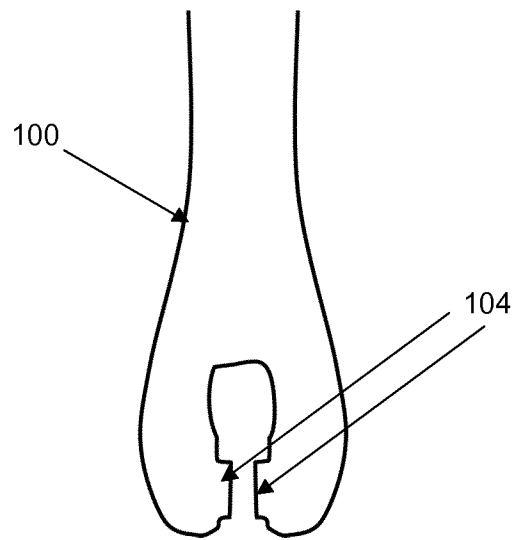


FIGURE 8B

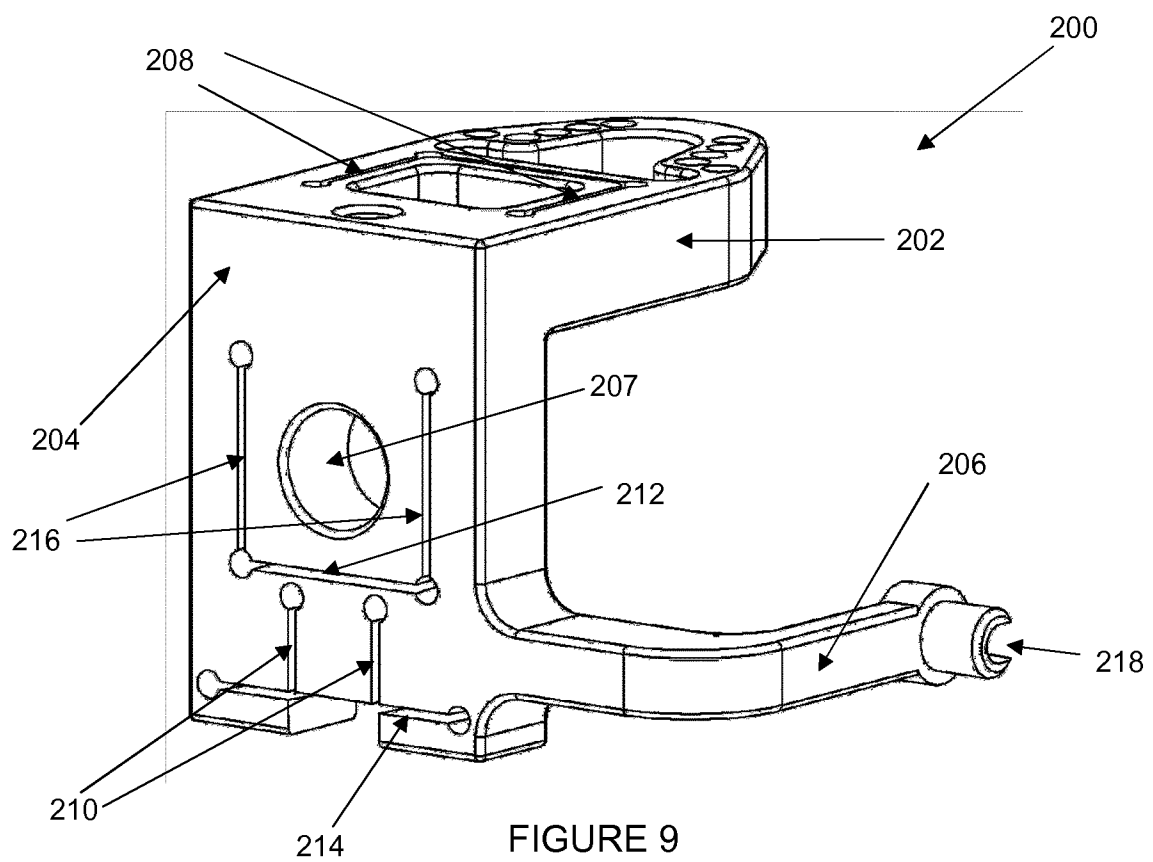


FIGURE 9

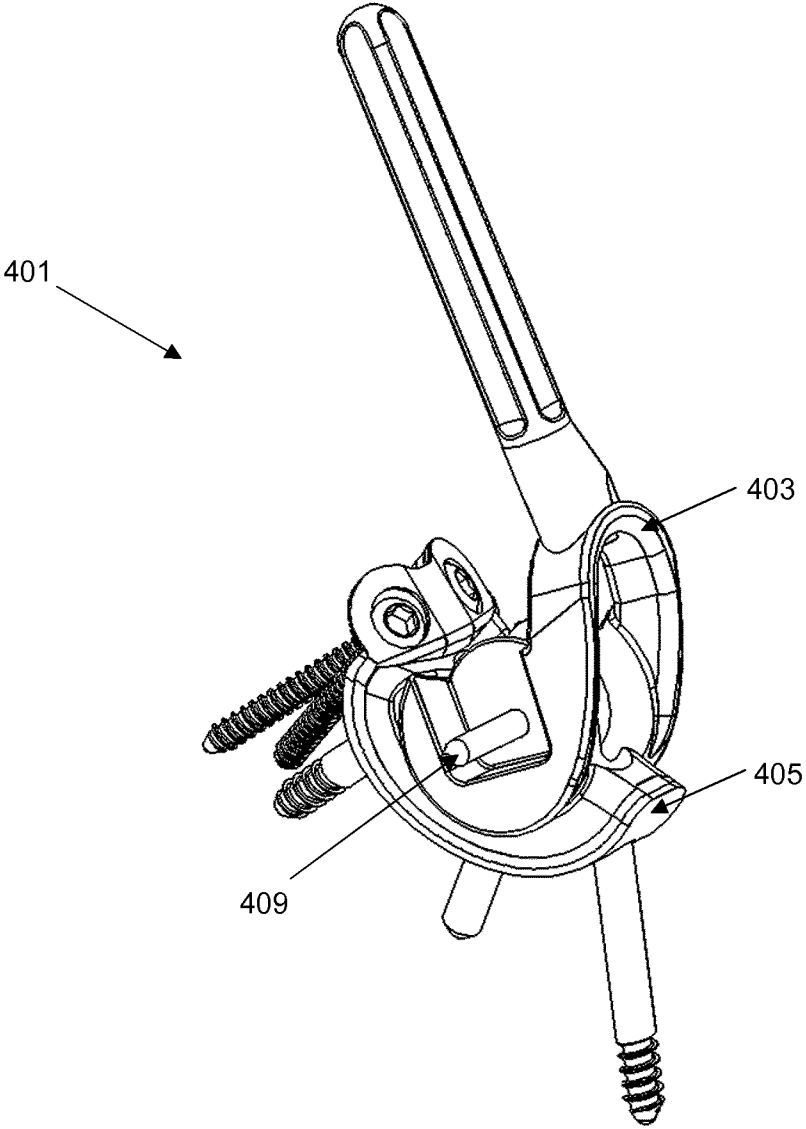
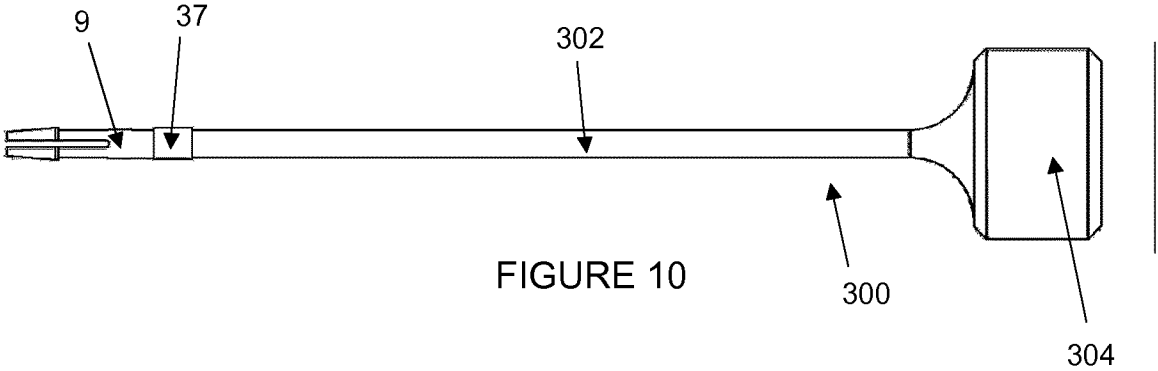


FIGURE 11

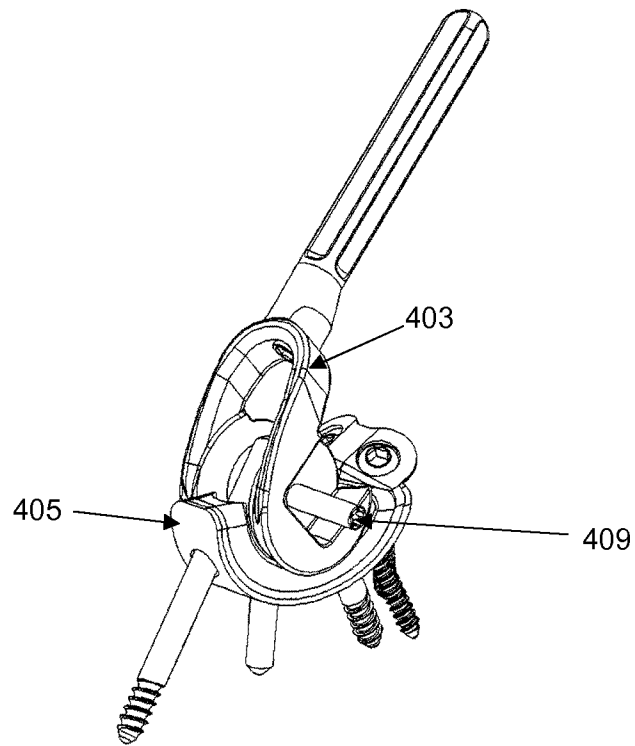


FIGURE 12

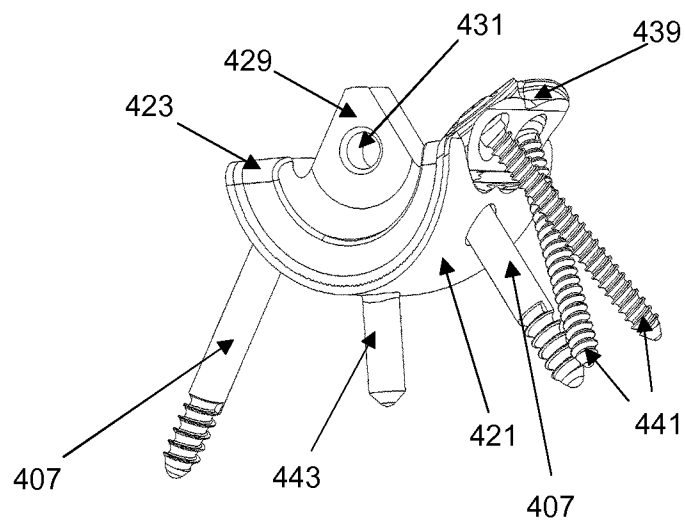


FIGURE 13

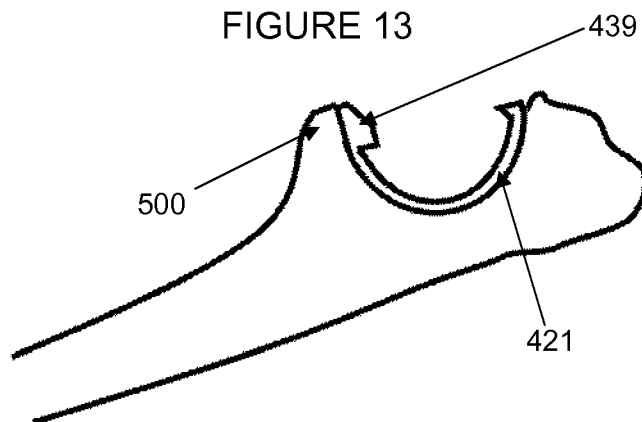


FIGURE 14

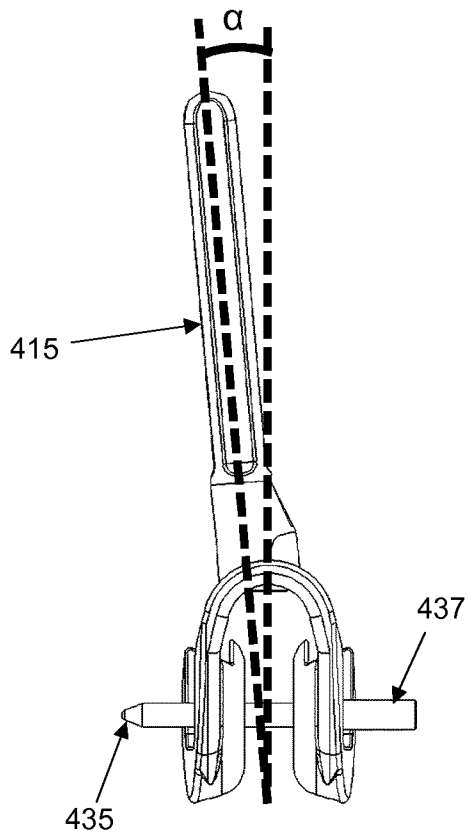


FIGURE 15

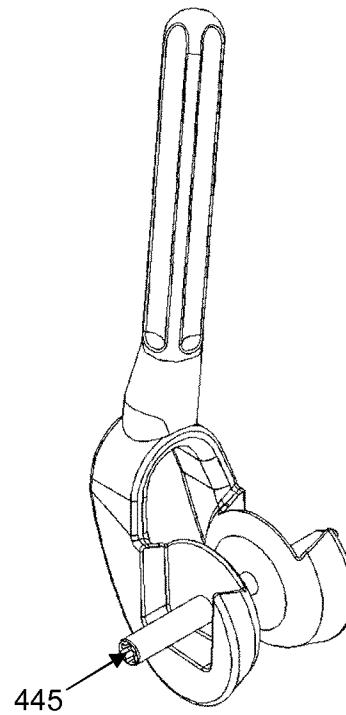


FIGURE 16

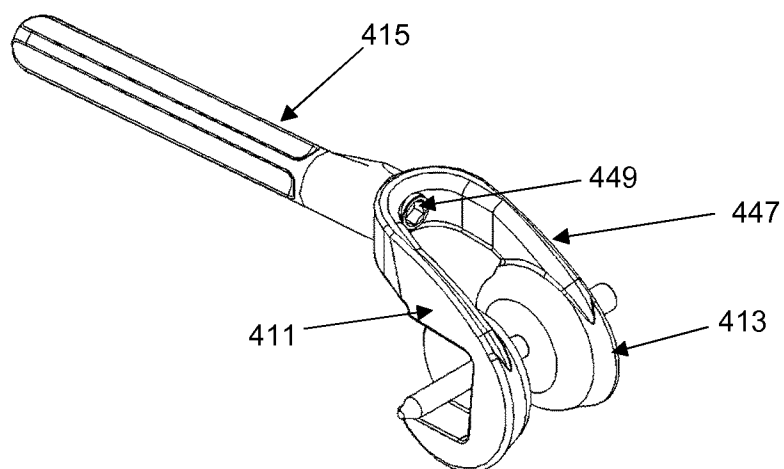


FIGURE 17

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/060496

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61F2/38 A61F2/30 A61B17/16
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61F A61B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	paragraphs [0065] - [0082] -----	3,4
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A	paragraphs [0058] - [0095] -----	3,4,9, 11,12
X	US 4 822 364 A (INGLIS ALLAN E [US] ET AL) 18 April 1989 (1989-04-18)	1,2,6-8, 10,13-17
A	column 2, line 18 - column 3, line 20 column 4, line 3 - column 5, line 38 -----	3-5,9, 11,12
	-/--	



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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search

21 July 2017

Date of mailing of the international search report

08/08/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Mingrino, Alessandra

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/060496

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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X A	----- WO 01/32109 A1 (DAVIES CHRISTOPHER ROBERT [GB]; KRIEK HANS RUDOLF [NL]) 10 May 2001 (2001-05-10) page 8, lines 12-22 page 17, line 27 - page 18, line 10 -----	1-8, 13-17 9-12

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Information on patent family members

International application No

PCT/EP2017/060496

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