(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 October 2023 (12.10.2023)

WIPO | PCT

(10) International Publication Number
WO 2023/194709 A1

(51) International Patent Classification:
A61B 17/80 (2006.01)

(21) International Application Number:
PCT/GB2023/050882

(22) International Filing Date:
03 April 2023 (03.04.2023)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2204880.5 04 April 2022 (04.04.2022) GB

(71) Applicant: **MOLYNEUX ORTHOPAEDICS LTD** [GB/GB]; 37 Leamington Terrace, Edinburgh EH10 4JS (GB).

(72) Inventor: **MOLYNEUX, Samuel Grant**; c/o Molyneux Orthopaedics Ltd, 37 Leamington Terrace, Edinburgh EH10 4JS (GB).

(74) Agent: **BRYER, Pamela**; Marks & Clerk LLP, 40 Torphichen Street, Edinburgh EH3 8JB (GB).

(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, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, 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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, 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, ME, 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: A FIXING MECHANISM FOR FIXING BONES

(57) Abstract: A fixing mechanism for fixing two or more elements together in a defined geometry is disclosed. The fixing mechanism comprises a support plate configured for attachment to at least one of the two or more elements; and at least one locking blade configured for penetration into at least one other of the two or more elements; wherein the at least one locking blade is coupleable to the support plate by a locking screw. The fixing mechanism is particularly suited for fixing bones in a defined geometry.

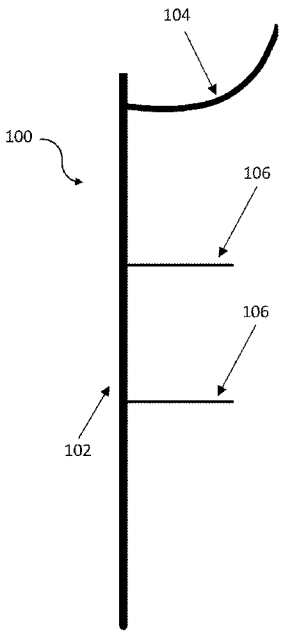

Fig. 1

WO 2023/194709 A1

A FIXING MECHANISM FOR FIXING BONES

FIELD OF DISCLOSURE

The disclosure relates to a fixing mechanism, particularly, but not exclusively, for fixing bones in a defined geometry.

BACKGROUND

Broken bones are usually pinned together using a combination of metal plates and screws.

The plates are generally planar although some anatomical profiling may be incorporated so that the plate generally lies along and follows the shape of a bone surface, with screws provided through holes in the plate to secure the plate to the bone.

Screws with or without threaded heads can be employed. However, by their nature, screws must be inserted into the bone in a straight line, generally perpendicular to the plane of the plate. Whilst this may provide an adequate fixing in some instances, in others, shear stresses caused by a bending force applied to the plate may result in areas of bone adjacent to the screws to fail. This later scenario is particularly common when the break is close to a joint.

Previous attempts to overcome the above have included bending an end of the plate into a straight blade forming a fixed angle (e.g. 90 degrees) with the plate and inserting the blade into the bone to reduce the chance of the plate being subject to a lifting or shearing force. However, this combined plate and blade is difficult to insert into a bone in a desired position due to the fixed angle between the plate and the blade.

The present disclosure therefore seeks to overcome shortcomings of the prior art systems and/or provide a useful alternative.

SUMMARY

One or more aspects of the present disclosure relate to a fixing mechanism for fixing two or more elements together in a defined geometry. Although the fixing mechanism is particularly useful for fixing broken bones, other applications, such as in joinery, are also possible. In general, aspects of the disclosure may be advantageous when a curved screw is required.

In accordance with a first aspect of the disclosure there is provided a fixing mechanism for fixing two or more elements together in a defined geometry, the fixing mechanism comprising:

a support plate configured for attachment to at least one of the two or more elements; and

at least one locking blade configured for penetration into at least one other of the two or more elements;

wherein the at least one locking blade is coupleable to the support plate by a locking screw.

Embodiments of the first aspect of the disclosure therefore relate to a fixing mechanism in which the locking blade and support plate are decoupled from each other. This allows the locking blade to be a linear or non-linear shape and also permits less awkward insertion of the locking blade into one of the elements since manipulation of the locking blade may be independent of the support plate. A locking screw is employed to couple the locking blade to the support plate once both are in a desired position. Accordingly, instead of using a straight screw to fix a plate to an element, a separate locking blade (which may or may not be straight) is used to fix the plate to the element and the screw is used between the plate and blade.

The locking blade may be curved in a direction of penetration. Accordingly, in medical applications, the locking blade may be anatomically-shaped or at least more closely shaped to follow a bone profile. This is particularly advantageous where the elements that require fixing are close to an end of a bone or adjacent a joint. The locking blade may have a single radius of curvature to allow for insertion in a defined passage without the need for any undercuts, thus preserving as much of the element (e.g. bone) as possible and ensuring a tight fit. The radius of curvature may be different for different applications (e.g. different bones or joints). Furthermore, a number of locking blades of

differing sizes (i.e. dimensions) may be provided for use with different elements (e.g. for different sizes of patients).

In some cases, the support plate may be secured to at least one of the two or more elements by only one locking blade. In other cases, more than one locking blade may be coupled to a single support plate. Optionally, one or more screws may be employed (in addition to at least one locking blade) to secure the support plate to at least one of the two or more elements.

The locking blade may comprise a locator configured for engagement in a receiving portion of the support plate and the locking screw is configured to secure the locator in the receiving portion.

The locator and the receiving portion may comprise inter-engaging elements configured to engage in a plurality of different positions such that the locator is receivable in the receiving portion in a plurality of different orientations.

The inter-engaging elements may comprise teeth.

The locator and the receiving portion may comprise complementary star-shapes in cross-section.

The locator may comprise a bore for engagement of at least a portion of the locking screw. The bore may form channel through at least the locator for accommodating a guidewire during a process of fixing the fixing mechanism in place. The channel may extend for the entire length of the locking blade.

The bore may comprise a threaded bore for threaded engagement of at least a portion of the locking screw.

The support plate may comprise a threaded bore for threaded engagement of at least a portion of the locking screw.

The threaded bore of the support plate may be axially aligned with the receiving portion.

The locking screw may comprise a shaft configured for engagement in the bore of the locator and a head configured for engagement in the threaded bore of the support plate.

The locator and the receiving portion may be inwardly tapered (e.g. conical or bowl-shaped) in a direction of penetration of the locking blade. In this case, there may be no need for the locking screw to engage directly with the locator. Instead, the locking screw may simply engage with the support plate to lock the locator in place.

The locator and the receiving portion may be configured to allow for a variation in angle between the locator and the receiving portion. For example, the locator may be locatable within the receiving portion at up to 15 degrees from a central axis (i.e. providing a total of 30 degrees of variation from one extreme to an opposite extreme).

The receiving portion may be configured to limit the variation in angle of the locator when received therein.

The locking screw may comprise an externally threaded disc.

The locking screw may be configured for coupling two or more locking blades to the support plate.

The locking blade may have a hollow cross-section when viewed from the direction of penetration. This may be advantageous in preserving as much bone as possible and ensuing that bone within the hollow cross-section of the locking blade does not die.

The locking blade may have a planar, U-shaped, star-shaped, circular-shaped or rectangular-shaped cross-section when viewed from the direction of penetration (i.e. a distal end). The U-shaped cross-section may comprise substantially squared-off corners. Some cross-sections, like the U-shaped cross-section, may be advantageous in minimising lateral movement of the locking blade during use and for improving or maximising the bending rigidity of the locking blade and support plate (particularly, when compared to a planar blade, for example).

The locking blade may have a U-shaped cross-section when viewed from the direction of penetration and wherein a height of each side of the U-shaped cross-section is tapered

from a highest height at a proximal end of the locking blade to a lowest height at a distal end of the locking blade. Having the highest height at the proximal end provides maximum strength at the proximal end, whilst having the lowest height at the distal end ensures less of the element (e.g. bone) is removed at the tip. In addition, having a small portion at the distal end may result in a sharp tip to aid in penetration (i.e. to help cut a channel for the locking blade to occupy).

The fixing mechanism may be configured for fixing bones in a defined geometry.

The fixing mechanism may be configured for fixing bones in a joint such as an ankle, foot, knee, hip, shoulder, elbow, wrist or hand. Where a locking blade with a U-shaped cross-section is employed, the sides of the U-shaped cross-section may be arranged to extend in a direction away from the joint (i.e. a flat base of the U-shaped cross-section may be provided closest to the joint). This ensures that the greatest support is provided in the area adjacent to the joint. This arrangement may also ensure that the locking blade (or at least a majority of it) is located in the subcortical bone, which sits adjacent to the hard outer cortex of the bone. This may provide a more secure attachment than would be possible with fixation in the softer bone further away from the cortex or joint surface. In some cases, a smaller support plate may be required than would otherwise be the case, due to the increased flexibility of the fixing as provided by the separate locking blade and its non-limited shape.

In accordance with a second aspect of the disclosure there is provided a locking blade for a fixing mechanism as defined above.

In accordance with a third aspect of the disclosure there is provided a method of fixing two or more elements together in a defined geometry, the method comprising:

attaching a support plate to at least one of the two or more elements;

penetrating at least one locking blade into at least one other of the two or more elements; and

coupling the at least one locking blade to the support plate by a locking screw.

The two or more elements may not be body parts. For example, the two or more elements may comprise wood or plastic material.

The two or more elements may be bones. In some cases, the method may comprise drilling an initial hole in the outer (hard) cortical bone and driving the locking blade into the inner (softer) cancellous bone for a better hold therein.

The method may comprise attaching the support plate using at least one screw. The method may comprise drilling at least an initial hole in at least one of the elements, through a hole in the support plate into which the locking blade will be inserted. The method may comprise positioning a centraliser in the hole in the support plate. The method may comprise inserting a guidewire through the hole and into at least one of the elements. The method may comprise using the centraliser to position the guidewire accurately. The method may comprise removing the centraliser and leaving the guidewire in position. The method may comprise inserting the locking blade into the hole in the support plate and passing the locking blade over the guidewire (e.g. by accommodating the guidewire in a channel of the locking blade). Once the locking blade has been penetrated into the at least one element to be fixed, the method may comprise locating the locator in the hole (e.g. receiving portion) of the support plate and removing the guidewire. The method may comprise inserting the locking screw into the hole and screwing the locking screw into at least the support plate to hold the locking blade in position relative to the support plate. Optionally, the method may comprise screwing the locking screw into the locator.

These and other aspects will be apparent from the embodiments described in the following. The scope of the present disclosure is not intended to be limited by this summary nor to implementations that necessarily solve any or all of the disadvantages noted.

Any features described in relation to one aspect of the disclosure may be applied to any one or more other aspect of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

Certain embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a schematic side representation of a fixing mechanism, in accordance with the disclosure;

Figures 2A to 2C show schematic side representations of various locking blades for a fixing mechanism, in accordance with the disclosure;

Figures 3A to 3B show schematic end representations of various locking blades for a fixing mechanism, in accordance with the disclosure;

Figure 4 shows a perspective view of a support plate for a fixing mechanism, in accordance with the disclosure;

Figure 5 shows an example x-ray of a broken ankle;

Figure 6 shows an example x-ray of a prior art fixing mechanism applied to the broken ankle of Figure 5;

Figure 7 shows an example x-ray of a fixing mechanism according to the present disclosure, applied to the broken ankle of Figure 5;

Figure 8 shows an example x-ray of a prior art fixing mechanism applied to a broken elbow;

Figure 9 shows an example x-ray of a fixing mechanism according to the present disclosure, applied to a broken elbow;

Figure 10A shows a schematic side perspective view of a locking blade for a fixing mechanism, in accordance with the disclosure;

Figure 10B shows a schematic front view of the locking blade of Figure 10A;

Figure 11A shows a schematic side cross-sectional view of a portion of a support plate for a fixing mechanism, in accordance with the disclosure;

Figure 11B shows a schematic front view of the portion of the support plate of Figure 11A;

Figure 12A shows a schematic side cross-sectional view of the locking blade of Figures 10A and 10B coupled to the support plate of Figures 11A and 11B, in accordance with the disclosure;

Figure 12B shows a schematic front view of the assembly of Figure 12A, with a transparent locking screw for ease of viewing;

Figure 13 shows a schematic side part cross-sectional view of another locking blade in a process of being coupled to another support plate, in accordance with the disclosure;

Figure 14 shows a method of fixing two or more elements together in a defined geometry, in accordance with the disclosure; and

Figures 15A through 15E show schematic side cross-sectional views showing consecutive steps in a method of fixing two or more elements together in a defined geometry, in accordance with the disclosure.

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific embodiments in which the inventive subject matter may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice them, and it is to be understood that other embodiments may be utilized, and that structural and logical changes may be made without departing from the scope of the inventive subject matter. Such embodiments of the inventive subject matter may be referred to, individually and/or collectively, herein by the term "invention" merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept if more than one is in fact disclosed.

The following description is, therefore, not to be taken in a limited sense, and the scope of the inventive subject matter is defined by the appended claims and their equivalents. In the following embodiments, like components/steps are labelled with like reference numerals.

As used herein, except wherein the context requires otherwise, the terms "comprises", "includes", "has" and grammatical variants of these terms, are not intended to be exhaustive. They are intended to allow for the possibility of further additives, components, integers or steps.

Specific embodiments will now be described with reference to the drawings.

Figure 1 illustrates a schematic side representation of a fixing mechanism 100, in accordance with the disclosure. The fixing mechanism 100 comprises a support plate 102 configured for attachment to a first element of at least two elements (not shown) to be fixed in a defined geometry and a locking blade 104 configured for penetration into at least one other of the at least two elements (not shown). As shown in Figure 1, the locking blade 104 is coupled to the support plate 102. Further details of the coupling between the locking blade 104 and the support plate 102 will be described below. In addition, the support plate 102 is attachable to the first element via two screws 106. #

As shown in Figure 1, the support plate 102 is has a planar longitudinal shape and the two screws 106 are arranged to project perpendicularly with respect to the longitudinal length of the support plate 102. The screws 106 are located, respectively, at approximately two fifths and three fifths of the length of the support plate 102. The locking blade 104 is located proximal to a top end of the support plate 102, as shown. However, the configuration of the support plate 102, screws 106 and locking blade 104 is highly variable and a combination of these components will be chosen to suit specific circumstances, in accordance with the disclosure.

The locking blade 104 initially projects from the support plate 102 in a similar direction to the screws 106 but then forms an arc curving upwardly to a position above the top end of the support plate 102. The position of the distal end of the locking blade 104 is in a plane parallel to the plane of the support plate 102 but further from the plane the of the support plate 102 than terminal ends of the screws 106. In other embodiments, the position of the distal end of the locking blade 104 may be in a plane parallel to the plane of the support plate 102 which is closer to the plane the of the support plate 102 than the terminal ends of the screws 106, or equal to the distance between the terminal ends of the screws 106 and the plane the of the support plate 102. The position of the distal end of the locking blade 104 may be located below the top end of the support plate 102 or may be parallel thereto. The locking blade 104 has a single radius of curvature that subtends an angle of approximately 45 degrees.

Figures 2A to 2C show schematic side representations of various locking blades for a fixing mechanism 100, in accordance with the disclosure. In particular, Figure 2A depicts a locking blade 104a with a higher degree of curvature than the locking blade 104. More specifically, the locking blade 104a has a single radius of curvature that subtends an angle of approximately 90 degrees. Figure 2B depicts a locking blade 104b with a lower degree of curvature than the locking blade 104. More specifically, the locking blade 104b has a single radius of curvature that subtends an angle of approximately 20 degrees. Figure 2C depicts a locking blade 104c with a lower degree of curvature than the locking blade 104b. More specifically, the locking blade 104c has a single radius of curvature that subtends an angle of approximately 10 degrees. In other cases, the locking blade 104 may be straight or may have a radius of curvature that subtends a different angle.

Figures 3A and 3B show schematic end representations of various locking blades for a fixing mechanism 100, in accordance with the disclosure. In particular, Figure 3A depicts a locking blade 104d with a squared U-shaped cross-sectional profile having a base portion 108a and two sidewalls 110a. A width of the base portion 108a is approximately equal to a height of each of the two sidewalls 110a. Figure 3B depicts a locking blade 104e with a squared U-shaped cross-sectional profile having a base portion 108b and two sidewalls 110b. A width of the base portion 108b is approximately two times the width of the base portion 108a and a height of each of the two sidewalls 110b is approximately a quarter of the height of the two sidewalls 110a.

In other cases, the width of the base portion 108 and the height of each of the two sidewalls 110 may be different. In some cases, the width of the base portion 108 may narrow towards a distal end of the locking blade 104. In some cases, the height of the two sidewalls 110 may reduce towards a distal end of the locking blade 104. In some cases, the height of each of the two sidewalls 110 may be different. In some cases, cross-sectional profile of the locking blade 104 may be different. For example, the locking blade 104 may have a cross-sectional profile that is planar, star-shaped, circular-shaped or rectangular-shaped when viewed from the distal end. A hollow cross-sectional profile maybe desired in preserving as much material as possible in the element into which the locking blade 104 penetrates.

In use, a particular configuration of the locking blade 104 (i.e. side and end profile) may be selected to suit the size and shape of the element being fixed. As such, a kit of parts may be provided with a selection of different locking blades 104 for use with one or more support plates 102 (which also may be provided with different sizes or shapes).

Figure 4 shows a perspective view of the support plate 102. As shown, the support plate 102 comprises a longitudinal metal plate 202 comprising a series of holes 204 therethrough. In this case, eight holes 204 are provided along the length of the metal plate 202. The holes 204 may be configured, respectively, for receipt of one of the screws 106 or the locking blade 104. Conveniently, either a screw 106 or a locking blade 104 may be provided in any of the holes 204. In other words, the holes 204 may be configured for receipt of a screw 106 or a locking blade 104, and a user may decide which holes 204 to use and whether to insert a screw 106 or a locking blade 104 into each selected hole 204.

Figure 5 shows an example x-ray 300 of a broken ankle joint 302 in which a distal end of a tibia 304 is broken into a first element 306 and a second element 308sub. There are also several other fracture elements affecting a surface of the ankle joint 302.

Figure 6 shows an example x-ray 400 of a prior art fixing mechanism applied to the broken ankle joint 302 of Figure 5. More specifically, a support plate 402 is attached to the tibia 304 via a plurality of the screws 404. Further screws 404 are provided through the first element 306 and the second element 308 to hold the bones together. However, as shown in Figure 6, because the screws 404 are all straight, many are required to try to hold all of the elements of the bones together in the correct geometry. Also none of the screws 404 can remain close to the joint along the entirety of their length. Remaining close to the joint may be advantageous in achieving a perfect (e.g. optimal) final position of the joint at the end of surgery and at the end of bone healing.

On the contrary, Figure 7 shows an example x-ray 500 of a fixing mechanism 501 according to the present disclosure, applied to the broken ankle joint 302 of Figure 5. The fixing mechanism 500 is similar to that shown in Figure 1 except that the support plate 502 has a profiled end 503 to curve around the distal end of the tibia 304. In addition, three screws 506 are provided to attach the support plate 502 to the tibia 304 and a single curved locking blade 504 is coupled to the profiled end 503 of support plate 502, which penetrates through and secures the first element 306 and the second element 308 in position with the tibia 304. In practice, multiple locking blades 504 may be employed (e.g. in parallel in a lateral direction) although only one is illustrated in Figure 7 for ease of reference. Each locking blade 504 may be attached to the same support plate 502 or multiple support plates 502 may be provided – for example, one for each locking blade 504.

The curved nature of the locking blade 504 is convenient to pass through the subcortical bone at the edge of the tibia 304. Moreover, if the locking blade 504 had a U-shaped profile like the locking blades 104d, 104e of Figures 3A or 3B, the base portion 108 may be provided closest to the ankle joint with the sidewalls 110 extending upwardly into the tibia 304 for increased stability. Accordingly, a much neater and simpler arrangement is possible using the fixing mechanism 501, with much stronger and more accurate fixation of the articular surface (the most important part of the fixation in terms of patient outcomes), when compared to the prior art arrangement of Figure 6.

Figure 8 shows an example x-ray 600 of a prior art fixing mechanism applied to a broken elbow 601. More specifically, a support plate 602 with a curved end 602a is attached to the ulna 603 via a plurality of perpendicularly extending screws 606. Further screws 608 are provided through the curved end 602a to be approximately orthogonal to the screws 606 to hold the bone together. However, as shown in Figure 8, because the screws 606 and 608 are all straight, the support plate 602 is relatively large and many screws 606 and 608 are required to try to hold all of the elements of the bone together in the correct geometry. It is also the case that approximately 50% of support plates (like the one shown in Figure 8), have to be removed as they prominent under the skin.

As shown, in Figure 9, use of a fixing mechanism 700 according to the present disclosure would reduce the chance of a support plate 702 being prominent under the skin as a much smaller support plate 702 could be used. More specifically, the support plate 702 may extend only over the curved end of the ulna 603 with a single long screw 706 securing the support plate 702 to the ulna 603 by extending longitudinally therein. A curved locking blade 704 is provided, coupled to a top end of the support plate 702 and following the curvature of the end of the ulna 603. Accordingly, a much neater and simpler arrangement is possible using the fixing mechanism 700, when compared to the prior art arrangement of Figure 8.

Figures 10A and 10B show a locking blade 800 for a fixing mechanism, in accordance with the disclosure. The locking blade 800 comprises a blade portion 802 for penetration into an element to be fixed or joined to another element (not shown) and a locator 804 for engagement in a receiving portion of a support plate (as will described below).

The blade portion 802 has a single radius of curvature that subtends an angle of approximately 30 degrees (although other angles may be used to suit different applications). A cross-section of the blade portion 802 is U-shaped having sidewalls 806 that are highest adjacent the locator 804 and lowest at a distal tip of the blade portion 802.

The locator 804 is generally cylindrical and has a star-shaped outer profile in cross-section comprising a plurality of triangular longitudinal ridges or teeth 808. The teeth 808 are configured for inter-engagement in a complementary shaped receiving portion of a support plate (as will described below). The locator 804 also comprises a threaded bore

810 for engagement with a locking screw (as will described below). In some cases, the bore 810 need not be threaded. The bore 810 also forms a channel through the locator 804 for accommodating a guidewire during a process of fixing the fixing mechanism in place. The channel may extend into a hollow area of the blade portion 802 for accommodating the guidewire along an entire length of the locking blade 800.

Figures 11A and 11B show a portion of a support plate 900 for a fixing mechanism, in accordance with the disclosure. The support plate 900 comprises a hole 204 including a receiving portion 902 for receipt of the locator 804 and a threaded bore 904 for threaded engagement of at least a portion of a locking screw (as will described below). As best shown in Figure 11B, the receiving portion 902 has a complementary star-shaped cross-section having triangular longitudinal ridges 906 to engage with the teeth 808 of the locator 804.

In this case, the threaded bore 904 of the support plate 900 is axially aligned with the receiving portion 902. In other cases, a single threaded bore 904 may be provided to encompass two or more receiving portions 902.

Figures 12A and 12B show the locking blade 800 of Figures 10A and 10B coupled to the support plate 900 of Figures 11A and 11B to form a fixing mechanism 1000, in accordance with the disclosure. A locking screw 1010 is provided to couple the locking blade 800 to the support plate 900. More specifically, the locking screw 1010 is configured to secure the locator 804 in the receiving portion 902 to couple the locking blade 800 to the support plate 900. As mentioned above, the locator 804 and the receiving portion 902 comprise inter-engaging star-shaped profiles configured to engage in a plurality of different positions such that the locator 804 is receivable in the receiving portion 902 in a plurality of different orientations. However, once an orientation has been determined and the inter-engaging elements engaged, the star-shaped profiles prevent relative rotation thereby providing rotational stability.

The locking screw 1010 comprises a shaft 1012 configured for threaded engagement in the bore 810 of the locator 804 and a head 1014 configured for threaded engagement in the threaded bore 904 of the support plate 900.

Figure 13 shows a schematic side cross-sectional view of another locking blade 800' in a process of being coupled to another support plate 900' to form another fixing mechanism 1100, in accordance with the disclosure.

In this case, the locator 804' and the receiving portion 902' are inwardly tapered (e.g. bowl-shaped) in a direction of penetration of the locking blade 800'. In which case, there is no need for the locking screw 1010 to engage directly with the locator 804'. Instead, the locking screw 1010 may simply engage with the support plate 900' to lock the locator 804' in place. In other words, the bore 810 of the locator 804' may not be threaded and the threaded shaft 1012 may simply be accommodated in the bore 810. Alternatively, the locking screw 1010 need not comprise a shaft 1012 and may simply comprise a threaded head 1014 or disc. In which case, a single (large) locking screw head 1014 may be configured for coupling two or more adjacent locking blades 800' to the support plate 900'.

As shown in Figure 13, the locator 804' and the receiving portion 902' comprise complementary ribs or teeth 808 along the contour of the bowl-shape to prevent rotational movement when in a desired relative orientation. However, when the receiving portion 902' is larger than the locator 804' a variation in angle between the locator 804' and the receiving portion 902' may be accommodated. For example, the locator 804' may be locatable within the receiving portion 902' at up to 15 degrees from a central axis (i.e. providing a total of 30 degrees of variation from one extreme to an opposite extreme). The receiving portion 902' may be configured (e.g. sized or shaped) to limit the variation in angle of the locator 802' when received therein.

Figure 14 shows a method 1200 of fixing two or more elements together in a defined geometry, in accordance with the disclosure. The method 1200 comprises a step 1202 of attaching a support plate to at least one of the two or more elements. A step 1204 of penetrating at least one locking blade into at least one other of the two or more elements and a step 1206 of coupling the at least one locking blade to the support plate by a locking screw.

The two or more elements may or may not be body parts. For example, the two or more elements may comprise bone, wood or plastic material.

Figures 15A through 15E show schematic side cross-sectional views showing consecutive steps in a method 1300 of fixing two or more elements, in this case bones, together in a defined geometry, in accordance with the disclosure.

Firstly, the support plate 900 is attached to at least one of the elements, using at least one screw. As shown in Figure 15A, the method 1300 then comprises uses a drill bit 1302 to drill at least an initial hole in at least one of the elements (e.g. in the near cortex), through a hole 204 in the support plate 900 into which the locking blade 800 will be inserted.

As shown in Figure 15B, a centraliser 1304 is then used, which is screwed into the hole 204 in the support plate 900. As shown in Figure 15C, a guidewire 1306 is then inserted through the centraliser 1304 and into at least one of the elements. The centraliser 1304 is used to position the guidewire 1306 accurately, although it is also possible to not use the centraliser 1304 or the guidewire 1306. Once the guidewire 1306 has been inserted, the centraliser 1304 is removed leaving the guidewire 1306 in position. Notably, in this case, the guidewire 1306 is curved and follows the path that the locking blade 800 should follow in the element being fixed.

It is also noted that the centraliser 1304 may comprise a cone 1308 and the cone 1308 may have an angle configured to limit an angle permitted for insertion of the guidewire 1306 so that the locator 804 and the locking screw 1010 will end up suitably positioned for secure attachment to the support plate 900, in a desired position.

As shown in Figure 15D, the locking blade 800 is then inserted into the hole 204 in the support plate 900 with the guidewire accommodated in the hollow channel and bore 810 of the locking blade 800. Once the locking blade 800 has been penetrated into the at least one element to be fixed, the locator 804 will be positioned in the hole 204 (e.g. receiving portion 902) of the support plate 900 and the guidewire 1306 removed.

As shown in Figure 15E, the locking screw 1010 will then be inserted into the hole 204 and will be screwed into at least the support plate 900 to hold the locking blade 800 in position relative to the support plate 900. Optionally, the locking screw 1010 may also be screwed into the locator 804.

Accordingly, the disclosure relates generally to a fixing mechanism and method in which the locking blade and support plate are decoupled from each other, allowing the locking blade to be a linear or non-linear shape and permitting less awkward insertion of the locking blade into the elements to be fixed since positioning of the locking blade may be largely independent of the support plate. A locking screw is employed to couple the locking blade to the support plate once both are in a desired position. Accordingly, instead of using a straight screw to fix a plate to an element, a separate locking blade (which may or may not be straight) is used to fix the plate to the element and the screw is used between the plate and the blade.

Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims. Furthermore, features described in relation to one embodiment may be mixed and matched with features from one or more other embodiments, within the scope of the claims.

CLAIMS:

1. A fixing mechanism for fixing two or more elements together in a defined geometry, the fixing mechanism comprising:

a support plate configured for attachment to at least one of the two or more elements; and

at least one locking blade configured for penetration into at least one other of the two or more elements;

wherein the at least one locking blade is coupleable to the support plate by a locking screw.

2. The fixing mechanism of claim 1 wherein the locking blade is curved in a direction of penetration.

3. The fixing mechanism of claim 1 or 2 wherein the locking blade comprises a locator configured for engagement in a receiving portion of the support plate and the locking screw is configured to secure the locator in the receiving portion.

4. The fixing mechanism of claim 3 wherein the locator and the receiving portion comprise inter-engaging elements configured to engage in a plurality of different positions such that the locator is receivable in the receiving portion in a plurality of different orientations.

5. The fixing mechanism of claim 4 wherein the inter-engaging elements comprise teeth.

6. The fixing mechanism of claim 4 or 5 wherein the locator and the receiving portion comprise complementary star-shapes in cross-section.

7. The fixing mechanism of any of claims 3 to 6 wherein the locator comprises a bore for engagement of at least a portion of the locking screw.

8. The fixing mechanism of claim 7 wherein the bore is a threaded bore for threaded engagement of at least a portion of the locking screw.

9. The fixing mechanism of any preceding claim wherein the support plate comprises a threaded bore for threaded engagement of at least a portion of the locking screw.

10. The fixing mechanism of claim 9, when dependent on any of claims 2 to 8, wherein the threaded bore of the support plate is axially aligned with the receiving portion.

11. The fixing mechanism of claim 10, when dependent on claim 7, wherein the locking screw comprises a shaft configured for engagement in the bore of the locator and a head configured for engagement in the threaded bore of the support plate.

12. The fixing mechanism of any of claims 2 to 6 wherein the locator and the receiving portion are inwardly tapered in a direction of penetration of the locking blade.

13. The fixing mechanism of claim 12 wherein the locator and the receiving portion are configured to allow for a variation in angle between the locator and the receiving portion.

14. The fixing mechanism of claim 13 wherein the receiving portion is configured to limit the variation in angle of the locator when received therein.

15. The fixing mechanism of any of claims 12 to 14 wherein the locking screw comprises an externally threaded disc.

16. The fixing mechanism of any preceding claim wherein the locking screw is configured for coupling two or more locking blades to the support plate.

17. The fixing mechanism of any preceding claim wherein the locking blade has a hollow cross-section when viewed from the direction of penetration.

18. The fixing mechanism of any preceding claim wherein the locking blade has a U-shaped, star-shaped, circular-shaped or rectangular-shaped cross-section when viewed from the direction of penetration.

19. The fixing mechanism of claim 18 wherein the locking blade has a U-shaped cross-section when viewed from the direction of penetration and wherein a height of each side of the U-shaped cross-section is tapered from a highest height at a proximal end of the locking blade to a lowest height at a distal end of the locking blade.

20. The fixing mechanism of any preceding claim configured for fixing bones in a defined geometry.

21. The fixing mechanism of claim 20 configured for fixing bones in an ankle, foot, knee, hip, shoulder, elbow, wrist or hand.

22. A locking blade for a fixing mechanism according to any preceding claim.

23. A method of fixing two or more elements together in a defined geometry, the method comprising:

attaching a support plate to at least one of the two or more elements;

penetrating at least one locking blade into at least one other of the two or more elements; and

coupling the at least one locking blade to the support plate by a locking screw.

24. The method of claim 23 wherein the two or more elements are not body parts.

25. The method of claim 23 wherein the two or more elements are bones.

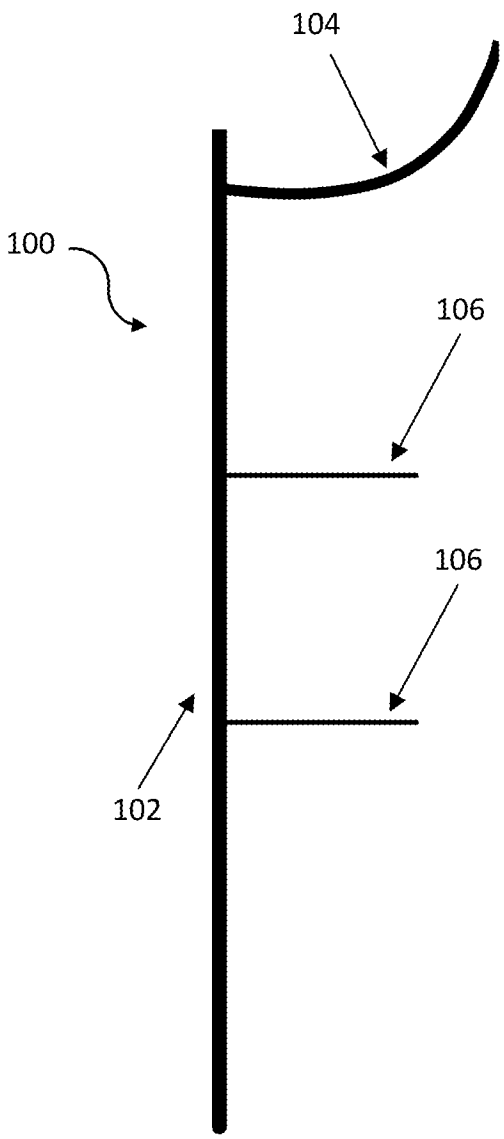

Fig. 1

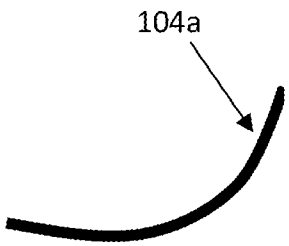

Fig. 2A

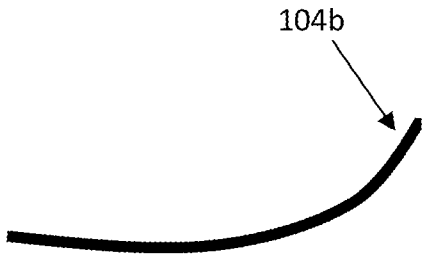

Fig. 2B

Fig. 2C

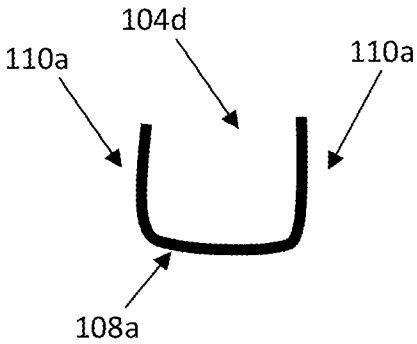

Fig. 3A

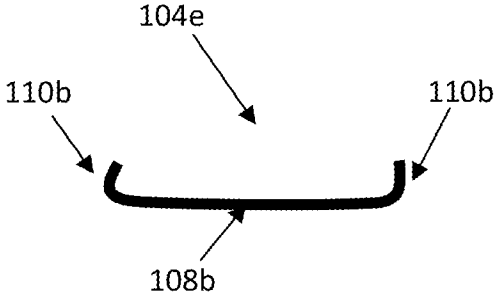

Fig. 3B

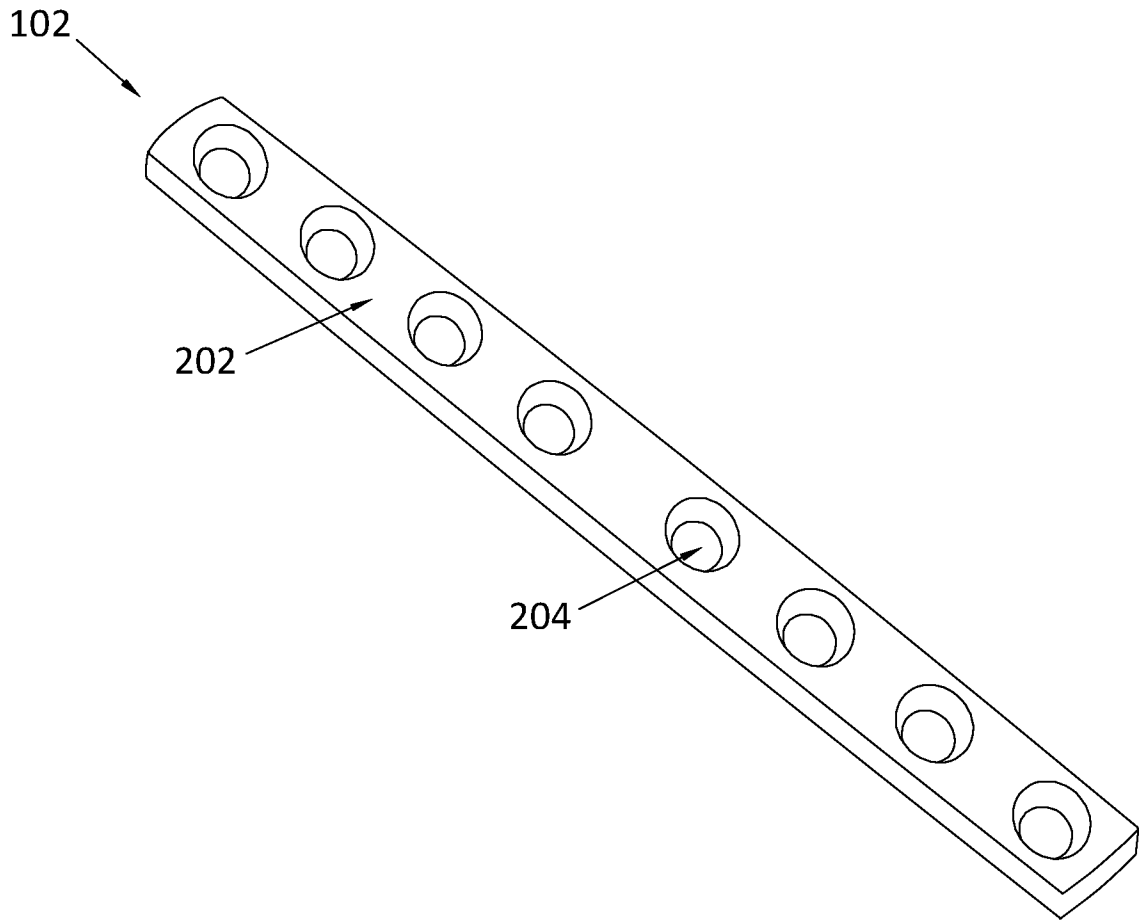

Fig. 4

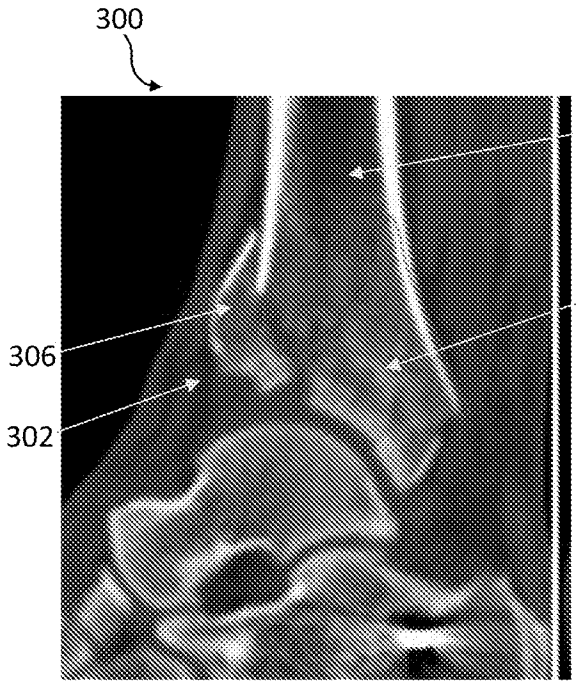

Fig. 5

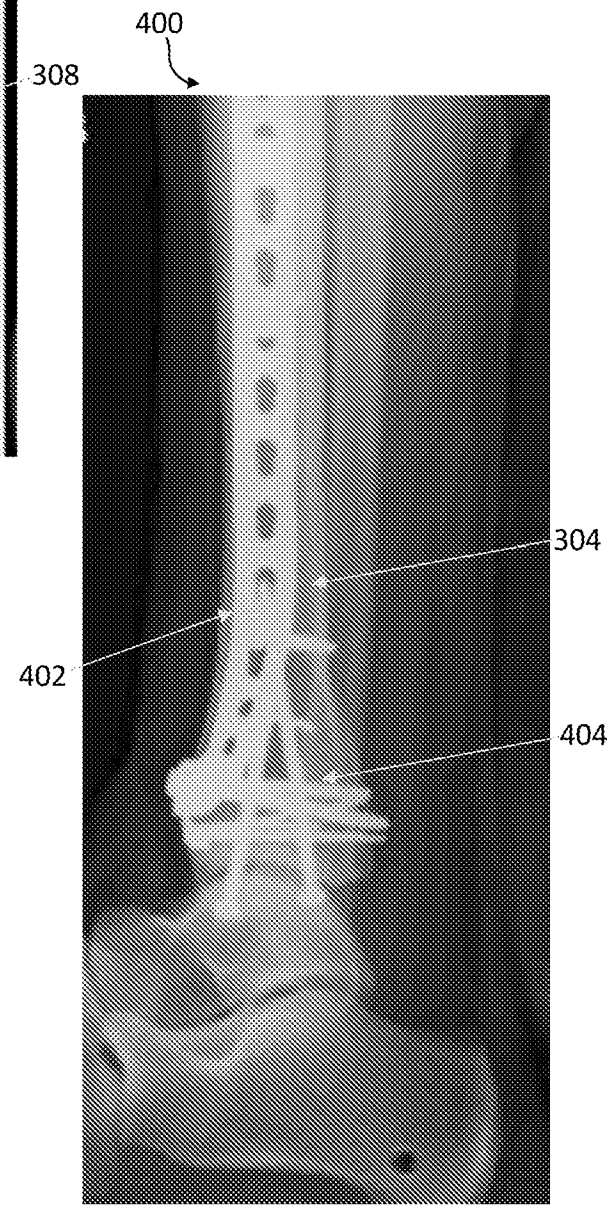

Fig. 6
PRIOR ART

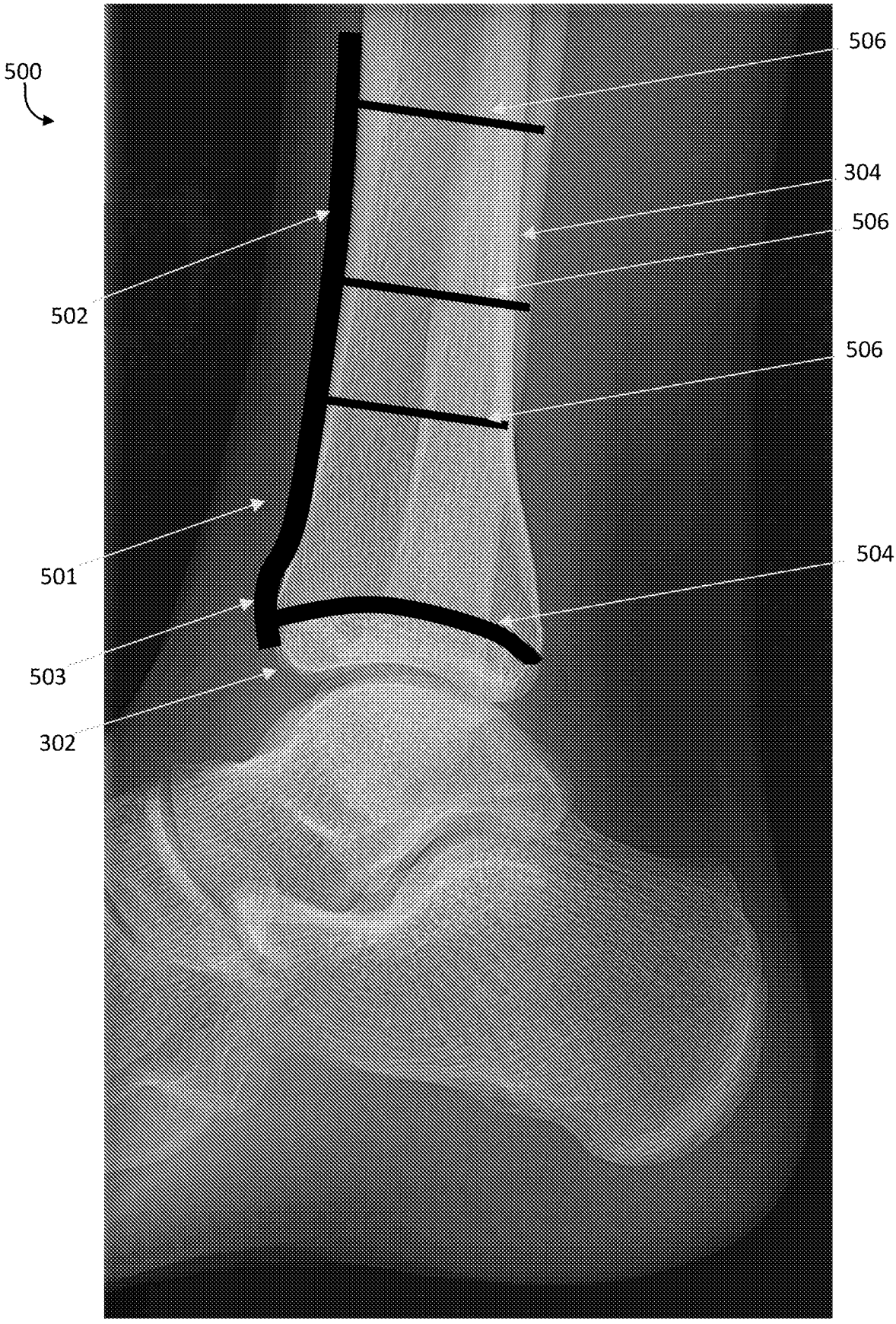

Fig. 7

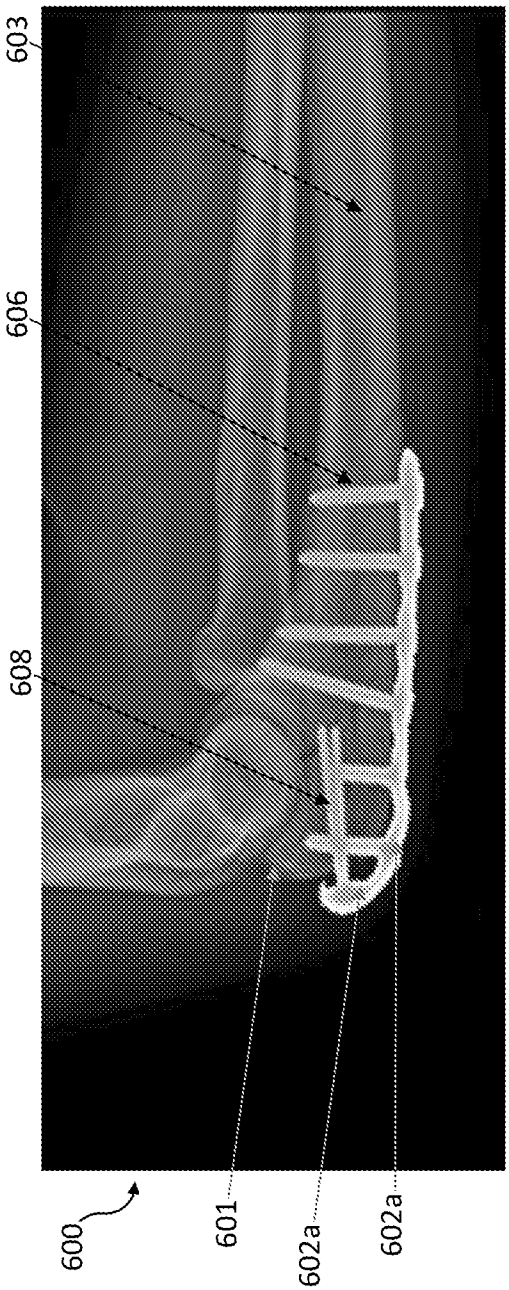

Fig. 8
PRIOR ART

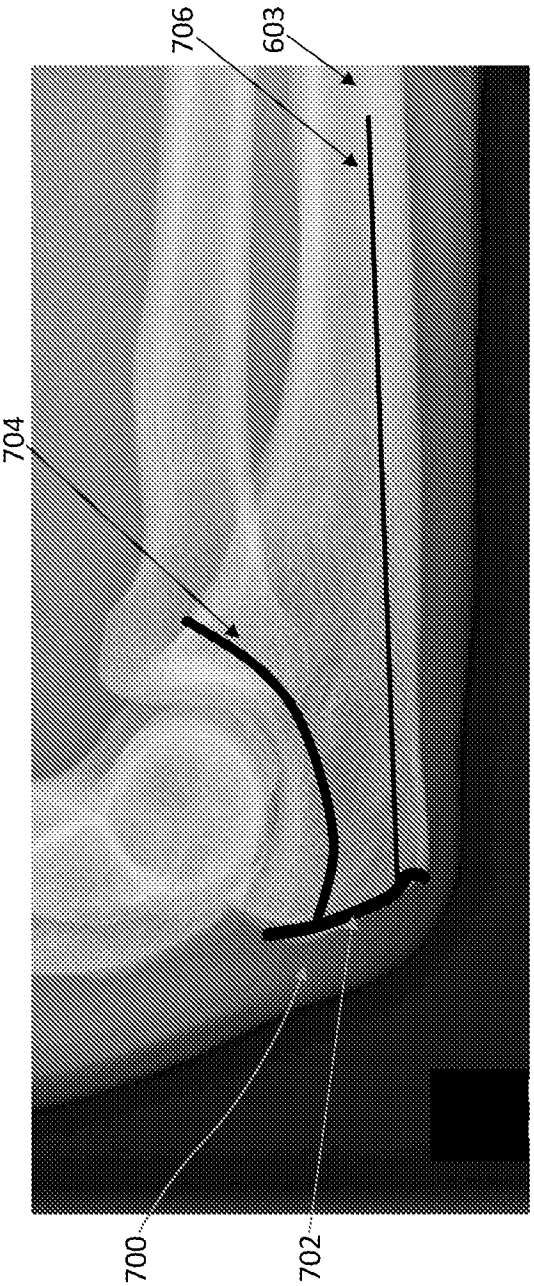

Fig. 9

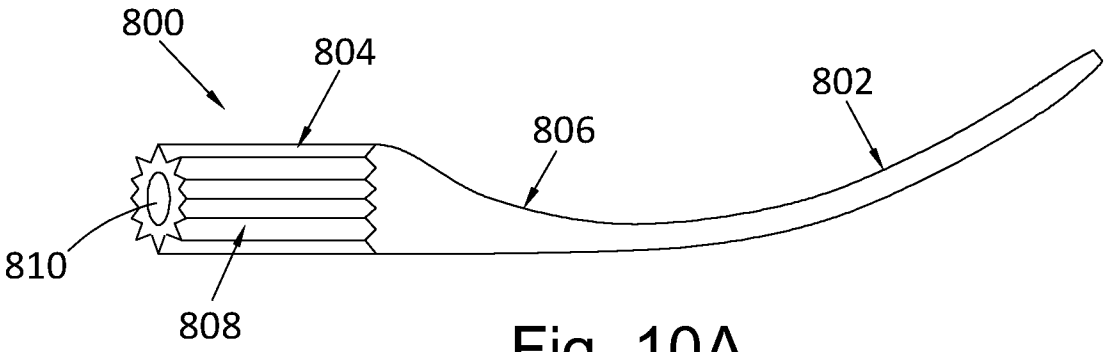

Fig. 10A

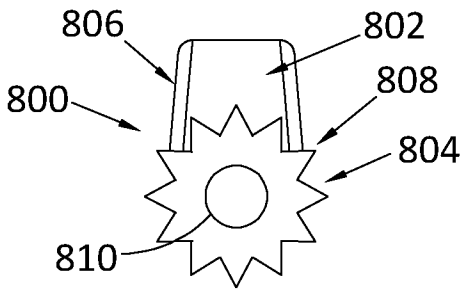

Fig. 10B

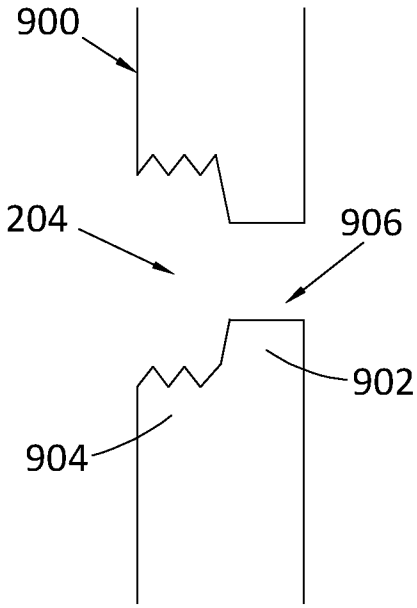

Fig. 11A

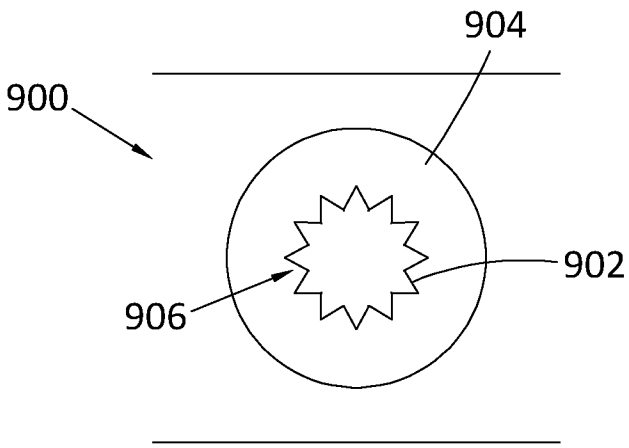

Fig. 11B

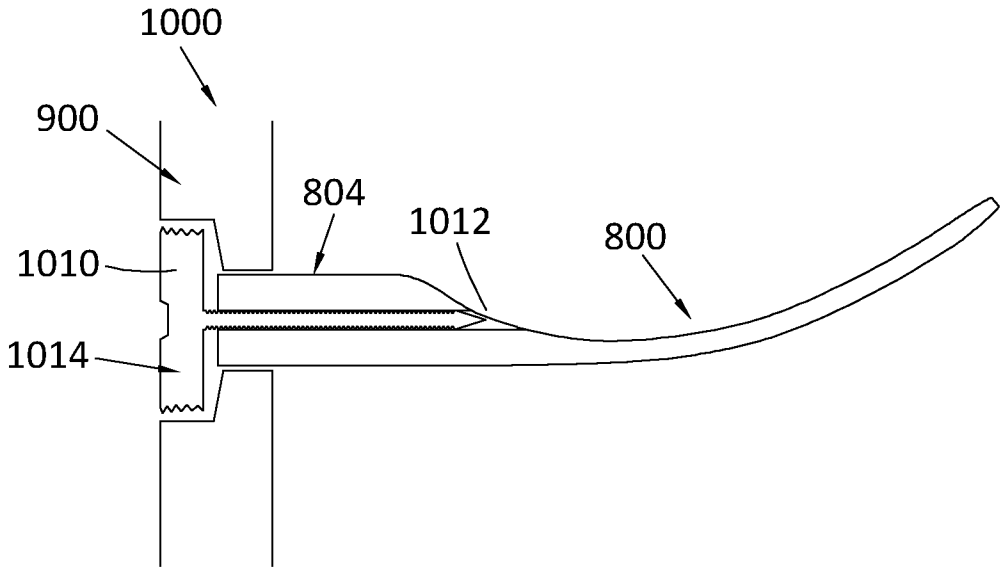

Fig. 12A

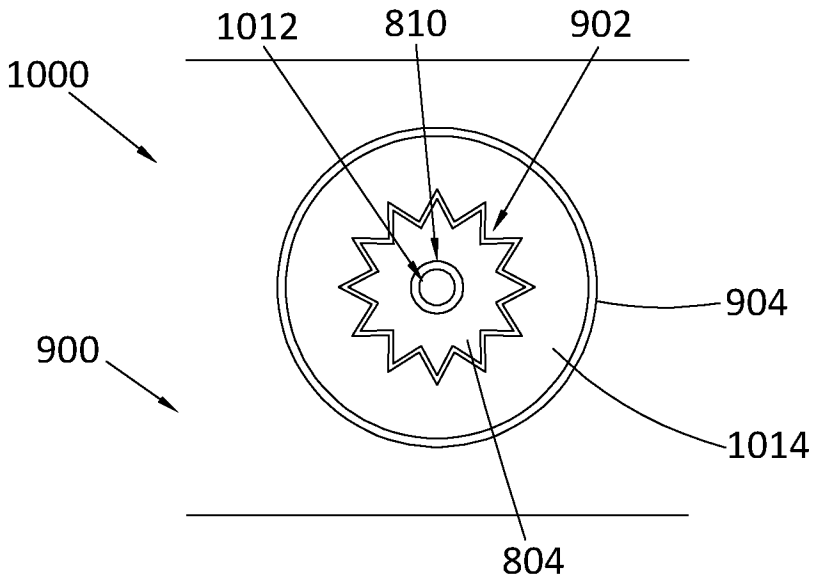

Fig. 12B

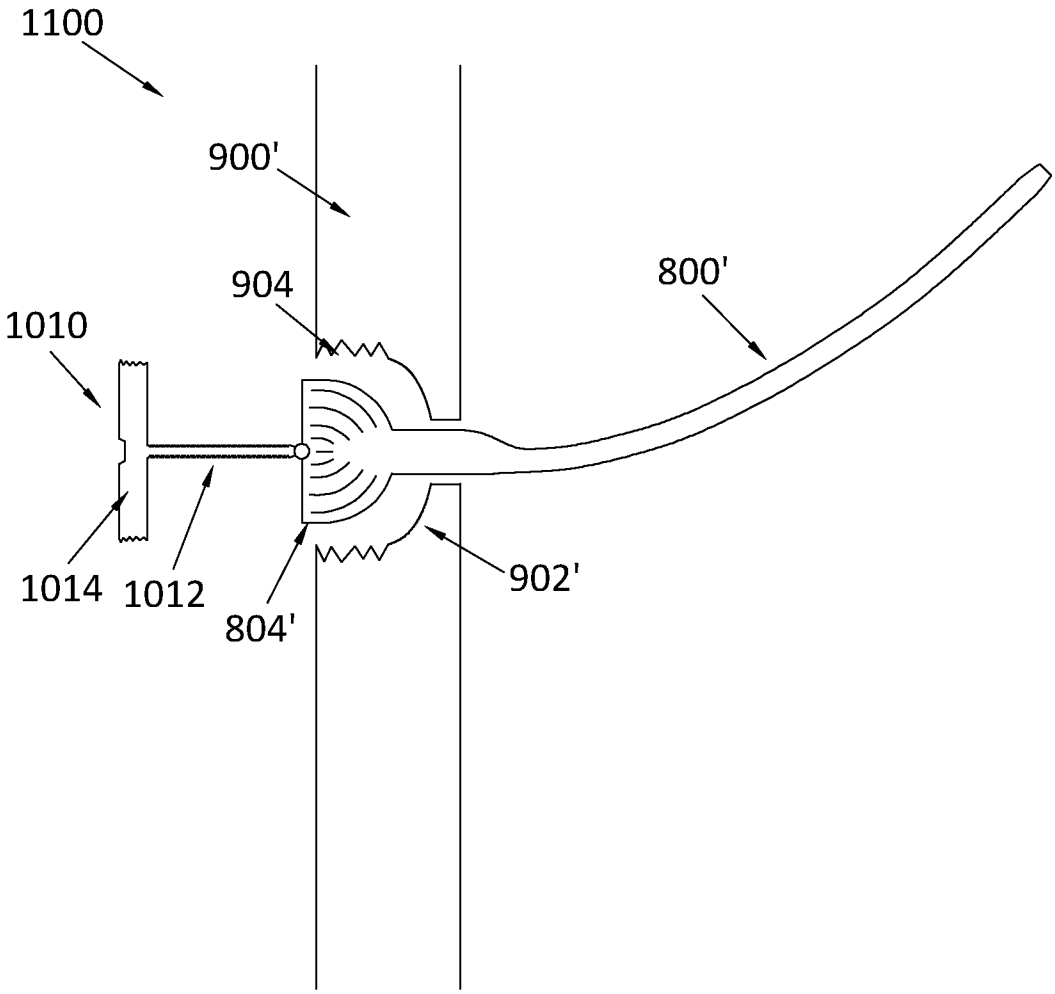

Fig. 13

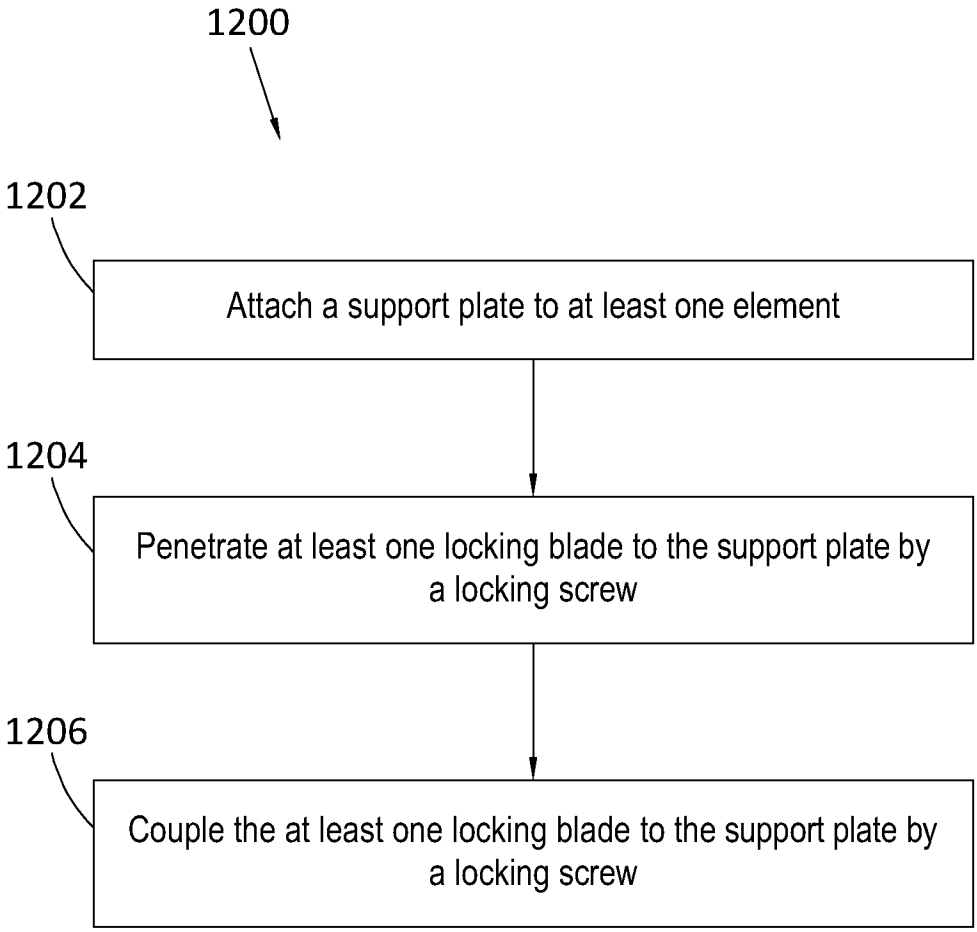
1200
1202
Attach a support plate to at least one element
1204
Penetrate at least one locking blade to the support plate by a locking screw
1206
Couple the at least one locking blade to the support plate by a locking screw

Fig. 14

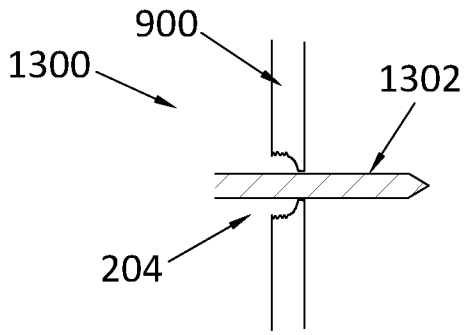

Fig. 15A

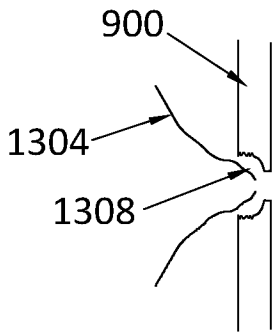

Fig. 15B

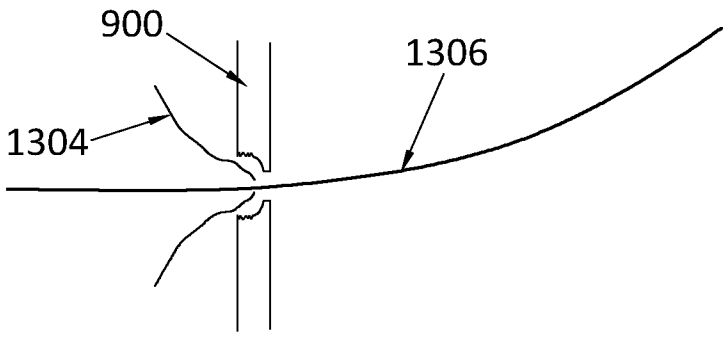

Fig. 15C

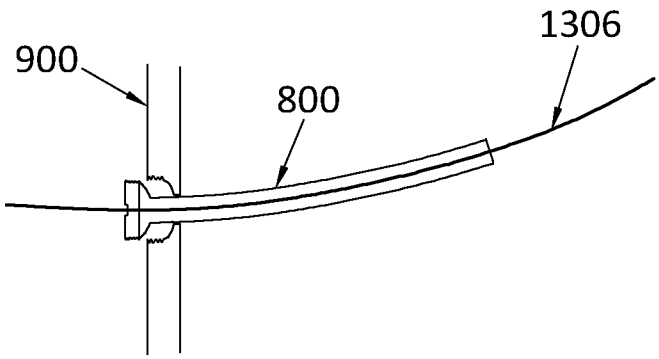

Fig. 15D

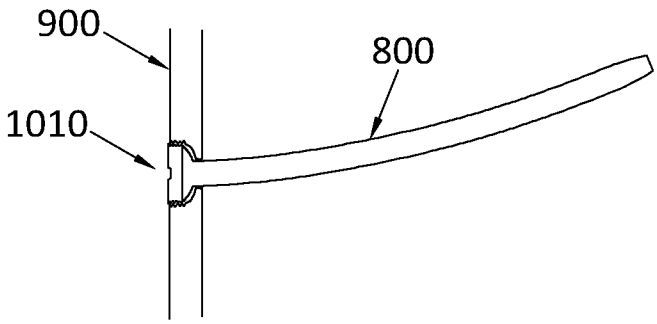

Fig. 15E

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2023/050882

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/80
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)
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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 006 120 A (CARTER PETER R [US]) 9 April 1991 (1991-04-09)	1-11,15, 16,18-22
A	column 2, line 46 - column 4, line 15; figures 1,1a,2-4 column 5, line 30 - line 37	12-14

X	US 2016/066968 A1 (ORSAK JAMES [CA] ET AL) 10 March 2016 (2016-03-10)	1,3,7,8, 12,15, 18,20-22
	paragraph [0055] - paragraph [0057]; figures 11-18 paragraph [0050] - paragraph [0052]; figures 1-4	

X	US 2021/401475 A1 (LUETH JEFFREY S [US] ET AL) 30 December 2021 (2021-12-30)	1,9, 20-22
A	paragraph [0167] - paragraph [0182]; figures 31-44	10-19

☐ 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
5 July 2023	13/07/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Filali, Salima

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2023/050882

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 23-25
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT)

2. [ ] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims;; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2023/050882

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5006120 A	09-04-1991	CA 2026268 A1	11-04-1991
		CH 680562 A5	30-09-1992
		US 5006120 A	09-04-1991
US 2016066968 A1	10-03-2016	AU 2015316132 A1	20-04-2017
		CA 2960304 A1	17-03-2016
		EP 3191001 A1	19-07-2017
		ES 2770084 T3	30-06-2020
		US 2016066968 A1	10-03-2016
		WO 2016037272 A1	17-03-2016
US 2021401475 A1	30-12-2021	US 2018289402 A1	11-10-2018
		US 2019365437 A1	05-12-2019
		US 2021401475 A1	30-12-2021