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(54) Title: MEDICAL BONE CLAMP

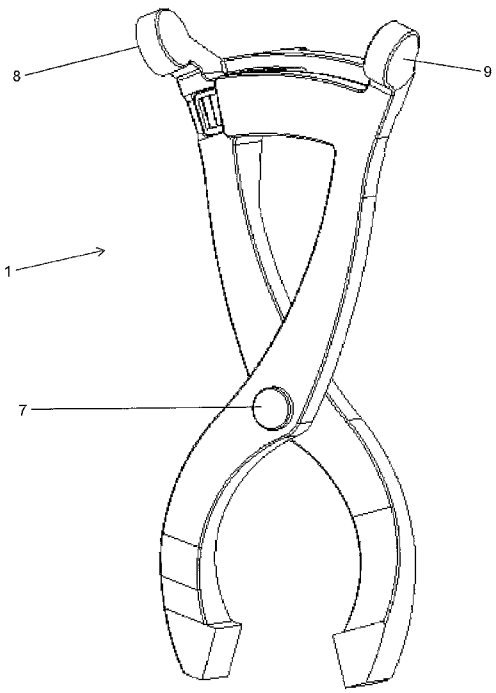

Figure 2

(57) Abstract: A bone clamp for being attached to a bone, comprising two levers which are connected via a pivot joint in a scissor-like manner, wherein each lever has a first lever arm from a first end of the respective lever to the pivot joint and a second lever arm from a second end of the respective lever opposite to the first end to the pivot joint, the first end is to get in contact with the bone and the lengths of the second lever arms are equal to or less than two times the lengths of the corresponding first arms, the bone clamp further comprising a ratchet mechanism provided at the second lever arms, the ratchet mechanism comprising a profile at each of the second lever arms, wherein the profiles are adapted to engage with each other when the bone clamp is closed.

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MEDICAL BONE CLAMP

TECHNICAL FIELD

The present invention relates to a bone clamp for being attached to a bone.

SUMMARY

Bone clamps, in particular specialized spine clamps or spinal clamps, are often used in the medical field. A typical application is a fixation of the bone to which the clamp is attached. Another typical application is using the bone clamp as a mechanical interface for attaching an object, such as a marker device, to the bone. The advantage of a clamp over other types of fixation units is that damage to the bone is minimized, in particular compared to devices which require one or more screws to be screwed into the bone. Known bone clamps have a screw mechanism for fixing the bone clamp to the bone.

The bone clamp and a bone clamp system are defined by the appended independent claims. Advantages, advantageous features, advantageous embodiments and advantageous aspects of the present invention are disclosed in the following and contained in the subject-matter of the dependent claims. Different advantageous features can be combined in accordance with the invention wherever technically expedient and feasible. Specifically, a feature of one embodiment which has the same or a similar function to another feature of another embodiment can be exchanged with said other feature, and a feature of one embodiment which adds an additional function to another embodiment can in particular be added to said other embodiment.

According to the present invention, a bone clamp for being attached to a bone comprises two levers which are connected via a pivot joint in a scissor-like manner. Each lever has a first lever arm from a first end of the respective lever to the pivot joint and a second lever arm from a second end of the respective lever to the pivot joint. The second end of a lever is opposite to the first end of the lever. The first end is to get in contact with the bone. This means that the bone is clamped between the two first ends of the two levers. In this document, regarding the contact between the bone clamp and the bone, the first end of a lever is not limited to the very end of the lever, but also comprises a portion extending towards the pivot joint.

The two levers being connected in a scissor-like manner means that the two levers basically form an X. If the two second ends of the two levers are moved towards each other, the pivot joint also causes the first end of the two levers to move towards each other. The pivot joint is a joint which enables a relative rotation between the two levers about an axis which is also referred to as pivot axis or joint axis.

The lengths of the second lever arms are equal to or less than two times the lengths of the corresponding first arms. In other words, the distance between the very end of a second lever arm of a lever to the pivot joint is at most twice the distance between the very end of the first lever arm of the same lever to the pivot joint.

In some example, the lengths of the second lever arms are less than 1.5 times or 1.2 times the lengths of the corresponding first lever arms. In another example, the lengths of the second lever arms are even less than the lengths of the corresponding first lever arms.

The bone clamp according to the present invention further comprises a ratchet mechanism provided at the second lever arms, wherein the ratchet mechanism comprises a profile at each of the second lever arms and the profiles are adapted to engage with each other when the bone clamp is closed. The profiles engaging with each other means that the profiles prevent the bone clamp from opening and thus from detaching from the bone.

With the limited lengths of the second lever arms compared to the first lever arms, the space required for applying the bone clamp is reduced. In addition, a relative rotation between the second ends of the two levers about an axis which is not parallel to the axis of the pivot joint is limited, thus enabling a secure engagement of the two profiles.

With the ratchet mechanism instead of a screw mechanism, the time and efforts for applying the bone clamp can be significantly reduced. Operating a screw mechanism can also be more difficult, in particular in scenarios with limited working space. In addition, a screw mechanism is typically heavier and larger than a ratchet mechanism.

In one embodiment, the profiles are tooth profiles, each comprising a plurality of teeth. The closer the two second ends of the two lever arms are, the more teeth of the two profiles engage with each other.

Upon attaching the bone clamp to the bone, the bone clamp is closed until the bone is in contact with the first ends of both levers. When the bone clamp is further tightened by moving the second ends of the lever arms towards each other, the levers deform and act like a spring and exert a clamping force onto the bone. When the profiles engage with each other, further tightening the bone clamp means that the profiles glide over each other until they engage again one notch tighter.

In one embodiment, each tooth of a profile extends linearly in a plane which is perpendicular to the axis of the pivot joint. In one implementation, the prolongations of all teeth of a profile intersect at a vanishing point. This vanishing point is a virtual point, since the actual extent of a tooth is limited. So each tooth extends radially along a line which passes through the vanishing point. This means that the teeth of a profile are not exactly parallel. This allows the profiles to securely engage with each other at a rotational relative movement between the two levers about the pivot joint.

In one embodiment, the vanishing point has a non-zero distance to the axis of the pivot joint. With such a non-zero distance, which is defined for a state in which the levers are not deformed, for example when the bone clamp is not attached to a bone, a deformation of the levers during the application of the bone clamp can be compensated. When the bone clamp is applied, the two levers rotate relative to each other about the pivot joint until the first ends of the levers contact the bone. If a further closing force or moment is applied to the second lever arms, the bone between the first lever arms hinders the rotation and the second lever arms become deformed, for example in a plane perpendicular to the axis of the pivot joint. This deformation results in a displacement of the vanishing point relative to the axis of the pivot joint.

In one embodiment, the non-zero distance of the vanishing point to the axis of the pivot joint is selected such that the deformation of the second lever arm during the application shifts the vanishing point such that it lies or in the proximity of the axis of the pivot joint when the bone clamp is closed. The teeth of the profile are then aligned with the axis of the pivot joint, such that the two profiles securely engage with each other.

In one embodiment, the non-zero distance is adjustable, for example by a mechanism for adjusting an angle between the profile and the corresponding second lever arm. The bone clamp can thus be adapted to different bone dimensions.

In one embodiment, each tooth of a profile extends linearly in a plane which is perpendicular to the axis of the pivot joint, but the teeth are parallel to each other. In this embodiment, the profile of at least one lever is rotatable relative to the lever about an axis parallel to the axis of the pivot joint. The other profile then aligns the rotatable profile relative to the lever such the profile securely engage with each other.

In one embodiment, the profile of at least one lever is moveable relative to the lever. In this embodiment, the word "moveable" means a translational shift. If the bone clamp is opened in order to detach it from the bone, the moveable profile is dragged

by the other profile and does therefore not hinder the process of opening the bone clamp.

In one embodiment, the relative movement of the profile has a tangential component with respect to a rotation of the lever about the pivot joint. The other profile can thus pull the moveable profile away from its lever. This facilitates the process of opening the bone clamp.

In one embodiment, the relative movement of the profile is curved on a circular arc, for example centered about the axis of the pivot joint. Such a curved movement of the profile has the advantage that there is no relative movement between the profiles in a direction perpendicular to the axis of the pivot joint.

In the preceding embodiments, the relative movement occurs in a plane which is orthogonal to the axis of the pivot joint. In addition or as an alternative, the relative movement of the profile has a linear component in the direction of the axis of the pivot joint. This means that the relative movement of the profile can have components in at least two different directions. In one example, the trajectory of the movement of the profile relative to its lever can have the shape of at least a part of a helix, wherein the longitudinal axis of the helix is preferably parallel to the axis of the pivot joint.

If the relative movement of the profile has a linear component in the direction of the axis of the pivot joint, the moveable profile automatically disengages from the other profile, thus facilitating the process of opening the bone clamp.

The bone clamp for example comprises a guidance structure which guides the movement of the profile relative to the lever. This guidance structure for example comprises a surface on which the profile can glide relative to the lever.

In one embodiment, the bone clamp further comprises a releasable locking mechanism for the moveable profile. The locking mechanism is locked while the

bone clamp is attached to the bone and / or in the process of being attached to the bone, and is released for detaching the bone clamp from the bone. The locking mechanism hinders or even prevents the relative movement between the profile and the lever.

In one embodiment, the locking mechanism comprises a release lever. In one position of the release lever, the locking mechanism is locked, and in another position of the release lever, the locking mechanism is released.

In one embodiment, the release lever is coupled to the profile. This means that a movement of the profile relative to the lever translates into a movement of the release lever and vice versa. With this configuration, the relative movement between the profile and the lever can be controlled via the release lever, such that an operator of the bone clamp can control the process of opening the bone clamp.

In one embodiment, the two profiles form an undercut. This strengthens the engagement of the profiles and prevents an unintended release of the bone clamp.

In one embodiment, the bone clamp further comprises at least one bone pin on a first lever arm. A bone pin is a component, like a cone, which is pushed against and/or into the bone in order to improve the contact between the clamp and the bone. There are for example one or more bone pins on both lever arms. The bone pins may be located at or close to the first end of a lever. So if a first end of a lever contacts the bone, this may mean that a bone pin contacts the bone and optionally subsequently penetrates the bone.

In one embodiment, the bone clamp further comprises a mechanical interface for attaching a marker device to the bone clamp. The bone clamp can thus be used for attaching a marker to the bone, for example for tracking the bone with a medical tracking system or medical navigation system.

The present invention further relates to a bone clamp system comprising a bone clamp as described herein and an applicator tool for attaching the bone clamp to a bone. Due to the limited length of the second lever arm compared to the first lever arm, it might be difficult to apply the force or moment which is required to attach and tighten the bone clamp. This required force or moment can be applied by use of the applicator. The applicator can thus be understood as acting like pliers.

In one embodiment, the applicator tool indicates the force or moment it applies to the bone clamp. This might involve a force sensor which indicates the force or a moment sensor which indicates the moment via an indication instrument and / or transmits the force or moment to an external display system, such as a medical tracking system or a medical navigation system. In another example, a force indicator or moment indicator indicates a deformation of the applicator tool which corresponds to the force or moment applied to the bone clamp. This might involve an incision in a lever of the applicator tool, such that the incision deforms together with the lever. The lever can include a scale on one side of the incision and a pointer on the opposite side of the incision, such that the pointer indicates the applied force or moment on the scale.

In one embodiment, the applicator tool comprises a force limiting mechanism which limits the force or a moment limiting mechanism which limits the moment that can be applied to the bone clamp by the applicator tool.

In one embodiment, the applicator tool comprises an infeed limitation mechanism which limits the infeed of the bone clamp, that is the movement of the second ends of the levers of the bone clamp towards each other, to a predetermined or an adjustable value.

The force limiting mechanism, the moment limiting mechanism and / or the infeed limiting mechanism prevent a maloperation of the applicator tool which could result in damage of the bone to which the bone clamp is being attached.

DEFINITIONS

It is the function of a marker to be detected by a marker detection device (for example, a camera or an ultrasound receiver or analytical devices such as CT or MRI devices) in such a way that its spatial position (i.e. its spatial location and/or alignment) can be ascertained. The detection device is for example part of a navigation system. The markers can be active markers. An active marker can for example emit electromagnetic radiation and/or waves which can be in the infrared, visible and/or ultraviolet spectral range. A marker can also however be passive, i.e. can for example reflect electromagnetic radiation in the infrared, visible and/or ultraviolet spectral range or can block x-ray radiation. To this end, the marker can be provided with a surface which has corresponding reflective properties or can be made of metal in order to block the x-ray radiation. It is also possible for a marker to reflect and/or emit electromagnetic radiation and/or waves in the radio frequency range or at ultrasound wavelengths. A marker preferably has a spherical and/or spheroid shape and can therefore be referred to as a marker sphere; markers can however also exhibit a cornered, for example cubic, shape.

A marker device can for example be a reference star or a pointer or a single marker or a plurality of (individual) markers which are then preferably in a predetermined spatial relationship. A marker device comprises one, two, three or more markers, wherein two or more such markers are in a predetermined spatial relationship. This predetermined spatial relationship is for example known to a navigation system and is for example stored in a computer of the navigation system.

In another embodiment, a marker device comprises an optical pattern, for example on a two-dimensional surface. The optical pattern might comprise a plurality of geometric shapes like circles, rectangles and/or triangles. The optical pattern can be identified in an image captured by a camera, and the position of the marker device relative to the camera can be determined from the size of the pattern in the image, the orientation of the pattern in the image and the distortion of the pattern in the image. This allows to determine the relative position in up to three rotational

dimensions and up to three translational dimensions from a single two-dimensional image.

BRIEF DESCRIPTION OF DRAWINGS

In the following, the invention is described with reference to the enclosed figures which represent preferred embodiments of the invention. The scope of the invention is not however limited to the specific features disclosed in the figures, which show:

Figure 1 a bone clamp in an open state;
Figure 2 a bone clamp with contact surfaces for an applicator tool;
Figure 3 an applicator tool for the bone clamp of Figure 2;
Figure 4 vanishing points of profiles of a bone clamp;
Figure 5 the vanishing points of Figure 4 for a tightened bone clamp;
Figure 6 a bone clamp with a locking mechanism for a moveable profile;
Figure 7 the bone clamp of Figure 6 with the locking mechanism being released;
Figure 8 details of the locking mechanism; and
Figure 9 details of an alternative locking mechanism.

DETAILED DESCRIPTION

Figure 1 shows a bone clamp 1 according to the present invention in an open state. The bone clamp 1 comprises two levers 2 and 3 which are connected via a pivot joint 7 in a scissor-like manner. This means that the two levers 2 and 3 can rotate relative to each other about the pivot joint 7. In the illustration of Figure 1, the axis of the pivot joint 7 about which the two levers 2 and 3 rotate relative to each other is orthogonal to the drawing plane. The location of this axis, which is also referred to as pivot axis or joint axis, is in the center of the pivot joint 7.

The lever 2 has a first lever arm 2a from a first end of the lever 2 to the pivot joint 7, in particular to the center of the pivot joint 7, and a second lever arm 2b from a second end of the lever 2 to the pivot joint 7, in particular the center of the pivot joint

7. In analogy, the lever 3 has a first lever arm 3a from a first end of the lever 3 to the pivot joint 7, in particular the center of the pivot joint 7, and a second lever arm 3b from a second end of the lever 3 to the pivot joint 7, in particular the center of the pivot joint 7. The first end and the second end of a lever 2 or 3 are at different ends of the respective lever 2 or 3. In the illustration shown in Figure 1, the first ends of the levers 2 and 3 are the lower ends and the second ends are the upper ends.

In the illustration of Figure 1, which shows the basic structure of the bone clamp 1, the two levers 2 and 3 are basically identical. However, there might be differences between the two levers as explained with reference to some modifications below.

At its second end, the first lever 2 has a tooth profile 4. At its second end, the lever 3 has a tooth profile 5. When the bone clamp 1 is closed, the tooth profiles 4 and 5 engage with each other such that an automatic opening of the bone clamp 1 is prevented. During closing of the bone clamp 1, the second ends of the levers 2 and 3 move towards each other, such that the tooth profiles 4 and 5 glide over each other. The tighter the bone clamp 1 is closed, the further the two profiles 4 and 5 overlap.

As can be seen from Figure 1, the first lever arms 2a and 3a each have a length L1 and the second lever arms 2b and 3b each have a length L2. According to the present invention, $L2 / L1 \leq 2$, for example $L2 / L1 \leq 1.5$, $L2 / L1 < 1.2$ or even $L2 / L1 < 1$.

At their respective first ends, the levers 2 and 3 each have a plurality of bone pins 6 which are to get in contact with a bone in order to prevent a relative motion between the bone clamp 1 and the bone once the bone clamp 1 is attached to the bone.

The bone clamp 1 in this exemplary embodiment is a spinal clamp. It has a clamping width, which represents the largest size of a bone to which it can be attached, of 0mm to 20mm. The arm length L1+L2 is between 70mm and 100mm, and the maximum clamping force exerted on the bone is 400N. The tooth profiles 4 and 5 are

designed such that the steps in which the clamping force can be adjusted is 50N wide or less.

Figure 2 schematically shows the bone clamp 1 of Figure 1 with additional functional surfaces 8 and 9 at the second ends of the levers 2 and 3, respectively. The functional surfaces 8 and 9 are contact surfaces for contact with an applicator tool which can be used for applying the bone clamp 1 to a bone. The functional surfaces 8 and 9 are protrusions which protrude from the second ends of the levers 2 and 3, respectively, basically in the direction of the joint axis of the pivot joint 7.

Figure 3 shows an applicator tool 10 for use with the bone clamp 1 shown in Figure 2. The applicator tool 10 can be understood as pliers for exerting a force or a moment on the second ends of the levers 2 and 3. The applicator tool 10 has long arms for being operated by a user and short arms carrying functional surfaces 11 for interacting with the functional surfaces 8 and 9 of the levers 2 and 3, respectively. The functional surfaces 8, 9 and 11 can for example be hemispheric, but can have other shapes, such as shapes which result in a form fit between the functional surfaces. This form fit might allow only one relative orientation between the applicator tool 10 and the bone clamp 1.

Due to the length ratios of the first lever arms 2a, 3a to the second lever arms 2b, 3b, the moment which can be manually applied to the second ends of the levers 2 and 3 is limited. By use of the applicator tool 10, this moment can be increased depending on the geometry of the applicator tool 10.

Figure 4 shows the bone clamp 1 of Figure 1 with a modified lever arm 2. Compared to the implementation shown in Figure 1, the tooth profile 4 shown in Figure 4 is moveable relative to the lever 2. The bone clamp 1 of Figure 4 further has a locking mechanism which locks the movement of the tooth profile 4 relative to the lever 2. In the present case, the locking mechanism includes a release lever 12. In the position of the release lever 12 as shown in Figure 4, the movement of the tooth profile 4

relative to the lever 2 is blocked. This blocking can be released by turning the release lever 12 counter-clockwise.

As can be seen from Figure 4, the teeth of the tooth profiles 4 and 5 are not parallel, but fall in line at vanishing points V1 and V2, respectively. This has the effect that the tooth profiles 4 and 5 securely engage with each other, even if they approach each other on a curved path rather than on a straight path.

As can be further seen from Figure 4, the vanishing points V1 and V2 have a non-zero distance from the joint axis of the pivot joint 7. When the bone clamp 1 is being attached to a bone, first the first ends of the levers 2 and 3 contact the bone. If a further force or moment is applied to the second ends of the levers 2 and 3, the bone hinders that the first ends of the levers 2 and 3 further approach each other, such that this further applied force or moment rather leads to a deformation of the second lever arms 2b and 3b. Due to this deformation, the vanishing points V1 and V2 are shifted towards the joint axis of the pivot joint 7. When the tooth profiles 4 and 5 engage with each other, the vanishing points V1 and V2 preferably lie near or on the joint axis of the pivot joint 7. This state is shown in Figure 5.

In Figure 5, the closed bone clamp 1 is shown without a bone, such that the first ends of the levers 2 and 3 contact each other. However, the non-zero distance of the vanishing points V1 and V2 from the joint axis of the pivot joint 7 can be adapted to the size of the bone to which the bone clamp 1 is to be attached. The deformation of the second lever arms 2b and 3b when the tooth profiles 4 and 5 fully overlap as shown in Figure 5 depends on the size of the bone to which the bone clamp 1 is to be attached.

Figure 6 shows the illustration of Figure 5, wherein the lever 3 is only indicated by a dashed line, such that the tooth profile 4 of the lever 2 and the release lever 12 can be seen. The deformed second lever arms 2b and 3b act as springs which urge the second ends of the levers 2 and 3 to move away from each other. However, the engagement of the tooth profiles 4 and 5 prevents this movement. The arrow in

Figure 6 indicates the direction into which the tooth profile 5 of the lever 3 would pull the tooth profile 4 of the lever 2. However, a movement of the tooth profile 4 relative to the lever 2 is prevented by the release lever 12.

In the illustration of Figure 7, the release lever 12 is opened and thus releases the tooth profile 4. The deformation of the second lever arms 2b, 3b cause the tooth profile 5 to drag the tooth profile 4 in the direction indicated by the arrow. Due to this movement of the tooth profile 4 relative to the lever 2, the second ends of the levers 2 and 3 can move away from each other, such that the bone clamp 1 opens.

Since the deformation of the second lever arms 2b, 3b occurs basically in a plane which is perpendicular to the joint axis of the pivot joint 7, the force applied by the tooth profile 5 on the tooth profile 4 basically lies in this plane. However, an additional movement of the tooth profile 4 relative to the lever 2 in a direction parallel to the joint axis of the pivot joint 7 can cause disengagement of the tooth profiles 4 and 5.

Figure 8 shows an implementation in which the tooth profile 4 slides along a slanted guidance surface 13, which has a non-zero angle with a plane perpendicular to the joint axis of the pivot joint 7. As can be seen from the right part of Figure 8, the tooth profile 5 of the lever 3 does not only pull the tooth profile 4 to the right, but also causes a movement in a direction parallel to the joint axis of the pivot joint 7. This means that the tooth profiles 4 and 5 fully disengage, and thus allow the bone clamp 1 to be fully opened.

This implementation has the additional advantage that the bone clamp 1 cannot be locked in its closed state if the release lever 12 is in a release position. In this case, the tooth profiles 4 and 5 cannot engage with each other, such that the bone clamp 1 does not remain closed automatically.

The lever 2 can comprise a guidance structure, such as at least one guidance rail, which restricts the movement of the tooth profile 4 to a gliding movement on the surface 13.

In the implementation shown in Figure 8, the tooth profile 4 is moved relative to the lever 2 only by the tooth profile 5 once the release lever 12 is opened. Figure 9 shows an alternative implementation in which the release lever 12 is coupled to the tooth profile 4. This means that the position of the release lever 12 corresponds to the position of the tooth profile 4 relative to the lever 2. With this configuration, a user of the bone clamp 1 can manually control the process of opening the bone clamp 1.

It shall be noted that the release lever 12 in Figures 8 and 9 is rotated by 90 degrees compared to Figure 4 to 7. This is for illustrative purposes only in order to clearly depict the function of the release lever 12.

Claims

1. A bone clamp (1) for being attached to a bone, comprising two levers (2, 3) which are connected via a pivot joint (7) in a scissor-like manner, wherein each lever (2, 3) has a first lever arm (2a, 3a) from a first end of the respective lever (2, 3) to the pivot joint (7) and a second lever arm (2b, 3b) from a second end of the respective lever (2, 3) opposite to the first end to the pivot joint (7), the first end is to get in contact with the bone and the lengths (l2) of the second lever arms (2b, 3b) are equal to or less than two times the lengths (l1) of the corresponding first lever arms (2a, 3a), the bone clamp (1) further comprising a ratchet mechanism provided at the second lever arms (2b, 3b), the ratchet mechanism comprising a profile (4, 5) at each of the second lever arms (2b, 3b) , wherein the profiles (4, 5) are adapted to engage with each other when the bone clamp (1) is closed.

2. The bone clamp (1) of claim 1, wherein the profiles (4, 5) are tooth profiles comprising a plurality of teeth.

3. The bone clamp (1) of claim 2, wherein each tooth of a profile (4, 5) extends linearly in a plane which is perpendicular to the axis of the pivot joint (7) and the prolongations of all teeth of a profile intersect at a vanishing point (V1, V2).

4. The bone clamp (1) of claim 3, wherein the vanishing point (V1, V2) has a non-zero distance to the axis of the pivot joint (7).

5. The bone clamp (1) of any one of claims 1 to 4, wherein the profile (4) of one lever (2) is movable relative to the lever (2).

6. The bone clamp (1) of claim 5, wherein the relative movement of the profile (4) has a tangential component with respect to a rotation of the lever (2) about the pivot joint (7).

7. The bone clamp (1) of claim 5, wherein the relative movement of the profile (4) is curved on a circular arc about the axis of the pivot joint (7).

8. The bone clamp (1) of any one of claims 5 to 7, wherein the relative movement of the profile (4) has a linear component in the direction of the axis of the pivot joint (7).

9. The bone clamp (1) of any one of claims 5 to 8, further comprising a releasable locking mechanism for the movable profile (4).

10. The bone clamp (1) of claim 9, wherein the locking mechanism comprises a release lever (12).

11. The bone clamp (1) of claim 10, wherein the release lever (12) is coupled to the profile (4).

12. The bone clamp (1) of any one of claims 1 to 11, wherein the two profiles (4, 5) form an undercut.

13. The bone clamp (1) of any one of claims 1 to 12, further comprising at least one bone pin (6) on a first lever arm (2a, 3a).

14. The bone clamp (1) of any one of claims 1 to 13, further comprising a mechanical interface for attaching a marker device to the bone clamp (1).

15. A bone clamp system comprising a bone clamp (1) of any one of claims 1 to 14 and an applicator tool (10) for attaching the bone clamp (1) to a bone.

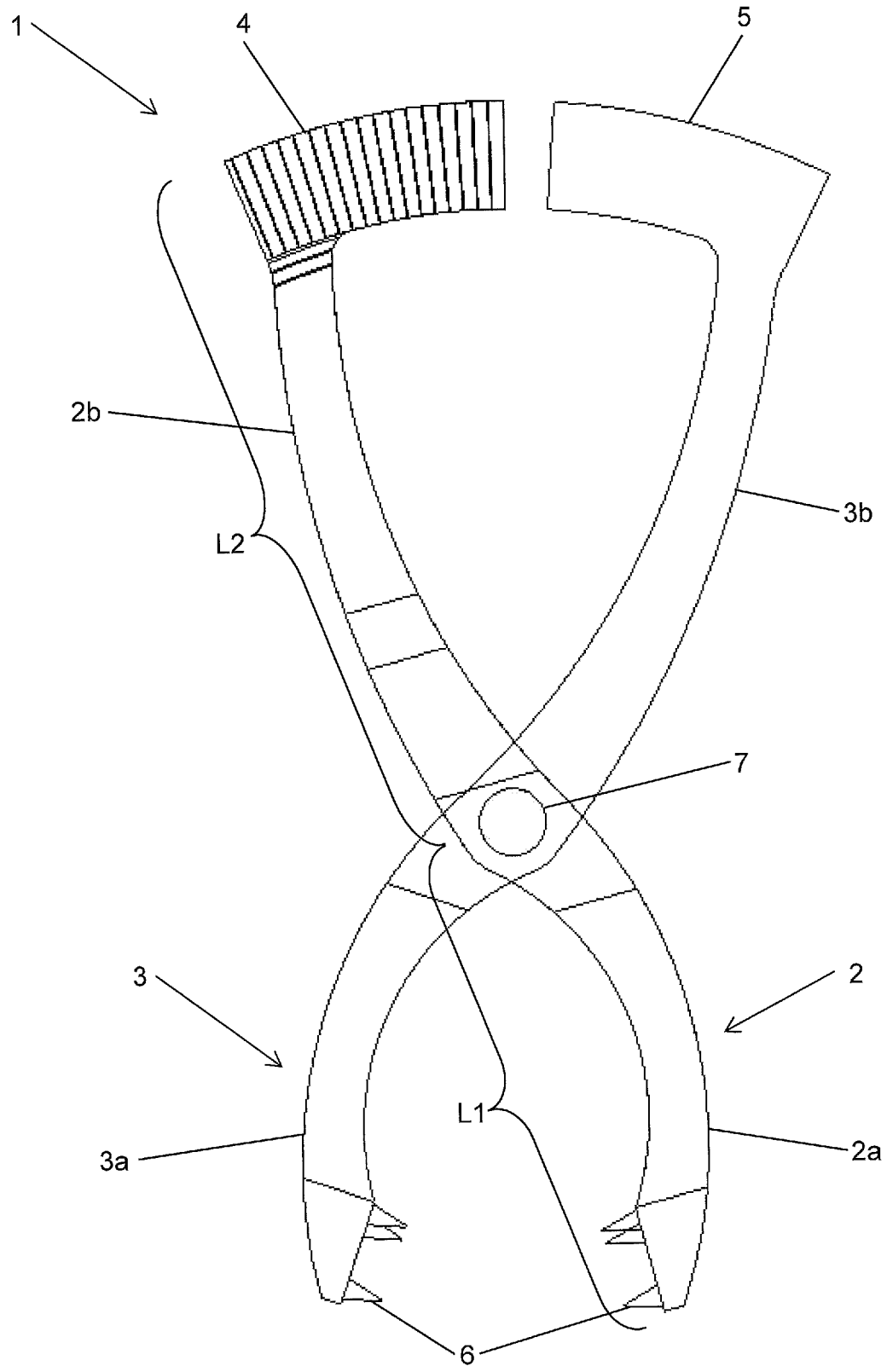

Figure 1

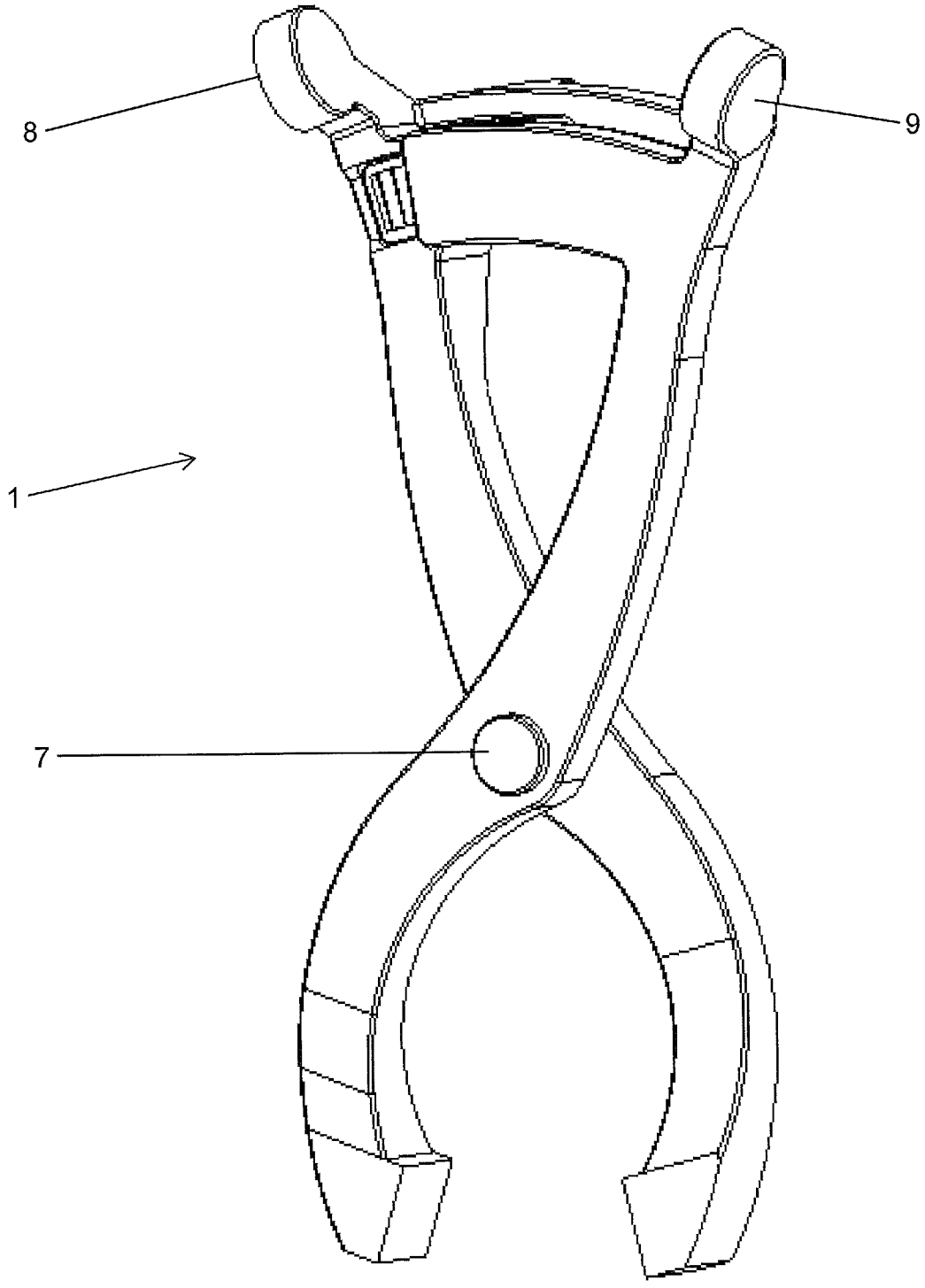

Figure 2

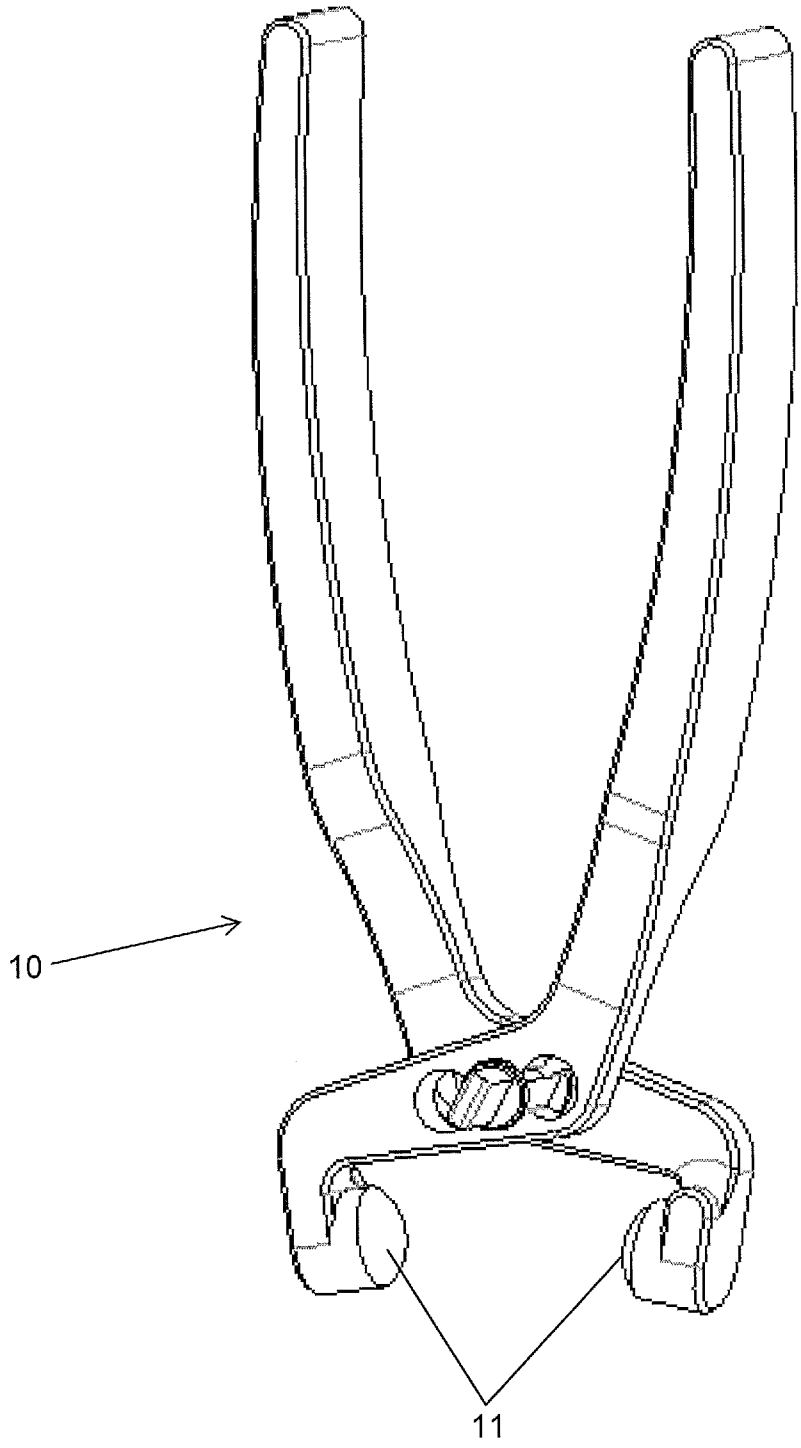

Figure 3

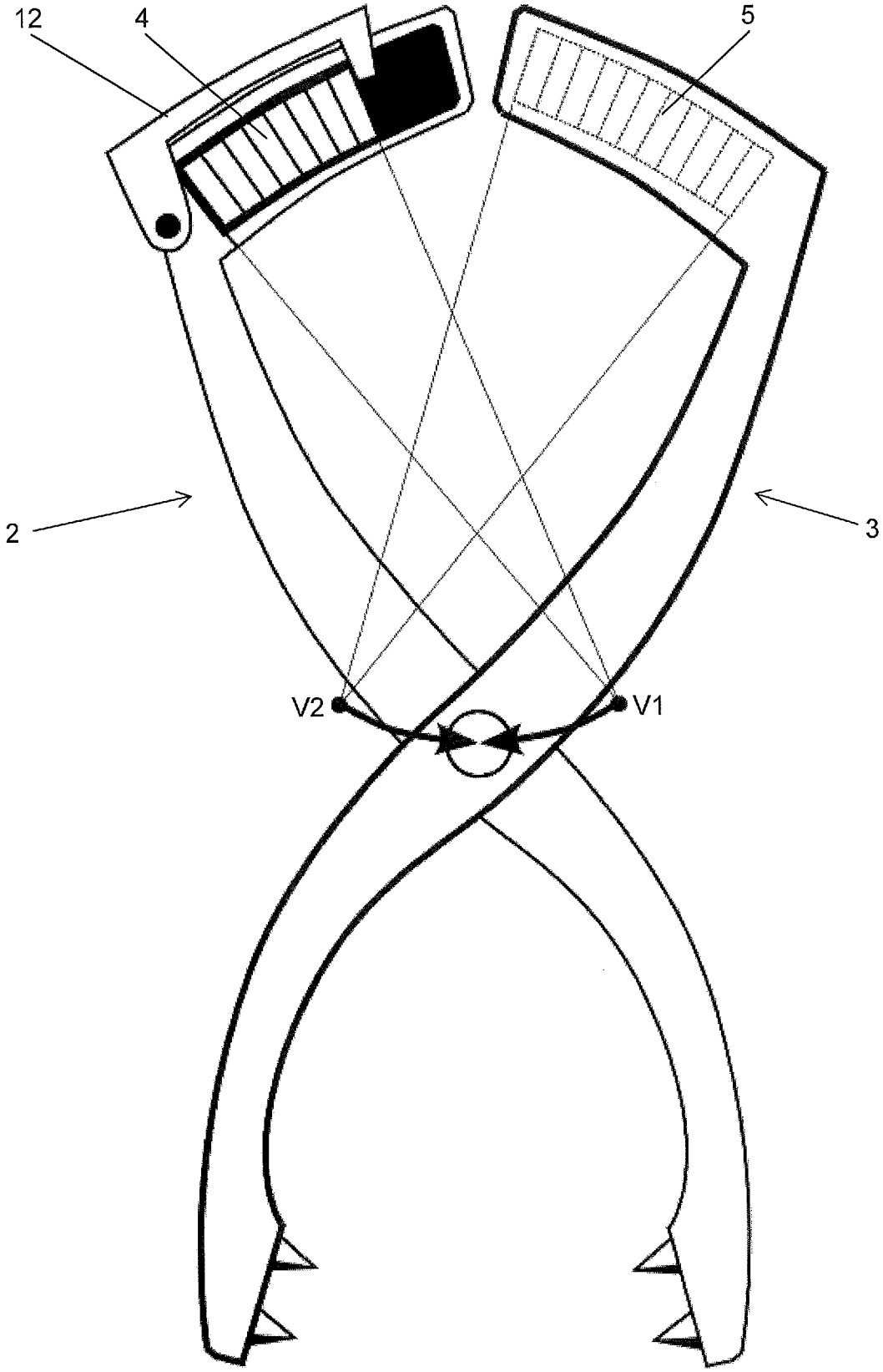

Figure 4

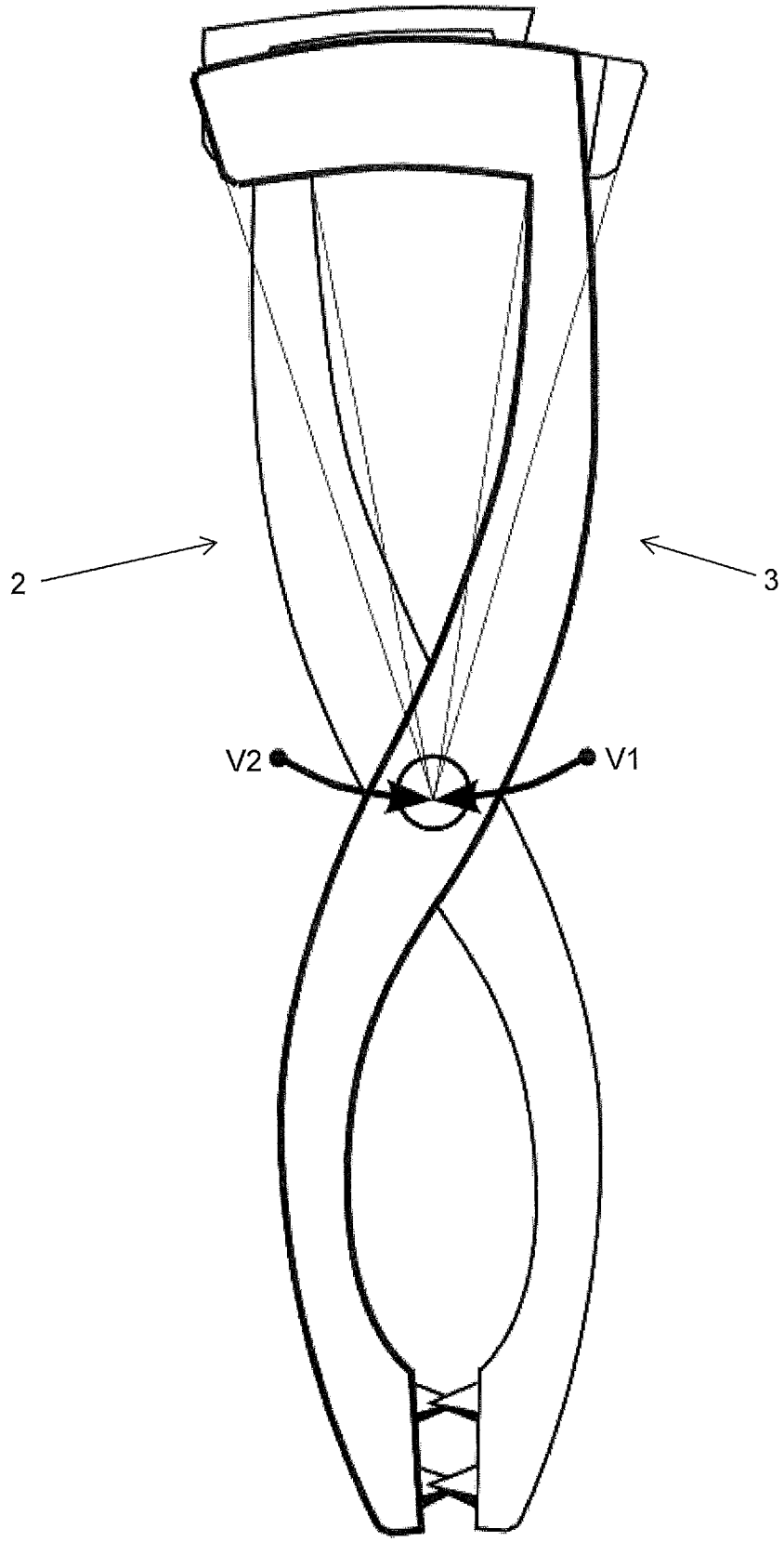

Figure 5

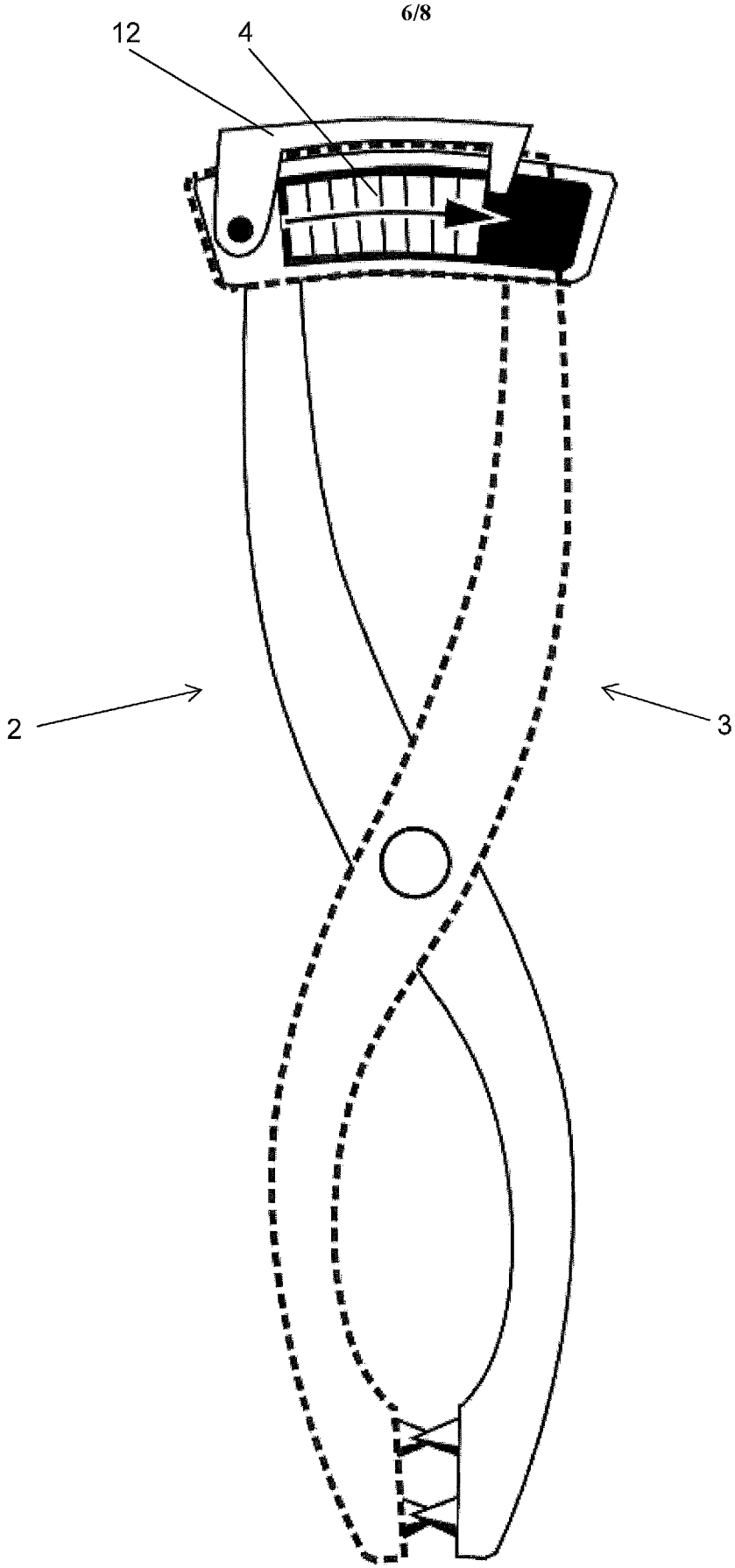

Figure 6

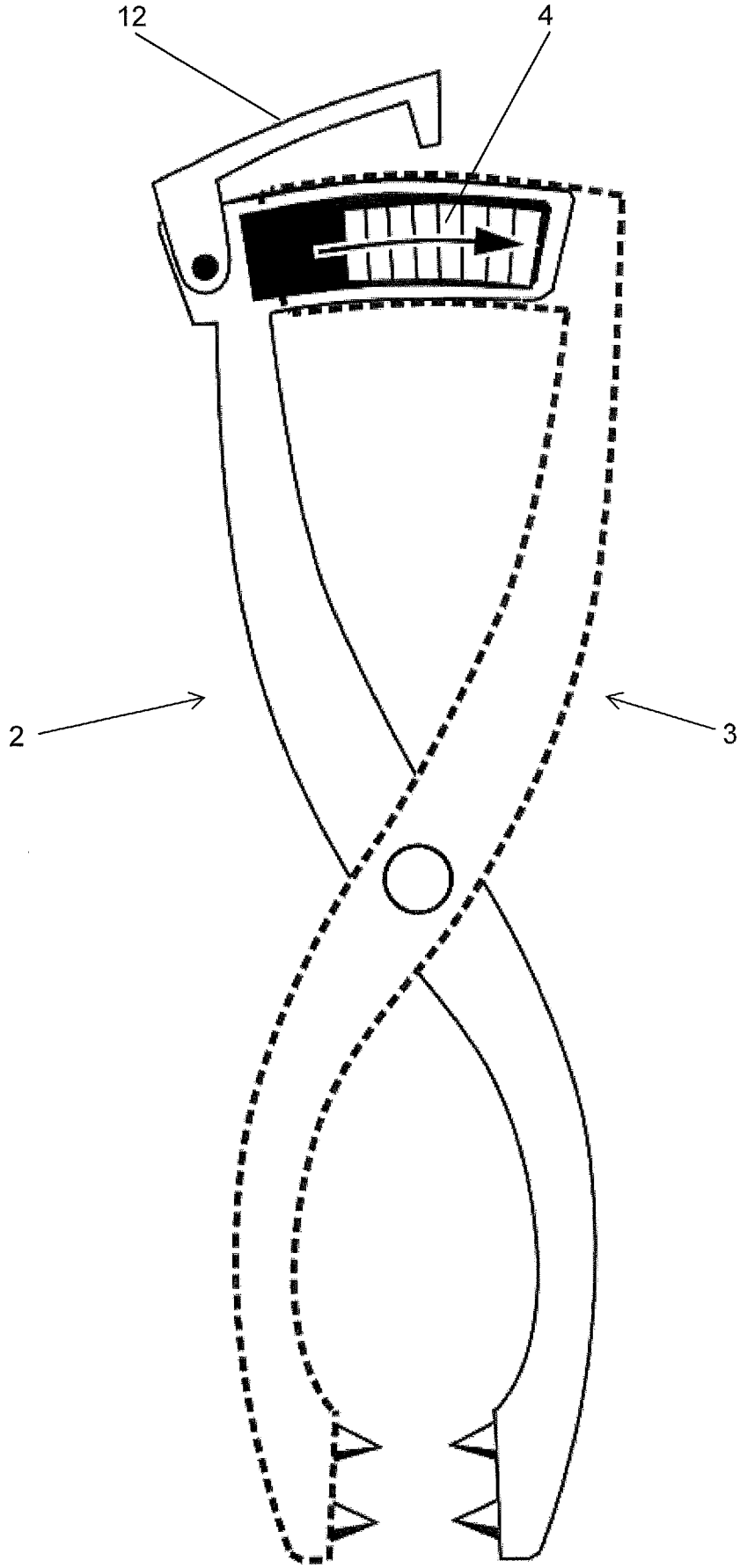

Figure 7

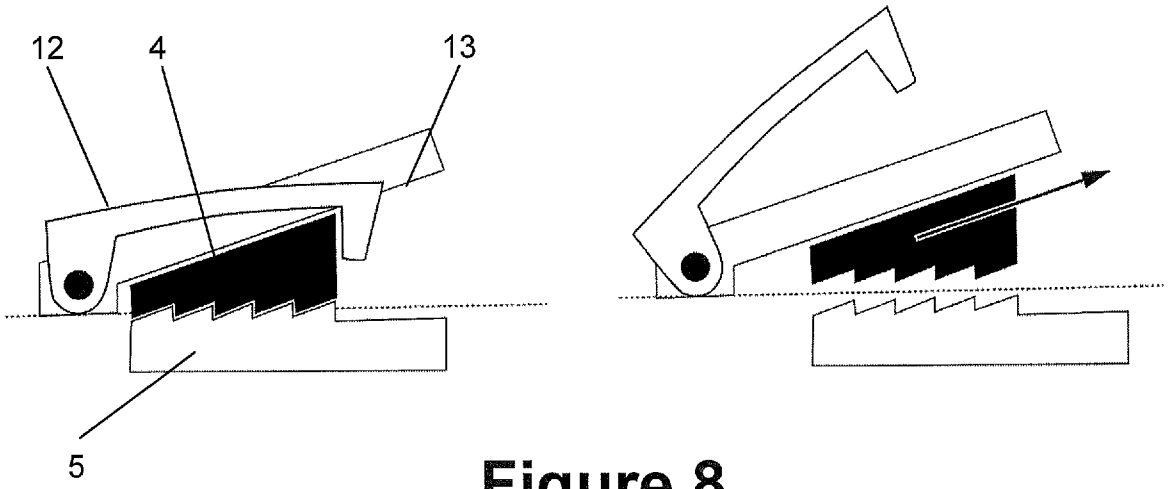

Figure 8

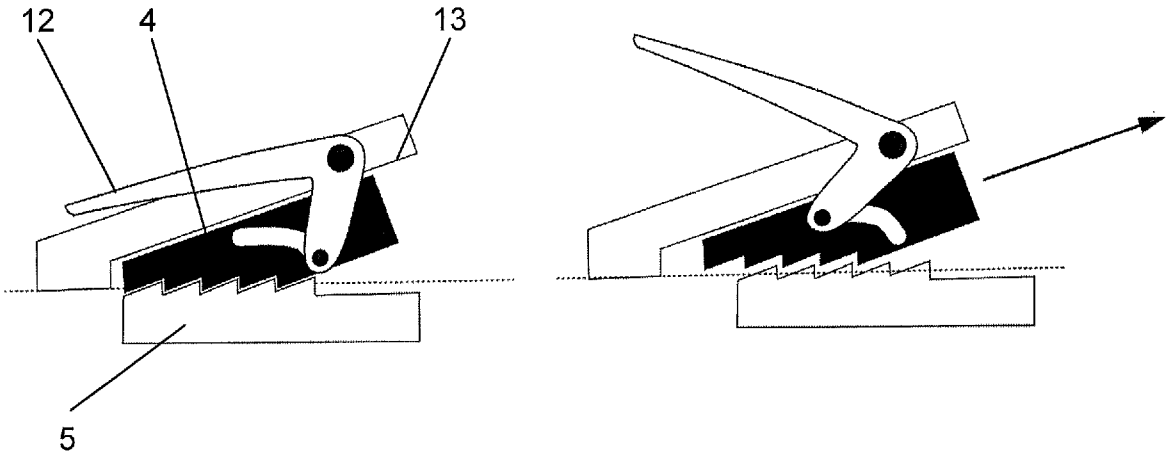

Figure 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/055757

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/70 A61B17/88 A61B17/28
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 A	US 4 475 544 A (REIS NORMAN I [US]) 9 October 1984 (1984-10-09) figure 1 -----	1-3, 12-14 4
X	EP 1 044 653 A2 (ACCURATE SURGICAL & SCIENT INS [US]) 18 October 2000 (2000-10-18) figure 1 -----	1-3, 12-14
X	US 4 944 739 A (TORRE RANDALL J [US]) 31 July 1990 (1990-07-31) figure 2 -----	1-3, 12-14
X	WO 2013/191819 A1 (DEPUY SYNTHES PRODUCTS LLC [US]) 27 December 2013 (2013-12-27) figure 1 -----	1-3, 12-14

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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
23 September 2016	07/12/2016

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	Fernández Arillo, J

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 490 220 A (BIOMET MFG CORP [US]) 24 October 2012 (2012-10-24) figure 2A -----	1-3, 12-14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2016/055757

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. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

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:

see additional sheet

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.:

1-4, 12-14

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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-4, 12-14

   The bone clamp of claim 3, wherein the vanishing point has a non-zero distance to the axis of the pivot joint (claim 4), for solving the problem of allowing a more secure ratchet locking attachment of the second lever arms when the bone clamp is in use, that is when the second lever arms are deformed after the distal bone-contacting ends of the levers are in contact with the bone.

   ---

2. claims: 5-11

   The bone clamp of claim 1, wherein the profile of one lever is movable relative to the lever (claim 5), thereby solving the problem of facilitating the process of opening the bone clamp.

   ---

3. claim: 15

   A bone clamp system comprising the bone clamp of claim 1 and further comprising an applicator tool, thereby solving the problem of allowing the required force or moment to be applied.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/055757

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4475544 A	09-10-1984	NONE	
EP 1044653 A2	18-10-2000	AT 254886 T	15-12-2003
		DE 60006737 D1	08-01-2004
		DE 60006737 T2	23-09-2004
		EP 1044653 A2	18-10-2000
		HK 1032519 A1	18-06-2004
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WO 2013191819 A1	27-12-2013	EP 2863819 A1	29-04-2015
		US 2013345762 A1	26-12-2013
		WO 2013191819 A1	27-12-2013
GB 2490220 A	24-10-2012	DE 102012205820 A1	25-10-2012
		GB 2490220 A	24-10-2012
		US 2012271366 A1	25-10-2012