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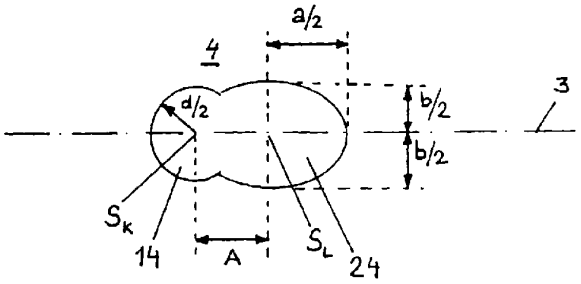
(54) Title: BONE PLATE

(54) Bezeichnung: KNOCHENPLATTE



(57) Abstract: The invention relates to a bone plate with an upper side (1), a lower side (2) that contacts the bone, and a plurality of holes (4) along the longitudinal axis (3) of the plate that link the upper side with the lower side (1; 2) and that accommodate bone screws (11). At least one of the holes (4) is a combination of a circular hole (14) having a diameter (d) and a center of symmetry (S_k) and an oblong hole (24) having a center of symmetry (S_l) that has a long axis (a) running parallel to the longitudinal axis of the plate and a perpendicular short axis (b), the distance (A) between the centers of symmetry (S_k and S_l) being smaller than the sum of d/2 + a/2 and the two centers of symmetry being disposed in the area of the longitudinal axis (3) of the plate. The inventive bone plate allows for the uncompromising use as a compression plate and as a so-called fixateur interne.

(57) Zusammenfassung: Die Knochenplatte besitzt eine Oberseite (1), eine für den Knochenkontakt bestimmte Unterseite (2) sowie mehrere die Ober- mit der Unterseite (1; 2) verbindende, entlang der Plattenlängsachse (3) angeordnete Löcher (4) für die Aufnahme von Knochenschrauben (11). Mindestens eines der Löcher (4) besteht aus einer Kombination eines kreisförmigen Loches (14) mit dem Durchmesser (d) und dem Symmetriezentrum (S_k) mit einem Langloch (24) mit dem Symmetriezentrum (S_l), welches eine, in Richtung der Plattenlängsachse verlaufende, lange Achse (a) und eine senkrecht dazu verlaufenden, kurze Achse (b) besitzt, wobei der Abstand (A) zwischen den Symmetriezentren (S_k und S_l) kleiner ist als die Summe von d/2 + a/2 und die beiden Symmetriezentren im Bereich der Plattenlängsachse (3) angeordnet sind. Die Knochenplatte erlaubt eine kompromisslose Verwendung als Kompressionsplatte und als sogenannter Fixateur interne.

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Bone plate

The invention relates to a bone plate and to a fixation device including such a bone plate.

Generally, bone plates are used in connection with two types of osteosynthesis.

The first type is referred to as "rigid osteosynthesis". Rigid osteosynthesis is applied for the fixation of joint fractures, simple fractures of a bone shaft (where nailing is not practicable), and in cases of osteotomy. In addition to the possibility of anatomical reduction, the bone itself supports the stability of osteosynthesis, which makes it possible for the patient to use the injured limb earlier and to feel less pain when putting weight on it. The advantages of a stable fixation of a fracture are also evident in cases where due to the trauma the blood circulation in the bone is significantly reduced. For the fixation of "non-unions" or in the case of an infection, the fractured bone has to be stabilized in order to enable its recovery and to avoid any additional irritation that might be caused by instabilities in the fracture gap.

The second type is referred to as "flexible osteosynthesis". The greatest advantages of flexible (biological) osteosynthesis are to be observed in

connection with comminuted fractures occurring in the shaft portion of long bones. With these fractures, the aim is to maintain the length of the bone and to keep the end portions of the bone (joints) in correct position to one another. The fracture zone itself is not directly fixated or manipulated so that no additional reduction of the blood flow through the bone will occur in this zone. The function of the bone plates is comparable to that of an intramedullary nail anchored only in the metaphyses.

On considering these two (extreme) examples of osteosynthesis by means of plating, one easily notices how different they are from each other. Since fractures, as far as their fixation is concerned, often cannot be clearly divided up into one or the other type of osteosynthesis mentioned above, the surgeon generally has to make compromises, as there exists no implant allowing him or her to effectively combine the two methods. Such a combination would be useful, for example, where a fractured joint can be compressed with the help of tension screws extending through the bone plate while the entire joint segment is fixed to the diaphysis by means of an internal fixator with the aid of angularly stable screws. Another application would be the case of an osteoporotic bone where a bone plate can be anchored by means of axially and angularly stable screws in the metaphysial fragment so that the diaphysial zone can be plated in a stable manner, the plate assembly being supported by a tension screw passing through the plate at the fracture zone. This procedure permits to achieve a primary stabilisation of the fractured bone.

As a consequence of this situation, bone implants for both types of osteosynthesis have been developed and put on the

market. Both implant categories are optimally adapted to the particular method they have been designed for. The disadvantage, however, is that the two systems cannot be combined with each other.

US 5 709 686 TALOS ET AL. discloses such a combined plate with a cylindrical screw thread formed in the central portion of the elongate hole. This known plate has the following disadvantages:

1) Due to the location of the screw thread in the centre of the elongate hole of the plate, the range of the thread is limited to an angle of between 60° and 179°.

2) Due to the location of the screw thread in the centre of the elongate hole (fixation screw hole) of the plate, there is a risk that the lateral ribs of the elongate hole may be enlarged.

3) Due to the cylindrical form of the thread, a specially shaped screw head must be used that can be supported by the surface of the plate as the screw is driven into the bone.

The above discussion of background art is included to explain the context of the present invention. It is not to be taken as an admission that any of the documents or other material referred to was published, known or part of the common general knowledge in Australia at the priority date of any one of the claims of this specification.

It would be desirable to remedy these drawbacks and to permit an effective and unrestricted utilisation of the plate as a compression plate and as an internal fixator. The invention comprises a bone plate which makes it possible to combine both types of osteosynthesis without resulting in any restrictions in either of the two conventional plating methods.

According to a first embodiment of the invention there is provided a bone plate with a top surface, a bottom surface for contact with the bone, and a plurality of holes situated along the longitudinal axis of the plate and connecting the top surface and the bottom surface for receiving bone screws, wherein (a) at least one of the holes consists of a combination of (i) a circular hole with a diameter d and a centre of symmetry S_k and (ii) an elongate hole with a centre of symmetry S_l, having a long axis a extending in the direction of the longitudinal axis of the plate, and a short axis b extending vertically thereto, (b) the distance A between the centres of symmetry S_k and S_l being shorter than the sum d/2 + a/2 and both centres of symmetry being situated along the longitudinal axis of the plate, and (c) the circular hole is provided with a three-dimensionally structured portion.

According to a second embodiment of the invention there is provided a fixation device including a bone plate of the first embodiment, wherein said plate comprises in addition at least one bone screw.

The elongate hole of the invention may be defined as a hole the diameter of which is greater in the direction of the longitudinal axis of the plate than the diameter of said hole vertically in relation to the longitudinal axis of the plate. Said hole may thus be of oval, elliptical or rectangular shape or may show a combination of these shapes; the only forms to be excluded by this definition are circular holes.

In a preferred embodiment, the circular hole of the set of combined holes is provided with a three-dimensionally structured portion, preferably in the form of an internal screw thread or a peripheral lamella or lip. The three-dimensionally structured portion may be arranged in one plane parallel to the top surface of the bone plate, or in a plurality of planes parallel to said top surface.

The diameter d of the circular hole is preferably smaller than the short axis b of the elongate hole of the set of combined holes. Typically, d is by 5 to 25% smaller than b.

The utilisation of the plate as an internal fixator exposes the plate-screw interface to a greatly increased mechanical strain, as the plate is not pressed against the bone and the bone fracture is fixated by means of friction between the plate and the bone. In a preferred embodiment, this additional mechanical strain is taken into account by the fact that the screw thread in the elongate hole extends over an angle of at least 180°, enclosing the thread of the screw head at least over this range. Where thin bone plates are to be used, this feature is of particular importance.

According to a preferred improvement of the invention, the three-dimensionally structured portion formed in the set of combined holes, e. g. in the form of an internal screw thread, has a - preferably conical - form tapered towards the bottom surface of the bone plate. The advantage of this improvement is that the fixation of the screw ensues from the engagement between the conical thread of the hole provided in the bone plate and the corresponding conical thread of the screw head. This type of fixation is particularly important in cases where self-drilling screws are used. Due to the conical thread in the head portion of the screw, the position of the plate need not be taken into consideration while the screw is driven into the bone. The blocking of the screw occurs only when the threaded cone of the screw head engages with the internal screw thread of the elongate hole of the plate. Although the beginning of the threaded engagement in the conical hole of the plate and in the bone occurs at different points, the conical thread of the screw head will automatically come into a centred position in the threaded cone of the plate.
During the tightening of the conical screw thread, radial forces will occur in the plate hole. In order to be able to effectively absorb these forces, the conical hole of the plate must be of sufficient solidity.

In a preferred embodiment, the conical internal screw thread, tapered towards the bottom surface of the bone plate, suitably has a cone angle of between 5° and 20°, typically 10°.

In a further preferred embodiment of the invention, the internal screw thread - considered in the direction of the longitudinal axis of the plate - is formed in one of the

two end portions of the elongate hole. In terms of design, this end position permits to increase the threaded portion, which may extend e. g. over an angle of between 190° and 280°, preferably 200° and 250°, of the geometrical body that it forms.

If the elongate hole is conically shaped, measurements of the dimension of the internal screw thread carried out on the bottom surface and on the top surface of the plate will yield different results. Measured at the top surface, the threaded portion should preferably extend over an angle ranging between 180° and 230°; measured at the bottom surface, over an angle ranging between 200° and 270°.

In a further preferred embodiment, the conical screw thread formed in the end portion of the elongate hole (fixation screw hole) is formed in the end portion situated closer to the centre of the plate. The advantage of this arrangement is that the fixing capacity of the fixation screw holes of the plate is not negatively affected.

In a further preferred embodiment, the set of combined holes has in its upper portion, facing the top surface, a concave, preferably spherical enlargement for receiving a bone screw with a spherically shaped screw head. Such concave, spherical enlargement is optimally shaped to match the spherical screw head of a conventional bone screw. This is of particular utility if the bone screw is inserted eccentrically, a technique required for achieving fracture compression.

In a further preferred embodiment, the bottom surface is concavely shaped. The concave bottom surface of the plate

allows a better adaptation to the round cross-sections of the tibia, the femur, the humerus, and the bones of the forearm. The concave embodiment of the hole in the bottom surface of the plate permits a conventional bone screw to be driven obliquely through the plate hole. This may be of particular importance for seizing a small bone fragment which must be drawn close to the plate.

In another preferred embodiment, the internal screw thread extends over the entire thickness of the bone plate, from the bottom surface to the top surface, in order to provide a maximum of solidity.

In another preferred embodiment, the set of combined holes is enlarged in the unstructured portion formed in its lower part, facing the bottom surface of the plate, in order to enable a precise orientation of the bone screw.

A further embodiment comprises, in addition to the bone plate of the invention, at least one bone screw; said screw may show a structured portion formed in the screw head, e.g. in the form of an external screw thread, which corresponds to said three-dimensionally structured portion and is preferably self-tapping and/or self-drilling. If the bone plate is used as a compression plate, the geometry of the plate hole is not negatively affected by the conical threaded hole formed in its end portion. The conical design of the threaded hole has the advantage that the position of the plate need not be taken into account while the screw is driven into the bone, as the fixed engagement between the screw and the plate occurs only when the conically shaped, threaded screw head is driven into the corresponding internal thread of the plate. This is particularly

important where self-drilling, self-tapping screws are used.

In the following, the invention and further developments of the invention will be illustrated in greater detail with reference to the partially diagrammatic representations of several embodiments.

In the drawings:

Fig. 1 is a diagrammatic representation of the set of combined holes consisting of a circular hole and an elongate hole;

Fig. 2 is a top plan view of a bone plate of the present invention showing a set of combined holes with a three-dimensionally structured portion;

Fig. 3 is a longitudinal section of the circular hole of the set of combined holes of Fig. 2; and

Fig. 4 is a perspective view showing the bone plate of the present invention with a bone screw inserted in the screw thread integrated in the set of combined holes.

The bone plate of the present invention as shown in Fig. 2 has a top surface 1, a bottom surface 2 for contact with the bone, and two holes 4 situated along the longitudinal axis 3 of the plate, connecting the top surface 1 and the bottom surface 2, for receiving bone screws 11. Arrow 7 indicates the direction towards one end of the bone plate whereas arrow 8 indicates the direction towards the centre of the plate.

The diameter of the hole 4 situated closer to the centre of the plate is greater in the direction of the longitudinal axis 3 of the plate than the diameter of said hole vertically in relation to the longitudinal axis 3 of the plate.

As diagrammatically shown in Fig. 1, the hole 4 consists of two overlapping holes, a circular hole 14 with a diameter d and a centre of symmetry S_k, and an elongate hole 24 with a centre of symmetry S_l.

The elongate hole 24 has a long axis a extending in the direction of the longitudinal axis 3 of the plate and a short axis b extending vertically thereto, the distance A between the centres of symmetry S_k and S_l being smaller than the sum d/2 + a/2. Both centres of symmetry are situated along the longitudinal axis 3 of the plate.

In its upper portion, facing the top surface 1, the elongate hole 24 has a concave, preferably spherical enlargement 6 for receiving a bone screw with a spherical screw head.

As shown in Fig. 3, the three-dimensionally structured portion 5, in the form of an internal screw thread 5 of the hole 4 situated closer to the end of the plate, extends over the entire thickness of the bone plate, from the top surface 1 to the bottom surface 2.

In the preferred embodiment of the invention shown in Figs. 2 and 3, the internal screw thread is formed in the end portion of the elongate hole which is situated closer to the centre of the plate. Measured on the bottom surface

2, the internal screw thread, as suggested by the circular arc 9, extends over an angle of 256°, whereas measured on the top surface 1, it extends over an angle of 223°, as suggested by the circular arc 10.

Thus the following preferred parameters are obtained, depending on the diameter of the internal screw thread 5:

Screw thread diameter	2.4 mm	3.5 mm	5.0 mm
double thread	YES	YES	YES
thread pitch	0,6	0,8	1,0
thread depth (= half the difference between outside and inside diameter)	0,175	0,2295	0,2810
angle (on top surface)	200°	200°	190°
angle (on bottom surface)	260°	240°	250°

Fig. 4 shows a fixation device including a bone plate according to Fig. 2, comprising a bone screw 11 with an external screw thread 12 formed in the screw head 13 which corresponds to the internal thread of the bone plate.

Suitably, the bone screw 11 is a self-drilling and/or self-tapping screw.

Throughout the description and claims of this specification, the word "comprise" and variations of that word, such as "comprising" and "comprises" are not intended to exclude other additives, steps or integers.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A bone plate with a top surface, a bottom surface for contact with the bone, and a plurality of holes situated along the longitudinal axis of the plate and connecting the top surface and the bottom surface for receiving bone screws, wherein

(a) at least one of the holes consists of a combination of

(i) a circular hole with a diameter d and a centre of symmetry S_k and

(ii) an elongate hole with a centre of symmetry S_1, having a long axis a extending in the direction of the longitudinal axis of the plate, and a short axis b extending vertically thereto,

(b) the distance A between the centres of symmetry S_k and S_1 being shorter than the sum d/2 + a/2 and both centres of symmetry being situated along the longitudinal axis of the plate, and

(c) the circular hole is provided with a three-dimensionally structured portion.

2. A bone plate as claimed in claim 1, wherein the three-dimensionally structured portion is in the form of an internal screw thread or a peripheral lamella or lip.

3. A bone plate as claimed in claim 2, wherein the three-dimensionally structured portion is arranged in a plane parallel to the top surface.

4. A bone plate as claimed in claim 2, wherein the three-dimensionally structured portion is arranged in a plurality of planes parallel to the top surface.

5. A bone plate as claimed in any of the claims 1 to 4, wherein the diameter d of the circular hole is smaller, preferably by 5 to 25%, than the short axis b of the elongate hole.

6. A bone plate as claimed in any of the claims 1 to 5, wherein the three-dimensionally structured portion extends over an angle of at least 180° of the circular hole.

7. A bone plate as claimed in claim 6, wherein the three-dimensionally structured portion extends over an angle of between 190° and 280°, preferably between 200° and 250°, of the circular hole.

8. A bone plate as claimed in claim 6 or 7, wherein the three-dimensionally structured portion - measured on the top surface - extends over an angle of between 180° and 230° and - measured on the bottom surface - over an angle of between 200° and 270°.

9. A bone plate as claimed in any of the claims 1 to 8, wherein the combined holes have a tapered form from the top surface to the bottom surface.

10. A bone plate as claimed in any of the claims 1 to 9, wherein the three-dimensionally structured portion - considered in the direction of the longitudinal axis of the plate - is formed in the end portion of the combined holes which is situated closer to the centre of the plate.

11. A bone plate as claimed in any of the claims 1 to 10, wherein the elongate hole has in its upper portion, facing the top surface, a concave, preferably spherical enlargement for receiving a bone screw with a spherical screw head.

12. A bone plate as claimed in any of the claims 1 to 11, wherein the bottom surface has a concave or planar shape.

13. A bone plate as claimed in any of the claims 1 to 12, wherein the three-dimensionally structured portion extends over the entire thickness of the bone plate, from the top surface to the bottom surface.

14. A bone plate as claimed in any of the claims 1 to 13, wherein the combined holes have an enlargement in the unstructured portion of their lower part, facing the bottom surface.

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15. A bone plate as claimed in any of the claims 1 to 14, wherein the distance A between the centres of symmetry S_k and S_1 fulfils the following condition:

$$0{,}5\ (d/2 + a/2) < A < 1{,}0\ (d/2 + a/2).$$

16. A bone plate as claimed in any of the claims 1 to 15, wherein the axis of at least one of the holes forms an angle of between 70° and 110° relative to a plane parallel to the top surface.

17. A bone plate as claimed in any of the claims 1 to 16, wherein said plate consists of a plurality of sections which preferably result in an L-shaped or T-shaped form of the plate, the longitudinal axes of the individual plate sections forming an acute or an obtuse angle between each other.

18. A bone plate as claimed in claim 17, wherein at least two sections of the bone plate are arranged in different planes.

19. A bone plate as claimed in claim 17 or 18, wherein the three-dimensionally structured portion of the longest section of the bone plate - considered in the direction of the longitudinal axis of this longest section - is formed in the end portion of the combined holes which is situated closer to the adjacent, shorter section of the bone plate.

20. A bone plate as claimed in any of the claims 1 to 19, wherein the elongate hole is designed as a fixation screw hole.

21. A fixation device including a bone plate as claimed in any of the claims 1 to 20, wherein said plate comprises in addition at least one bone screw.

22. A fixation device as claimed in claim 21, wherein the bone screw comprises an external structured portion - preferably in the form of an external screw thread - formed in the screw head, which corresponds to the three-dimensionally structured portion.

23. A fixation device as claimed in claim 21 or 22, wherein the bone screw is a self-tapping and/or self-drilling bone screw.

24. A bone plate with a top surface, a bottom surface for contact with the bone, and a plurality of holes situated along the longitudinal axis of the plate and connecting the top surface and the bottom surface for receiving bone screws, which bone plate is substantially as hereinbefore described with reference to the figures.

25. A fixation device including a bone plate of claim 24, wherein said plate comprises in addition at least one bone screw.

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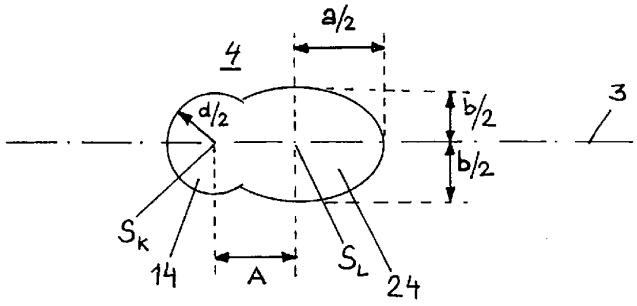


Fig. 1

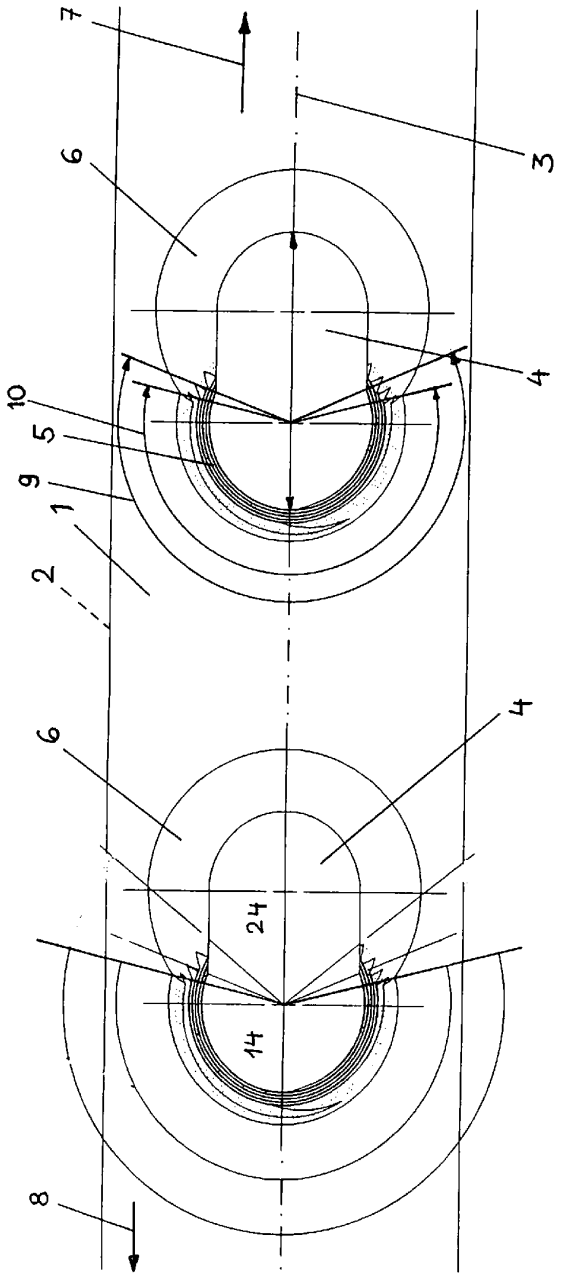
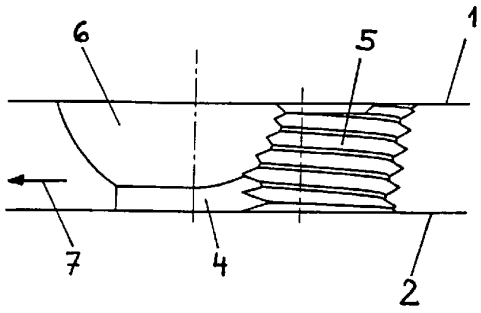


Fig. 2

Fig. 3



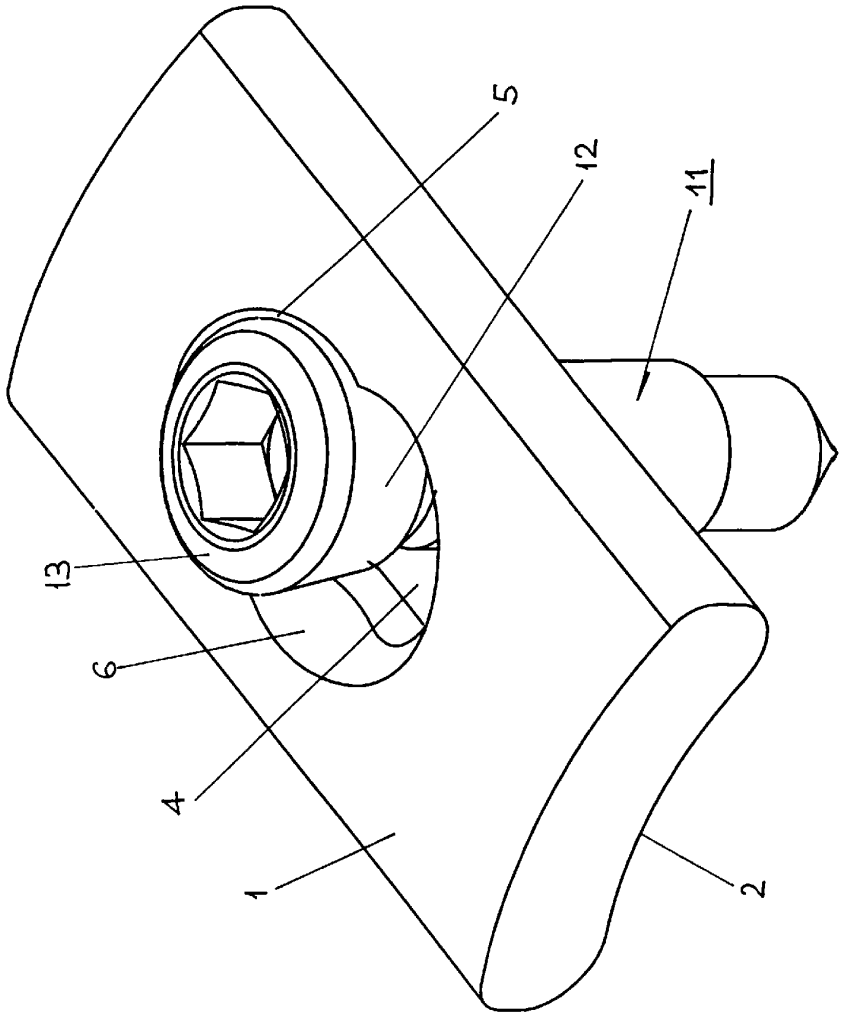


Fig. 4