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Bone screw with axially two-part screw head

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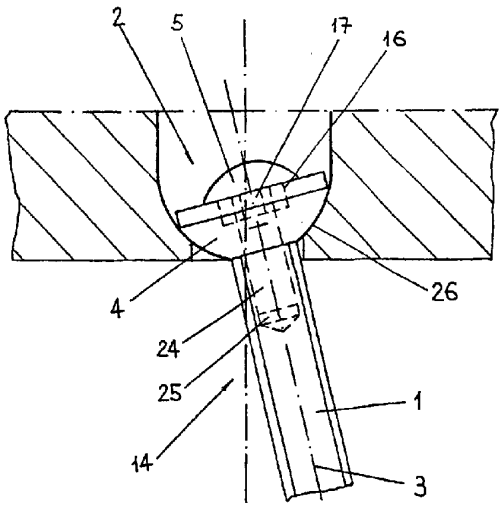
(54) Title: BONE SCREW WITH AXIALLY TWO-PART SCREW HEAD

(54) Bezeichnung: KNOCHENSCHRAUBE MIT AXIAL ZWEISTÜCKIGEM SCHRAUBENKOPF



(57) Abstract: The invention relates to a bone screw (14; 28) that is provided with a screw shaft (1) that is to be anchored in the bone in a direction coaxial with respect to the longitudinal axis (3) of the screw and with a screw head (2). Said bone screw (14; 28) is configured as an axially composite element. At least the screw head (2) is axially two-part and comprises a screw shaft lower part (4) and a terminal upper part (5) that is linked with the lower part (4) and/or the screw head (1). The invention also relates to a device for the osteosynthetic bone fixation with at least one such bone screw (14; 28). Said device comprises A) at least one plate-shaped, prismatic or cylindrical fixation element (41) that is provided with at least one bore (37) with a center axis (30) for receiving the bone screw (14; 28) and a screw shaft lower part (36) and a screw head upper part (33). The invention is also characterized in that B) the bore (37) comprises a concave section (39) that tapers in the direction of the lower part (36); and C) the diameter of the lower part (4) is chosen such that the lower part (4) can be accommodated in the concave section (39) of the bore (37) at different angles between the longitudinal axis (3) of the screw and the center axis (30) and is placed on the wall (40) of the bore (37).

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(57) **Zusammenfassung:** Knochenschraube (14; 28) mit einem zur Schraubenlängsachse (3) konzentrisch in einem Knochen zu verankernden Schraubenschaft (1) und einem Schraubenkopf (2), dadurch gekennzeichnet, dass die Knochenschraube (14; 28) axial mehrteilig ist, wobei mindestens der Schraubenkopf (2) in axialer Richtung zweistückig ist und ein schraubenschaftseitiges Unterteil (4) und ein endständiges, mit dem Unterteil (4) und/oder dem Schraubenschaft (1) verbindbares Oberteil (5) umfasst. Vorrichtung zur osteosynthetischen Knochenfixation mit mindestens einer solchen Knochenschraube (14; 28), wobei die Vorrichtung A) zusätzlich mindestens einen plattenförmigen, prismatischen oder zylindrischen Fixationskörper (41) umfasst, welcher mindestens eine Bohrung (37) mit einer Zentralachse (30) zur Aufnahme der Knochenschraube (14; 28), eine schraubenschaftseitige Unterseite (36) und eine schraubenkopfseitige Oberseite (33) auf weist, wobei B) die Bohrung (37) einen konkaven sich gegen die Unterseite (36) verjüngenden Abschnitt (39) umfasst; und C) der Durchmesser d des Unterteils (4) so dimensioniert ist, dass das Unterteil (4) im konkaven Abschnitt (39) der Bohrung (37) unter verschiedenen Winkeln zwischen Schraubenlängsachse (3) und Zentralachse (30) an der Wand (40) der Bohrung (37) zur Anlage bringbar ist.

Bone screw with axially two-part screw head

The invention relates to a bone screw for osteosynthetic bone fixation and to a device for osteosynthetic bone fixation.

Various devices for internal fixation of bone fragments in the human or animal body are already known from the prior art.

In the case of internal fixation of the spinal column or of parts of the spinal column, such devices often essentially comprise pedicle screws which are anchored by means of threads in the pedicles of the individual vertebrae to be joined, and one or more longitudinal supports which extend in the direction of the spinal column and have to be connected securely to the pedicle screw. For stable anchoring of the whole implant, the pedicle screws must on the one hand be screwed securely into the pedicles and, on the other hand, be connected rigidly to the longitudinal supports. The connection between the screw head of the pedicle screws and the longitudinal support is normally effected by means of clamp mechanisms which must permit a stable connection, even at different angles of the pedicle screw in relation to the longitudinal support. The clamp connection must be releasable so that the whole implant can be removed again without large tissue openings in the area of the spinal column.

Secure connections between bone screws and plates or supports are also common in other internal bone fixations. Here, too different angles of the bone screws relative to the plate or the support must be possible without adversely affecting the connections in terms of their stability.

Such a connection between a bone-anchoring screw and a stabilizer rod for internal fixation of vertebrae is known from US 5,466,237 BYRD. This known invention has a bone-anchoring screw with a screw head which is designed as a segment of a sphere on its side facing the screw shank and is convex at its end. The sperical segment part of the screw is mounted in a bore of the anchoring element, this bore comprising a concave portion which tapers toward the

screw shank so that a ball-joint-type connection is obtained between the bone screw and the anchoring element. This ball-joint-type connection is blocked by tightening a nut on the anchoring element, which nut presses against the longitudinal support which has been placed in the anchoring element and which consequently presses against the terminal convex part of the screw head and thus blocks the screw head in the anchoring element.

However, in the case of a screw head which is convex at the end, there is a danger that the means for inserting a screwdriver in the screw head, for example a centrally arranged hexagon socket, will impair the contact surface between a longitudinal support, pressing on the screw head, and the screw head itself.

The invention aims to remedy this situation.

The above discussion of background art is included to explain the context of the invention. It is not to be taken as an admission or suggestion 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.

In one aspect, the present invention provides a bone screw for osteosynthetic bone fixation, including a screw shank to be anchored concentric to the longitudinal axis of the screw in a bone or bone part, and a screw head, wherein the bone screw is in more than one part axially, at least the screw head being in two parts in the axial direction and having a bottom part toward the screw shank and a top part toward the end which can be connected to the bottom part and/or to the screw shank; wherein the upper part is of convex design; and wherein the bottom part is designed as a circular disk, whereby a rim of the lower part is stepped and has a lower edge.

In another aspect, the present invention provides a device for osteosynthetic bone fixation including at least one bone screw as just described, wherein it additionally includes at least one plate-shaped, prismatic or cylindrical fixation body which has at lease one bore

with a central axis for receiving the bone screw, an underside toward the screw shank, and an upper side toward the screw head, the bore including a concave portion tapering toward the underside, and the diameter d of the bottom part being dimensioned such that the bottom part, in the concave portion of the bore, can be made to bear on the wall of the bore at different angles between the longitudinal axis of the screw and the central axis.

Accordingly, the invention is based on the object of producing a bone screw with a two-part screw head, where the bottom part of the screw head is securely connected to the screw shank and the top part of the screw head can be connected to the bottom part after implantation of the bone screw. In this way it is possible for the top surface of a convex screw head to be made smooth in the area of contact with another implant part, for example a longitudinal support, as a result of which a punctiform contact can be achieved between the top part of the screw head and the longitudinal support. By means of the device according to the invention, a connection between bone screw and anchoring element can be produced which permits different angles between screw axis and anchoring element and which is stable.

Thus, in at least one embodiment the bone screw according to the invention comprises a screw shank to be anchored concentric to a longitudinal axis in a bone or bone part, and a likewise concentric, axially two-part screw head. The bottom part of a screw head toward the screw shank has a diameter which is greater than the diameter of the screw shank. The bottom part is designed as a segment of a sphere in the direction toward the screw shank. The top part of the screw head can be fitted on the bottom part or can be connected to the bottom part and screw shank by means of a press fit, a cone connection, a screw connection or a bayonet lock connection.

In the preferred embodiment of the bone screw according to the invention, the bottom part of the screw head and the screw shank are in one piece. In other embodiments, however, the bottom part can also be designed

as a separate part, for example as a circular disk which can be pushed over a corresponding peg on the screw shank and which is clamped securely between the screw head and the screw shank when the top part of the screw head is secured.

The diameter of the bottom part of the screw head is preferably between 8 and 10mm, while the diameter of the screw shank is preferably between 5 and 6mm.

In a further embodiment of the bone screw according to the invention, the bottom part of the two-part screw head is designed as a circular disk. The thickness of such a circular-disk-shaped bottom part is preferably between 1 and 2mm. The rim of such a bottom part is preferably stepped and has a lower edge for bearing on the wall of a bore with a curved surface. A

linear contact is achieved in this way.

The top part of the screw head can be of convex design at the end, in particular spherical and semispherical.

Depending on the embodiment, the bone screw according to the invention can be used for the fixation of bones or bone parts in an osteosynthesis fixation device and can serve, for example, for the fixation of bones or bone parts on a bone plate or for the fixation of vertebrae in a spinal column fixation device.

The device according to the invention for osteosynthetic bone fixation comprises at least one bone screw with a screw shank to be anchored in the bone or bone part and a screw head, and at least one fixation body which serves for stable fixation of the bones or bone parts. The fixation body has at least one bore for receiving the bone screw, this bore passing through the fixation body and comprising a concave portion tapering toward the end at the screw shank side. The bottom part of the screw head is in the shape of a segment of a sphere or in the shape of a circular disk, the diameter being dimensioned such that the bottom part, in the concave portion of the bore, can be made to bear on the wall of the bore at different angles between the longitudinal axis of the bone screw and the central axis of the bore. The configuration with a disk-shaped bottom part having a plane surface on the screw shank side, which surface bears on the concave wall of the bore upon tightening of the screw, permits a linear contact between the bone screw and the fixation body.

In one embodiment of the device according to the invention, this is used to connect a longitudinal support to the bone screw, designed as a pedicle screw, within a spinal column fixation system. The fixation body is designed as a receiving head which serves to connect the longitudinal support to the pedicle screw. Besides the through-bore passing through the receiving

head in order to receive the pedicle screw, there is additionally a channel extending transverse to the central axis of the receiving head and open toward the screw head side in order to receive the longitudinal support. The device additionally comprises clamping means which can be connected to the receiving head in a releasable manner at the screw head end and serve for fixing the longitudinal support and the pedicle screw within the receiving head. The through-bore comprises a concave portion tapering toward its screw shank end, so that the screw head of the pedicle screw can be made to bear on the wall of the through-bore, in the concave portion of the through-bore, at different angles between the screw axis and the central axis of the bore.

In a further embodiment of the device according to the invention, the bottom part of the screw head has a diameter d, and the concave portion is of spherical design and has a diameter D, where D = d. However, with this design, with a circular-disk-shaped bottom part, only small angles of the screw axis relative to the central axis of the bore in the fixation body are possible, since otherwise the linear contact is obtained only on one part of the collar circumference. For greater angles in the case of circular-disk-shaped bottom parts, a design of the concave portion is suitable with a diameter D, where D > d. In this case, the ratio d:D can be chosen between 0.5 and 1.0, preferably between 0.85 and 0.95. In addition, the diameter of the screw head is chosen such that, if the bone screw is in an inclined position, the screw head does not bear on the wall of the bore and thereby restrict an inclined position of the bone screw.

In yet another embodiment of the device according to the invention, the concave portion is designed in the manner of a spherical segment, where the spherical segment has a radius X while the diameter of the concave portion is D, so that $X \geq D$. The ratio

of D/2 to X is between 0.5 and 1.0, preferably between 0.85 and 0.95.

In a particular embodiment of the device according to the invention, the convex top part at the end of the screw head is of spherical or semispherical design. The center of the spherical top part can coincide with the sphere center of the spherical segment on the bottom part. In the case of the connection device between longitudinal support and pedicle screw, the advantage of this design lies in the fact that a longitudinal support clamped between screw head and clamping means presses on the screw head concentric to the central axis even if the pedicle screw is in an inclined position.

The convex screw head is axially in two parts, where the top part at the end of the screw head can be connected releaseably to the bottom part, which is made in one piece with the screw shank. Above all by means of the two-piece design, the means for inserting a screwdriver into the screw shank, for example a hexagon socket or internal thread, can be more easily provided. In addition, in the case of a central arrangement of, for example, a hexagon socket in the bottom part, the bearing between longitudinal support and screw head is not adversely affected by application of the top part after implantation of the bone screw.

In the case of a circular-disk-shaped bottom part, the rim of the bottom part is advantageously stepped, especially on the underside toward the screw shank, so that a lower edge is formed which is intended for linear contact with the wall of the concave portion.

The diameter D of the concave portion and the diameter d of the bottom part are advantageously between 8 and 10 mm. In the case of a circular-disk-shaped bottom part, the latter advantageously has a thickness of 1 to 2 mm.

The external diameter of the screw shank is

advantageously 5 to 6 mm.

The advantages afforded by the invention are essentially that, by virtue of the inventive design of the bone screw, the surface of the convex screw head in the area of contact with another implant part, for example the longitudinal support, is smooth and this contact zone is not impeded by means for receiving a screwdriver. The advantages of the device according to the invention lie in the design of the bore for receiving a bone screw and in the design of the bone screw with a screw head having a bottom part which is intended to bear in a concave portion of the bore so that, in the case of a circular-disk-shaped bottom part, a linear contact can be obtained which, upon fixation of the device, leads to a secure connection between bone screw and fixation body. In the case of a deformable bore wall, a form-fit connection between bottom part and bore wall can also be achieved as a result of the linear contact.

The invention and developments of the invention are discussed in greater detail below with reference to the partially diagrammatic representations of a number of illustrative embodiments.

Fig. 1 shows a view of an embodiment of the multi-part bone screw according to the invention;

Fig. 2 shows a view of a further embodiment of the multi-part bone screw according to the invention;

Fig. 3 again shows a view of a further embodiment of the multi-part bone screw according to the invention;

Fig. 4 again shows a view of a further embodiment of the multi-part bone screw according to the invention;

Fig. 5 shows a section, parallel to a longitudinal support, of an embodiment of the device according to the invention; and

Fig. 6 shows a section through the embodiment of the device according to the invention shown in Fig.

5, transverse to a longitudinal support.

The preferred embodiment of the two-part bone screw 14 according to the invention is represented in Fig. 1. The bone screw 14 comprises, concentric to the longitudinal axis 3 of the screw, a screw shank 1 and a screw head 2 which is in two parts in the axial direction and which consists of a bottom part 4 on the screw shank side and a top part 5 at the end. The screw shank 1 serves to anchor the bone screw in a bone or bone part. The bottom part 4 is of convex design toward the screw shank and has a bearing surface 26 in the form of a segment of a sphere. Bottom part 4 and screw shank 1 are in one piece. The connection between top part 5 and screw shank 4 is a press-fit connection. Arranged on the top part 5, concentric to the longitudinal axis 3 of the screw, there is a peg 24 which can be introduced into a bore 25 in the screw shank 1, which bore is concentric to the longitudinal axis 3 of the screw. To turn the screw shank 1 into the bone or the bone part, a hexagon socket 16 is arranged on the bottom part 4, concentric to the longitudinal axis 3, the wrench width of the hexagon socket 16 being chosen such that the side surfaces 17 of the hexagon socket 16 do not touch the peg 24. The top part 5 is of a spherical design axially at one end, so that the assembled screw head 2 is made convex at the end by the top part 5.

A further embodiment of the two-part bone screw 14 according to the invention is shown in Fig. 2. The bone screw 14 comprises, concentric to the longitudinal axis 3 of the screw, a screw shank 1 and a screw head 2 which is in two parts in the axial direction and which consists of a bottom part 4 on the screw shank side and a top part 5 at the end. The screw shank 1 serves to anchor the bone screw in a bone or bone part. The bottom part 4 is stepped and has, toward the screw shank, a plane bearing surface 7 with a lower edge 6. Bottom part 4 and screw shank 1 are in one piece. The

connection between top part 5 and screw shank 4 is a cone connection. Arranged on the top part 5, concentric to the longitudinal axis 3 of the screw, there is a conical peg 8 which can be secured in a bore 9 concentric to the longitudinal axis 3 of the screw, with an inner cone 10 in the screw shank 1. To turn the screw shank 1 into the bone or the bone part, a hexagon socket 16 is arranged on the bottom part 4, concentric to the longitudinal axis 3, the wrench width of the hexagon socket 16 being chosen such that the side surfaces 17 of the hexagon socket 16 do not touch the conical peg 8.

Fig. 3 shows another embodiment of the two-part bone screw 14 according to the invention, which differs from the embodiment shown in Fig. 2 only in that the connection between top part 5 and screw shank 1 is a screw connection. Arranged on the top part 5, concentric to the longitudinal axis 3 of the screw, there is a threaded peg 11 which can be screwed into a bore 12, concentric to the longitudinal axis 3 of the screw, with an internal thread 13 on the screw shank 1. Here once again, bottom part 4 and screw shank 1 are in one piece. The hexagon socket 16 passes axially through the bottom part 4, while the bore 12 with the internal thread 13 begins only at that end of the screw shank 1 toward the bottom part and extends into the latter. Also arranged on the top part 5 there are two or more surfaces 15 oriented parallel to the longitudinal axis 3 of the screw and acting as external two edges for turning the screw shank 1 by means of a suitable screwdriver. Instead of the external two edges, it is also possible to have an external square or external hexagon.

Fig. 4 again shows a further embodiment of the two-part bone screw 14 according to the invention, which embodiment differs from the embodiment shown in Fig. 3 only in that the connection between top part 5 and screw shank 1 is a bayonet lock. Arranged on the

top part 5, concentric to the longitudinal axis 3 of the screw, there is a peg 18 with a radially protruding pin 19 which can be snapped into a bore 20, with groove 21, concentric to the longitudinal axis 3 of the screw, the groove 21 having a part 22 extending parallel to the longitudinal axis 3 of the screw and a part 23 extending peripherally into the bore 20.

Figures 5 and 6 show an embodiment of the device according to the invention which serves to connect a longitudinal support 27 to a pedicle screw 28 within a spinal column fixation system. This device comprises a pedicle screw 28 which has, concentric to its longitudinal axis 3, a screw shank 1 to be anchored in the bone, a screw head 2, a receiving head 29 with the central axis 30, which serves to connect a longitudinal support 27 to the pedicle screw 28, and clamping means 31. These clamping means 31 are essentially in the form of a nut, can be screwed by means of an internal thread 32 over an external thread 34 adjoining the upper side 33 of the receiving head 29 toward the screw head, and serve to fix the longitudinal support 27 and the pedicle screw 28 within the receiving head 29.

The screw head 2 is in two parts and has a bottom part 4 and a top part 5, their connection being designed in accordance with one of the embodiments described in Figs. 1 through 4. The top part 5 is designed as a segment of a sphere axially at one end, the zenith 35 of the sphere segment lying on the longitudinal axis 3 of the screw and forming the screw-head end of the pedicle screw 28.

The receiving head 29 has an upper side 33 toward the screw head, an underside 36 toward the screw shank, a through-bore 37 passing through the receiving head 29, coaxial to the central axis 30, for receiving the pedicle screw 28 and, additionally, a channel 38 extending transverse to the central axis 30 and open toward the upper side 33 in order to receive a

longitudinal support 27. In this way, the longitudinal support 27 can be inserted from the upper side 33 into the open channel 38 and can be fixed therein in a releasable manner by the clamping means 31.

The through-bore 37 comprises a concave portion 39 which tapers toward the underside 36 and which, in the embodiment of the device according to the invention shown here, is designed as a segment of a sphere.

The two-part screw head 2 has a concentric circular-disk-shaped bottom part 4 with a diameter d. The concave portion 39 is spherical with a radius of curvature X and, toward the upper side 33, opens into a cylindrical portion with the diameter D. In the embodiment of the device according to the invention shown here, the radius of curvature X corresponds to the radius of the cylindrical portion $X = D/2$. Likewise, in the embodiment shown here, the diameter d of the bottom part 4 is smaller than the diameter D of the cylindrical portion $d < D$. This dimensioning of the bottom part 4 and of the concave portion 39 ensures that the bottom part 4, in the concave portion 39 of the though-bore 37, can be made to bear on the wall 40 of the through-bore 37 at different angles between the longitudinal axis 3 of the screw and the central axis 30.

Claims

1. A bone screw for osteosynthetic bone fixation, including a screw shank to be anchored concentric to a longitudinal axis of the screw in a bone or bone part, and a screw head, wherein the bone screw is in more than one part axially, at least the screw head being in two parts in the axial direction and having a bottom part toward the screw shank and a top part toward the end which can be connected to the bottom part and/or to the screw shank; wherein the upper part is of convex design; and wherein the bottom part is designed as a circular disk, whereby a rim of the lower part is stepped and has a lower edge.

2. A bone screw as claimed in claim 1, wherein the top part can be connected in a releasable manner to the bottom part and/or to the screw shank.

3. A bone screw as claimed in claim 1 or claim 2, wherein the bottom part and the screw shank are in one piece.

4. A bone screw as claimed in claim 2 or claim 3, wherein the top part can be connected to the screw shank by means of a cone connection.

5. A bone screw as claimed in claim 2 or claim 3, wherein the top part can be connected to the screw shank by means of a screw connection.

6. A bone screw as claimed in claim 2 or claim 3, wherein the top part can be connected to the screw shank by means of a bayonet lock.

7. A bone screw as claimed in any one of claims 1 to 6, wherein the bottom part is of convex design toward the screw shank.

8. A bone screw as claimed in claim 7, wherein the bottom part is designed as a segment of a sphere toward the screw shank.

9. A bone screw as claimed in any one of claims 1 to 8, wherein the top part is of spherical design.

10. A bone screw as claimed in claim 9, wherein the top part is of hemispherical design.

11. A bone screw as claimed in any one of claims 1 to 10, wherein the bottom part has a diameter between 8 and 10mm.

12. A bone screw as claimed in any one of claims 1 to 11, wherein the bottom part has a thickness of 1 to 2mm.

13. A bone screw as claimed in any one of claims 1 to 12, wherein the external diameter of the screw shank is 5 to 6mm.

14. A bone screw as claimed in any one of claims 1 to 13, wherein the diameter d of the bottom part is between 4 and 6mm.

15. A bone screw as claimed in claim 14, wherein the bottom part has a thickness of 0.5 to 1mm.

16. A bone screw as claimed in claim 14 or 15, wherein the external diameter of the screw shank is 3 to 5mm.

17. A bone screw as claimed in any one of claims 1 to 16, wherein it serves for the fixation of bones or bone parts in an osteosynthesis fixation device.

18. A bone screw as claimed in claim 17, wherein it serves for the fixation of bones or bone parts on a bone plate.

19. A bone screw as claimed in claim 17, wherein it is a pedicle screw and serves for the fixation of vertebrae in a spinal column fixation device.

20. A device for osteosynthetic bone fixation including at least one bone screw as claimed in any one of claims 1 to 19, wherein it additionally includes at least one plate-shaped, prismatic or cylindrical fixation body which has at lease one bore with a central axis for receiving the bone screw, an underside toward the screw shank, and an upper side toward the screw head, the bore including a concave portion tapering toward the underside, and the diameter d of the bottom part being dimensioned such that the bottom part, in the concave portion of the bore, can be made to bear on the wall of the bore at different angles between the longitudinal axis of the screw and the central axis.

21. A device as claimed in claim 20, wherein:

the bone screw is a pedicle screw with a convex screw head;

the fixation body is a receiving head with central axis, and additionally has a channel extending transverse to the central axis and open toward the upper side in order to receive a longitudinal support; and

the device additionally includes clamping means which can be connected to the receiving head in a releasable manner from the direction of the upper side and serve for fixing a longitudinal support and the pedicle screw within the receiving head.

22. A device as claimed in claim 20 or claim 21, wherein the bottom part has the diameter d, and the concave portion is of spherical design and has a diameter D, where D = d.

23. A device as claimed in claim 20 or claim 21, wherein the bottom part has the diameter d, and the concave portion is of spherical design and has a diameter D, where D > d.

24. A device as claimed in claim 23, wherein the ratio d:D is between 0.5 and 1.0.

25. A device as claimed in claim 24, wherein the ratio d:D is between 0.85 and 0.95.

26. A device as claimed in any one of claims 23 to 25, wherein the concave portion is designed as a segment of a sphere, where the spherical segment has a radius X, and $X \geq D/2$.

27. A device as claimed in claim 26, wherein the ratio of D/2 to X is between 0.5 and 1.0.

28. A device as claimed in claim 27, wherein the ratio of D/2 to X is between 0.85 and 0.95.

29. A device as claimed in any one of claims 20 to 28, wherein the diameter D of the concave portion and the diameter d of the bottom part are between 8 and 10mm.

30. A device as claimed in any one of claims 20 to 29, wherein the fixation body is a bone plate with at least one through-bore for a bone screw.

31. A bone screw for osteosynthetic bone fixation substantially as herein described with reference to the accompanying drawings.

32. A device for osteosynthetic bone fixation substantially as herein described with reference to the accompanying drawings.

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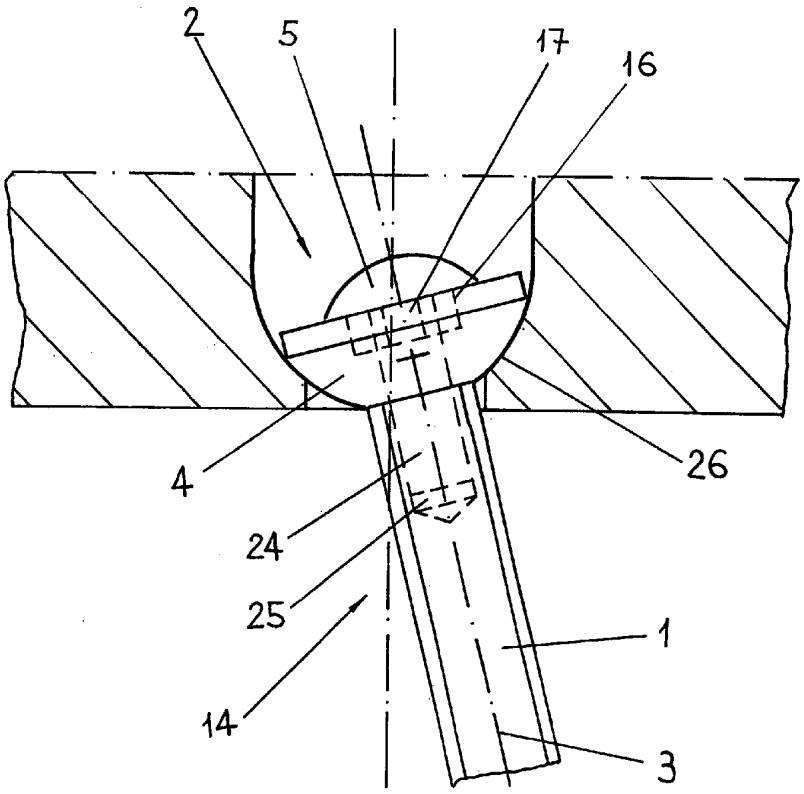


Fig. 1

Fig. 2

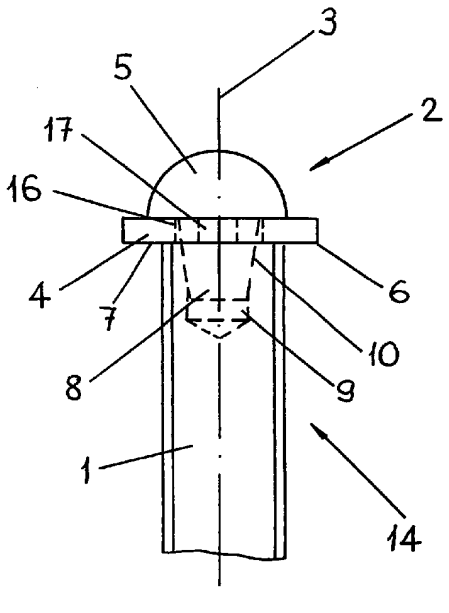


Fig. 3

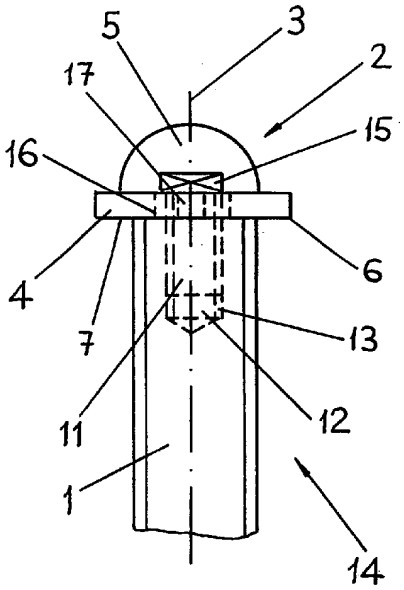
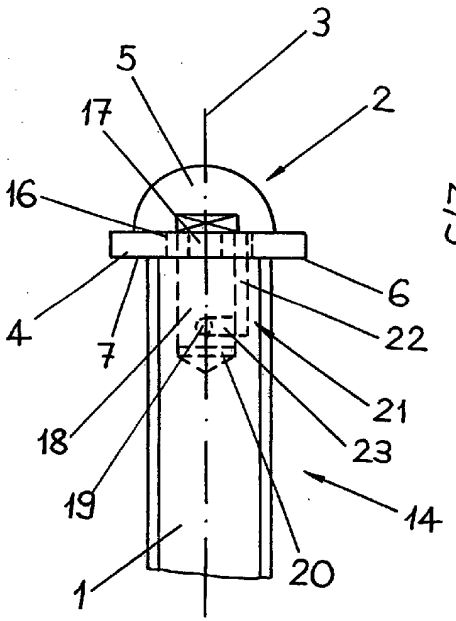


Fig. 4



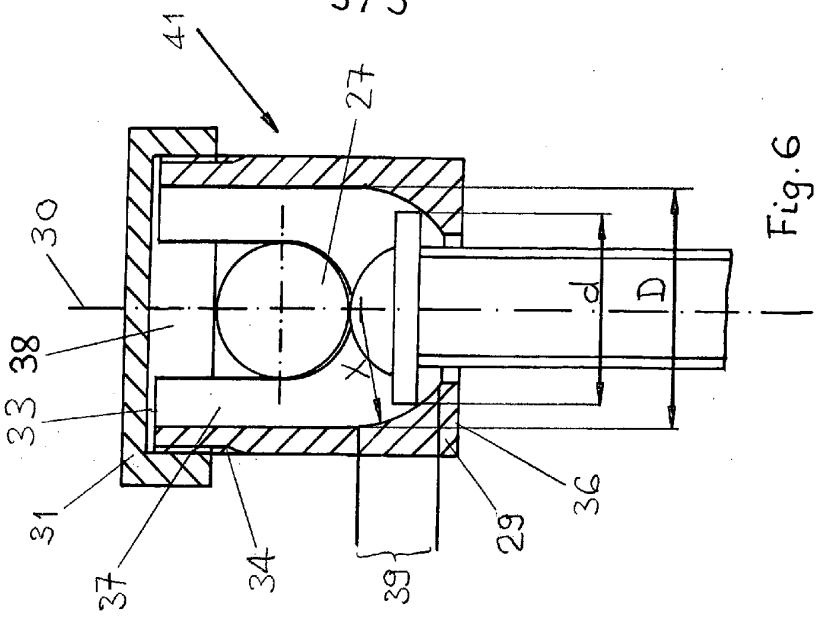

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Fig.6

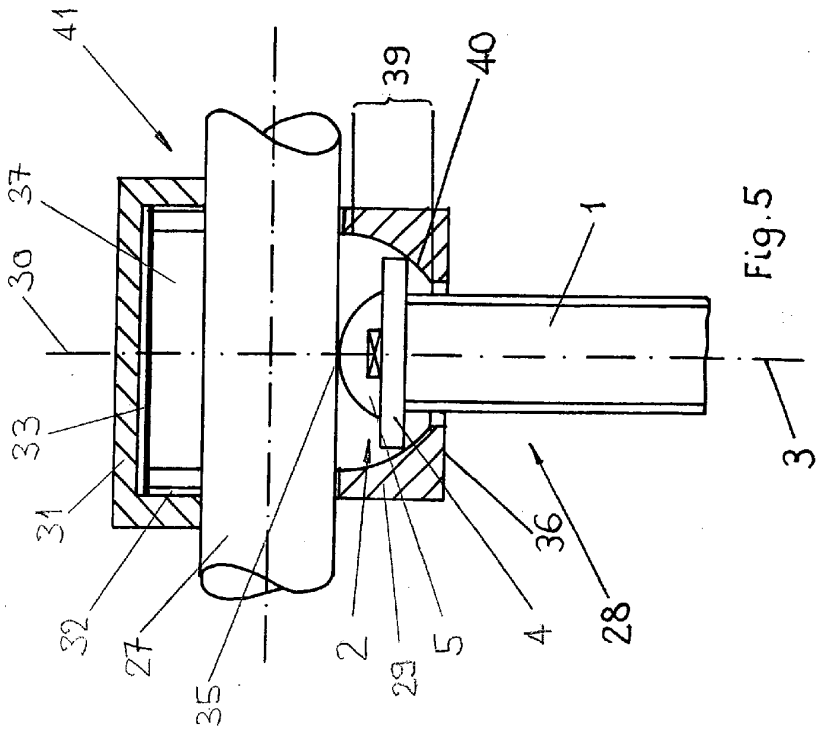
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Fig.5