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(54) Bone screw with self-constrained flexibility

(57) A bone screw is provided comprising
a longitudinal core member (10, 10') having a longitudinal axis (L) defining a longitudinal direction and having a surface, wherein a helical groove (15, 150, 15') is provided in a least a portion of the surface;
and
a helical thread body (20, 20') that is a separate part and that is provided in the groove (15, 150, 15');
wherein the groove (15, 150, 15') has a first width (wg) and the thread body (20, 20') has a second width (wt) and wherein the first width (wg) is greater than the second width (wt) such that the thread body (20, 20') can slide in the groove (15, 150, 15') in the longitudinal direction.

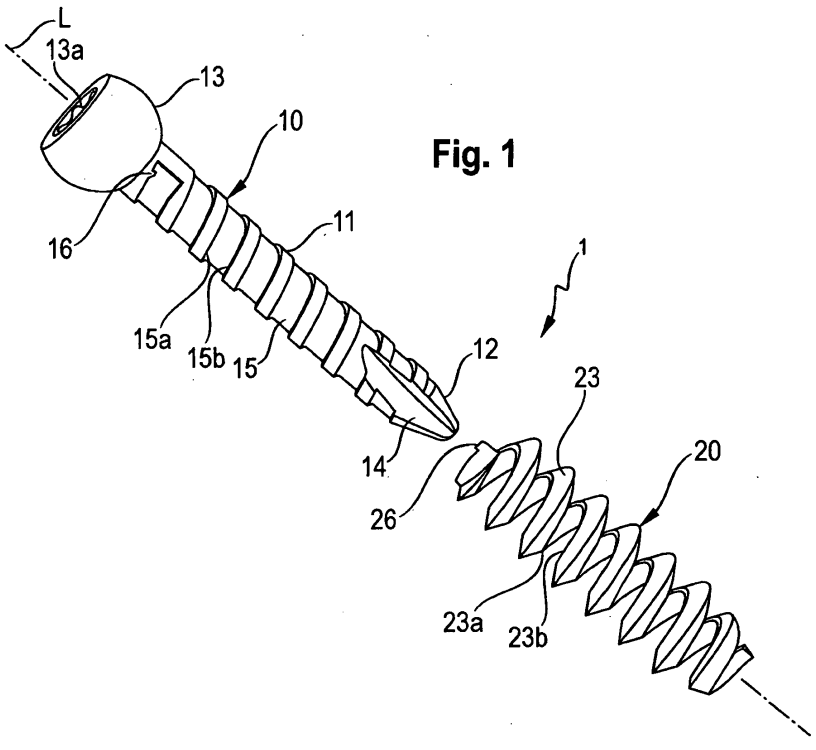

Fig. 1

EP 2 859 856 A1

Description

[0001] The invention relates to a bone screw comprising a longitudinal core member with a helical groove and a helical thread body that is provided in the groove. A width of the groove is greater than a width of a turn of the thread body so that the thread body is accommodated with a tolerance in the groove. This allows the thread body to slide in the groove in a longitudinal direction limited by the sidewalls of the groove. By means of this, the shank of the bone screw may perform a limited motion relative to the thread body.

[0002] A bone screw having a shank with an elastic or flexible element is known from US 2005/0154390 A1. The known flexible bone screw comprises a longitudinal bore and a helical slot-shaped opening in the wall of the shank. The flexibility is determined by the geometry of the hollow bore and the helical slot-shaped opening. To limit the flexibility or to strengthen the bone screw, a core may be provided in the hollow bore.

[0003] It is the object of the invention to provide a bone screw that has an improved strength while simultaneously exhibiting a certain degree of flexibility and capability of dynamic motion. The object is solved by the bone screw according to claim 1 and by a method of assembling such a bone screw according to claim 14. Further developments are given in the dependent claims.

[0004] The bone screw obtains its flexibility by the tolerance between the thread body and the groove provided in the surface of the screw shank.

[0005] A tension side of the bone screw is defined as the side where load is applied to the bone screw in a transverse direction and a compression side of the implant is defined by the side of the bone screw that is compressed when the load is applied in the transverse direction. Because the thread body is configured to abut against both sidewalls of the groove, the bending load can be transferred on the compression side as well as on the tension side. Simultaneously, the bending is limited by the stop surfaces provided by the sidewalls of the groove.

[0006] The micro-motion that is possible between the shank and the thread body which is anchored in the bone may cause a constrained motion of the bone screw, when, for example, bone resorption takes place. In such a case, the the flexible motion restriction and/or control can prevent loosening of the bone anchors inside the bone.

[0007] The solid body of the core member of the bone screw facilitates bending compared to a hollow shank while simultaneously exhibiting sufficient strength. In particular, it is possible to make the shank diameter smaller compared to shanks with a hollow bore.

[0008] If the core member and the thread body have a different pitch, it is possible to bias the thread body against the core member.

[0009] Because the thread body is a separate part that is attachable to the core member, the bone screw is a modular device that allows to select a suitable thread body in terms of thread pitch and/or thread form and to combine it with a core member while mounting it to the core member. In such a configuration, the thread body is able to maintain a compression or a distraction relative to the core member in the longitudinal direction.

[0010] Further features and advantages will become apparent from the description of embodiments by means of the accompanying drawings. In the drawings:

Fig. 1	shows a perspective exploded view of a bone screw according to a first embodiment.
Fig. 2	shows a perspective view of the bone screw of Fig. 1.
Fig. 3	shows a side view of the bone screw of Fig. 2.
Fig. 4a)	shows a cross-sectional view of the bone screw along line A-A in Fig. 3.
Fig. 4b)	shows an enlarged cross-sectional view of a detail of Fig. 4a).
Fig. 5a)	shows a cross-sectional view of the bone screw shown in Fig. 3 in a condition in which load is applied to the bone screw in a transverse direction.
Fig. 5b)	shows an enlarged cross-sectional view of a detail of Fig. 5a).
Fig. 6	shows a side view of the core member of the bone screw of Fig. 1.
Fig. 7	shows a side view of the thread body of the bone screw shown in Fig. 1.
Figs. 8a) to 8d)	show enlarged cross-sectional views of a portion of Fig. 4a) with various modifications of the shape of the thread body.
Fig. 9	shows an exploded perspective view of a second embodiment of a bone screw.
Fig. 10	shows a perspective view of the assembled bone screw according to the second embodiment.
Fig. 11	shows a cross-sectional view of the head of the bone screw according to the second embodiment, the cross-section taken in a plane containing the screw axis.

Fig. 12 shows a side view of the core member of the bone screw according to Fig. 9.

Fig. 13 shows a side view of the thread body of the bone screw according to Fig. 9.

Fig. 14 shows a side view of the bone screw according to the second embodiment in a first condition.

Fig. 15 shows a cross-sectional view of the bone screw shown in Fig. 14, the cross-section taken in a plane containing the screw axis.

Fig. 16 shows a side view of the bone screw according to the second embodiment in a second condition.

Fig. 17a) shows a cross-sectional view of the bone screw shown in Fig. 16, the cross-section taken in a plane containing the screw axis.

Fig. 17b) shows an enlarged cross-sectional view of a detail shown in Fig. 17a).

Fig. 18 shows a schematic view of a first step of inserting the bone screw according to the second embodiment into a pedicle of a vertebra.

Fig. 19a) shows a schematic view of a second step of inserting the bone screw according to the second embodiment into the pedicle of a vertebra.

Fig. 19b) shows an enlarged view of a portion of the bone screw during the insertion step shown in Fig. 19a).

Fig. 20a) shows a third step of the insertion procedure of the bone screw according to the second embodiment.

Fig. 20b) shows an enlarged view of a portion of the bone screw in the condition shown in Fig. 20a).

[0011] Figs. 1 and 2 depict a first embodiment of a bone screw 1 that is established as a two-piece unit comprising a core member 10 and a thread body 20 as a separate part. The thread body 20 is mounted to the core member 10 and the two pieces are movable relative to another to a predefined extent. Referring in more detail to Figs. 3 to 7, the core member 10 comprises a shank 11 with a tip 12 on one side of the shank 11 and a head 13 at the opposite side of the shank 11. The shank 11 defines the screw axis or longitudinal axis L. The head 13 may be equipped with a recess 13a provided at its free end surface for engagement with a tool. The shape of the head 13 is shown to be spherical segment-shaped, but is not limited thereto. Any shape of the head may be contemplated. At least one, preferably a plurality of notches 14 may be provided in the shank 11 that extend in a longitudinal direction from a position on the shank 11 to the tip 12. The notches 14 may be slightly twisted with respect to the longitudinal axis.

[0012] They may serve for allowing self-cutting of the bone screw during insertion. In the region of the tip 12, the shank 11 tapers towards the free end.

[0013] In the outer surface of the shank 11, a helical groove 15 is provided that extends from a position close to the head 13 up to a position at the beginning of the tapered section of the tip 12. The helical groove 15 has a width wg in the longitudinal direction that may be greater than a width ws of the shank portions that lie between two turns of the helical groove 15. As can be seen in particular in Figs. 4a) to 5b), a cross-section of the groove 15 is substantially rectangular. A depth d of the groove is smaller than the width wg of the groove. Opposing sidewalls 15a, 15b of the groove form abutment surfaces for the thread body 20 as described below. A first sidewall 15a is facing the tip 12 and a second sidewall 15b is facing the head 13. The end portion of the groove 15 that is close to the head 13 comprises an end surface 15c extending substantially in the longitudinal direction. In a side view, as seen in Fig. 6, the end portion of the groove has a substantially trapezoidal contour, i.e. the sidewalls 15a, 15b are slightly angled with respect to each other in such a manner that the groove 15 widens towards the transverse wall 15c. As can be seen in particular in Figs. 1 and 6, a nose-shaped projection 16 extends from the first sidewall 15a into the end portion of the groove 15. The nose-shaped projection 16 is formed such that it cooperates with a corresponding portion of the thread body in order to retain the thread body in the groove 15.

[0014] The number of turns of the groove 15 corresponds to the number of thread turns of a bone thread typically provided on the shank 11. The orientation of the helical groove corresponds to that of a right-hand thread. A thread pitch of the helical groove 15 forms a first thread pitch P_1 of the bone screw 1.

[0015] The end portion of the groove 15 that is opposite to the head 13 is open towards the tip 12 and ends substantially at a position, where the shank tapers to form the tip 12 (see, for example, Figs. 3 and 6). The open end portion of the groove 15 allows to engage the groove 15 with the thread body 20 from the tip side of the shank 11.

[0016] The core member 10 is a monolithic solid piece without a coaxial bore. Because of this, the shank diameter can be reduced compared to screw shanks that comprise a coaxial hollow bore. As depicted in particular in Figs. 1 and 7, the thread body 20 is a substantially hollow cylindrical member with a first end 21 and an opposite

second end 22 and consists of a helical thread 23 the turns of which wind around a hollow interior section 24. The thread 23 has the shape of a usual bone thread having a substantially triangular cross-section with a base consisting of opposing surfaces 23a, 23b that extend substantially perpendicular to the longitudinal axis in a cross-sectional view, seen in Fig. 4a) and Fig. 4b). A height of the opposing surfaces 23a, 23b is the same or substantially larger than a depth of the groove 15, as depicted in Fig. 4b). The opposing surfaces 23a, 23b of the base of the thread 23 are configured to cooperate with the opposing sidewalls 15a, 15b of the groove 15.

[0017] A width wt of a thread turn of the thread body 20 is smaller than the width wg of the groove 15, so that the thread body 20 can be placed into the groove 15 with a tolerance. The thread pitch of the thread body 20 is a second thread pitch P_2. In this embodiment, the second thread pitch P_2 is the same as the first thread pitch P_1 of the helical groove 15. An end surface 23c of the thread body 20 at the first end 21 extends substantially coaxial to the longitudinal axis L and is configured to abut against the end surface 15c of the groove 15. The thread-direction of the thread 23 is the same as that of the groove 15 so that the thread body 20 can be screwed onto the shank 11 thereby engaging the groove 15. Close to the end surface 23c there is a nose-shaped projection 26 of the thread body 20, that is configured to cooperate with the nose-shaped projection 16 in the end portion of the groove 15 such that when the nose-shaped projection 26 engages the nose-shaped projection 16 the thread body 20 is retained in the groove 15 and the core member 10 is prevented from being screwed out of the thread body 20.

[0018] At the second end 22, the height of the crest of the thread 23 decreases continuously while an inclination of the flank that faces towards the second end 22 continuously decreases. As can be seen in Fig. 2 and 5a), the last turn of the thread 23 of the thread body 20 or a portion thereof has a smaller outer diameter than the remainder of the thread body 20 to match the shape of the tip 12.

[0019] The bone screw 1 is assembled by screwing the thread body 20 from the tip side of the shank onto the shank 11. Thereby, the first end 21 of the thread body 20 engages the groove 15 and the thread body 20 is advanced until its first end 21 reaches the end portion of the groove 15. The nose-shaped projection 26 of the thread body slides along the nose-shaped projection 16 that projects into the groove until it snaps behind it and the noses engage each other. When the nose-shaped projection 26 passes along the nose-shaped projection 16, the enlarged end portion of the groove 15 provides the necessary space. In the mounted state, the end surface 23c of the thread body 20 abuts against the end surface 15c of the groove 15 of the shank 11. When the thread body 20 is fully mounted onto the shank, the sidewall 23b of the thread body 20 that is facing the head 13 abuts against the sidewall 15a of the groove 15 as can be seen in Figs. 3 to 4b). Because the width wg of the groove 15 is larger than the width wt of the thread 23, there is a gap 27 between the sidewall 23a of the thread body 20 and the second sidewall 15b of the groove that allows the thread body to move in a longitudinal direction relative to the shank 11 until the sidewall 23a of the thread body 20 abuts against the sidewall 15b of the groove 15.

[0020] The core member 10 and the thread body 20 are both made of a body-compatible material. Such body-compatible materials are in particular body-compatible metals such as titanium, stainless steel or body-compatible metal alloys, such as NiTi alloys, for example Nitinol. Body-compatible plastics are for example PEEK (polyetheretherketone). The core member 10 and the thread body 20 can be of the same or of different materials. For example, the core member 10 can be made of a body-compatible metal or metal alloy and the thread body 20 can be made of a body-compatible plastic material. Any other combination of materials may be contemplated.

[0021] The use of the dynamic bone screw will be explained referring to Figs. 4a) to 5b). When the bone screw 1 is inserted into a core hole prepared in a bone, a bone part or a vertebra, for example the pedicle of a vertebra, the core member 10 is in a straight state. Because the nose-shaped projections 26, 16 of the thread body 20 and the groove 15, respectively, are engaged, the turning motion of the bone screw when it is inserted does not cause the thread body 20 to disengage from the groove 15. Further, the turning motion has the effect that the thread body 20 abuts with its sidewall 23b against the first sidewall 15a of the groove 15, that faces the tip 12.

[0022] When load is applied to the bone screw in a direction transverse to the longitudinal direction and a transverse force F acts onto the core member 10, for example, onto the head 13, the side of the bone screw 1 to which the load is applied is defined as the tension side of the bone screw and the opposite side is defined as the compression side of the bone screw 1. The core member bends with respect to the longitudinal axis L while the thread body 20 still engages the surrounding bone material. Hence, the bending of the core member 10 relative to the thread body 20 causes the thread turns of the thread body 20 to move towards the opposite sidewall 15b of the groove 15 on the compression side as can be seen in Figs. 5a) and 5). Simultaneously, on the tension side, the thread turns of the thread body 20 still abut with their side surface 23b against the first side wall 15a of the groove 15. Therefore, the sidewalls 15a, 15b of the groove provide stops for a motion of the core member 10 relative to the thread body 20. This construction permits a limited micro-motion between the shank 11 and the thread body 20 that is anchored in surrounding bone material. In addition, the load can be transferred not only on the compression side, but also on the tension side when the sidewall 23b abuts against the sidewall 15a of the groove 15.

[0023] The bone screw may be used, for example, as a pedicle screw. In this case, it can be connected to a

receiving part to form a polyaxial or a mono-planar bone anchor. For the receiving part, all kinds of receiving parts can be used that allow to pivotably hold the head of the bone screw and connect the bone screw to a spinal stabilization rod. When the vertebrae move, transverse forces may act onto the pedicle screw. Due to the limited flexibility, the core member of the pedicle screw can bend and thus prevent a fracture of weak bone material. Also, in the case of bone resorption, the bone screw 1 may balance forces due to its dynamic characteristics that would otherwise have an adverse effect onto the stabilization device. In particular, loosening of the bone screw 1 in the bone due to bone resorption can be prevented.

[0024] Because the core member 10 and the thread body 20 are separate parts, a modular bone screw can be provided, wherein different combinations of core member 10 and thread body 20 may be selected. For example, the thread body 20 can be designed in various thread forms and a particular thread body 20 with a specific thread form can be mounted to the core member 10. Figs. 8a) to 8d) depict various thread forms that may be used. Fig. 8a) shows a thread 23" with a saw-tooth shape that comprises a horizontal flank facing the head 13 and an opposite inclined flank. Fig. 8b) shows a thread 23"' that has a substantially square-shape comprising two opposite horizontal flanks. Fig. 8c) shows a thread 23"" with the flank that faces the head 13 having a negative thread angle. Fig. 8d) shows a further modification of the design of the groove and the thread body. The groove 150 is a helix-shaped groove with a circular segment-shaped cross-section and the thread body is comprised of a thread helix 28 made of a round wire.

[0025] A second embodiment of the bone screw will be described with reference to Figs. 9 to 16. Parts and portions that are identical or similar to that of the first embodiment are marked with the same reference numerals and the description thereof will not be repeated. The bone screw 1' comprises a core member 10', a separate head 13' and a thread body 20'. Referring in particular to Figs. 11 to 13, the core member 10' comprises the shank 11 with the tip 12 at one end and a threaded portion 18 at the end opposite to the tip 12 that has an outer thread for connecting to the separate head 13'. At the free end-surface of the threaded portion 18, a slit 18a or another engagement portion for a screwdriver is provided. The head 13' comprises a threaded bore 17 at its side opposite to the engagement recess 13a that is in communication with the engagement recess 13a. An axial length of the threaded bore 17 is greater than an axial length of the threaded portion 18 of the shank 11 so that a total length in the longitudinal direction of the bone screw 1' can be varied by screwing the shank 11 more or less into the threaded bore 17.

[0026] The groove 15' differs from the groove 15 of the first embodiment in particular by the end section that is close to the threaded portion 18. In particular, the first sidewall 15a' that faces away from the threaded portion 18 extends at an angle of substantially 90° to the longitudinal axis L. There is also no nose-shaped projection. The opposing second sidewall 15b' in the end section has the same inclination throughout the shank 11. The pitch of the groove 15' is a first pitch P_1'.

[0027] The thread body 20' differs from the thread body 20 of the first embodiment mainly by its shape at the first end 21. The shape at the first end 21 is corresponding to the shape of the groove 15'. Consequently, it does not have a nose-shaped projection, either. As can be seen in Fig. 10, the first end 21 of the thread body 20 fits into the end section of the groove 15' with a tolerance.

[0028] The pitch of the thread 23' of the thread body 20' is a second pitch P_2'. In this embodiment, the second pitch P_2' is different from the first pitch P_1'of the groove 15'. The second pitch P_2'can be greater or smaller than the first pitch P_1'. In the specific embodiment shown, the second pitch P_2' is smaller than the first pitch P_1'

[0029] The bone screw 1' is assembled by screwing the thread body 20' onto the shank 11 of the core member 10' until the first end 21 of the thread body 20' is accommodated in the end section of the groove 15'. Because the first pitch P_1' is different from the second pitch P_2', the thread body 20' is biased against the core member 10'. In the embodiment, the thread body 20' is slightly extended in order to fit into the groove 15' with the greater pitch. The head 13' is mounted to the threaded portion 18 of the shank 11.

[0030] The function of the bone screw 1' will be described referring to Figs. 15 to 17b). When the thread body 20' is mounted onto the shank 11, the second surface 23b' of the thread 23' abut against the first side wall 15a' of the groove that faces away from the head 13'. Next, as shown in Figs. 16 to 17b), the shank 11 is turned with a tool engaging into the engagement slit 18a slightly into the head 13' while the thread body 20' remains engaged with the bone. In this condition, the threads move away from the first sidewall 15a' of the groove and move towards the middle of the groove, as shown in Fig. 17a) and 17b). Due to the different pitch, the biased thread body 20' exerts a compressing force onto the bone that is between the thread turns of the thread 23', as depicted in Fig. 17b). This prevents loosening of the bone screw in the bone. In a similar manner, if the second pitch P_2' associated with the thread body 20' is greater than the first pitch P_1' associated with the groove 15', the thread body 20' has to be compressed in order to fit into the groove 15'. As a result thereof, it exerts a distraction force onto the surrounding bone in a longitudinal direction.

[0031] The clinical application will be described with reference to Figs. 18 to 20d). First, as shown in Fig. 18, the assembled bone screw 1' is inserted into a prepared core hole 100 in the pedicle of a vertebra 101. When it is fully inserted, the thread body 20' abuts against the first sidewall 15a' of the groove 15', as shown in Figs. 19a) and 19b). In this condition, it is biased against the core member 10'. In a next step, as shown in Figs. 20a) and 20b), the shank 11 is moved deeper into the head 13'. Because the thread body 20' is anchored in the bone,

the thread 23' moves in an axial direction away from the abutment provided by the surface 15a' of the groove 15' thereby leaving a gap on either side of the thread in the groove (Fig. 20b). The biasing force of the thread body 20' in relation to the shank 11 exerts a compression force onto the bone.

[0032] In addition, a bending of the core member 10' out of the longitudinal axis is possible as described in connection with the first embodiment.

[0033] The bone screw 1' according to the second embodiment is also a modular bone screw. The core member 10' and the thread body 20' may be manufactured of the same or of different materials like the bone screw according to the first embodiment. Also, various thread forms can be selected for the thread body 20'.

[0034] Various other modifications of the embodiment may be contemplated. The groove may extend only along a portion of the shank and the thread body may cover only the portion of the shank, where the groove is provided.

[0035] In a further modified ambodiment, the width of the groove can vary along the length of the groove. For example, the relation wg/wt of the width of the groove wg to the width of the thread body wt can be such that it increases from 1 at the tip to a value greater than 1 towards the head. In this case, the thread body is accommodated in the groove without a tolerance at the tip side and with a tolerance at the head side.

[0036] The head may have different shapes, such as a lens-shape, a disc-shape or any other shape. The bone screw according to the first and also according to the second embodiment may even be provided without a head. The bone screw may also be used together with a bone plate. The tip may have a different shape or may even be omitted.

[0037] In a further embodiment, the head is spherical segment-shaped as shown in Fig. 1, for example, and is pivotally accommodated in a receiving part so that a polyaxial or a monoplanar bone screw is formed that can be connected to a rod. Instead of the spherical segment-shaped head, a receiving part for a rod may be provided at the end of the shank to form a monoaxial bone screw that can be connected to a rod.

Claims

1. A bone screw comprising
a longitudinal core member (10, 10') having a longitudinal axis (L) defining a longitudinal direction and having a surface, wherein a helical groove (15, 150, 15') is provided in a least a portion of the surface; and
a helical thread body (20, 20') that is a separate part and that is provided in the groove (15, 150, 15');
wherein the groove (15, 150, 15') has a first width (wg) and the thread body (20, 20') has a second width (wt) and wherein the first width (wg) is greater than the second width (wt) such that the thread body (20, 20') can slide in the groove (15, 150, 15') in the longitudinal direction.

2. The bone screw of claim 1, wherein the longitudinal core member (20, 20') is a solid body.

3. The bone screw of claim 1 or 2, wherein the helical groove (15, 150) comprises a first end and a second end and a first engagement portion (16) at or close to the second end and wherein the thread body (20) comprises a second engagement portion (26) that cooperates with the first engagement portion to hold the thread body in the groove at the second end.

4. The bone screw of one of claims 1 to 3, wherein the groove (15) has a first sidewall (15a, 15a') and an opposite second sidewall (15b, 15b') that form a first stop and a second stop to limit the motion of the thread body (20, 20') in the longitudinal direction.

5. The bone screw of claim 4, wherein the thread body (20, 20') abuts against the first sidewall (15a, 15a') when no transverse load is applied to the bone screw.

6. The bone screw of claim 4 or 5, wherein, when a transverse load is applied to the thread body (20, 20'), the thread body is configured to slide in the longitudinal direction until it abuts against the second sidewall (15b, 15b').

7. The bone screw of one of claims 1 or 6, wherein the helical groove (15) has a first pitch (P_1) and the thread body (20) has a second pitch (P_2) and wherein the first pitch and the second pitch are the same.

8. The bone screw of one of claims 1 to 6, wherein the helical groove (15') has a first pitch (P_1') and the thread body (20') has a second pitch (P_2') and wherein the first pitch and the second pitch are different.

9. The bone screw of one of claims 1 to 8, wherein the core member (10, 10') comprises a first end and a second end and a tip portion (12) at the first end and wherein the thread body (20, 20') comprises a reduced outer diameter at its end facing the tip portion (12) to match an outer diameter of the tip portion (12).

10. The bone screw of one of claims 1 to 9, wherein the core member (10, 10') comprises a first and a second end and a head (13, 13') at the second end.

11. The bone screw of claim 10, wherein the head (13') is a separate part that is connectable to a shank (11) of the core member (10').

12. The bone screw of claim 11, wherein the shank (11)

has a threaded portion (18) with an outer thread and wherein the head (13') has a threaded bore (17) that is configured to cooperate with the threaded portion (18) of the head (13').

13. The bone screw of one of claims 3 to 12, wherein the first end of the groove (15, 150, 15') is open.

14. A method of providing a bone screw, the method comprising the steps of selecting a longitudinal core member (10, 10') that comprises a helical groove (15, 150, 15') in at least a portion of a surface of the core member, and selecting a helical thread body, wherein the groove (15, 150, 15') has a first width (wg) and the thread body (20, 20') has a second width (wt) and wherein the first width (wg) is greater than the second width (wt)
and
screwing the helical thread body onto the core member.

15. The method of claim 14, wherein
the helical groove (15) has a first pitch P_1 and the thread body (20) has a second pitch (P_2) and wherein the first pitch and the second pitch are the same
or
the helical groove (15') has a first pitch (P_1') and the thread body (20') has a second pitch (P_2') and wherein the first pitch and the second pitch are different.

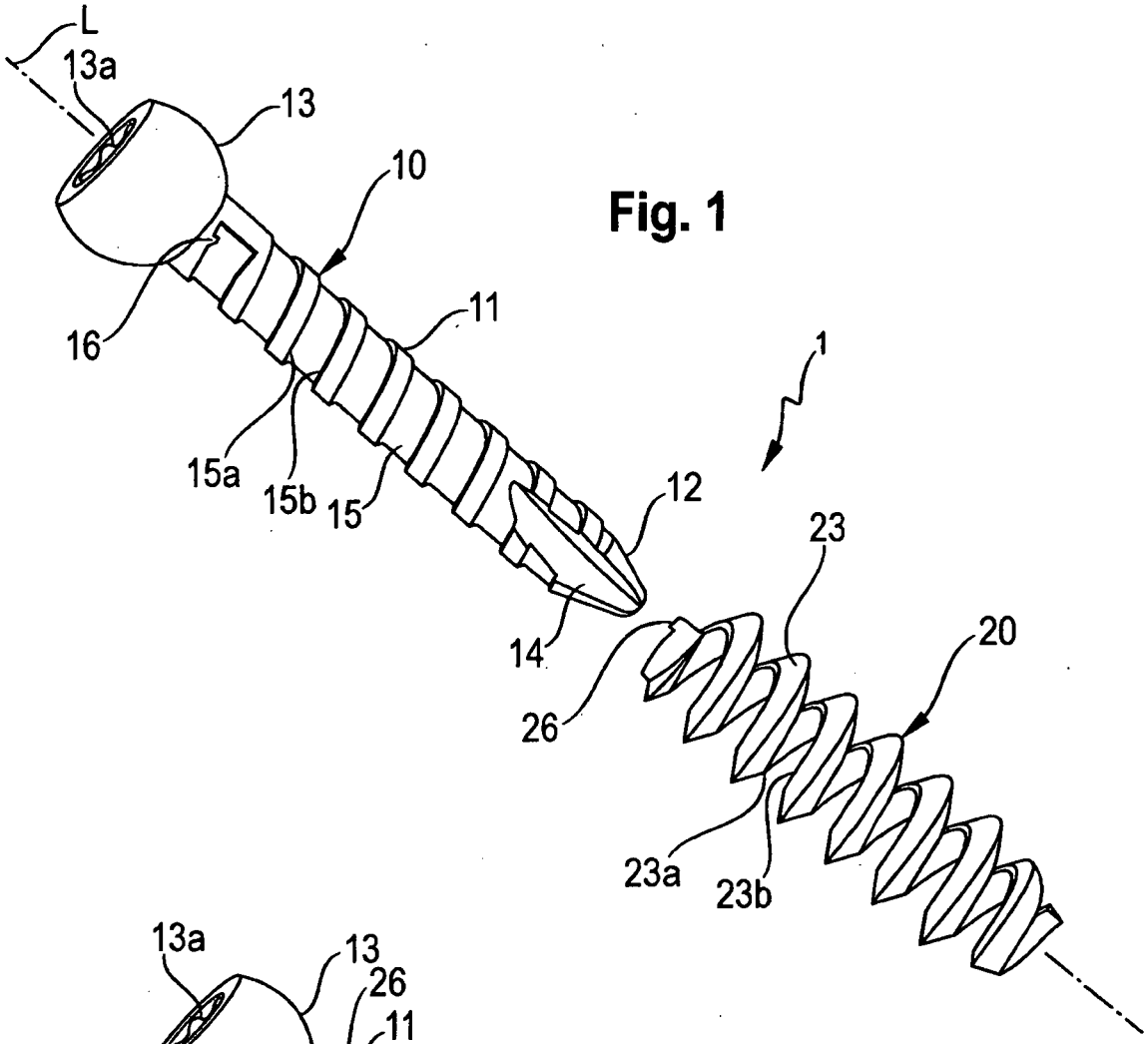
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Fig. 1

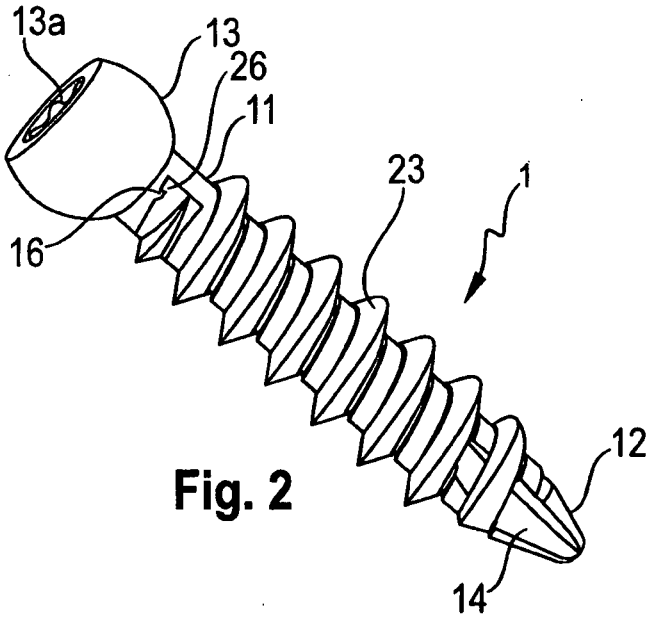
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Fig. 2

Fig. 3

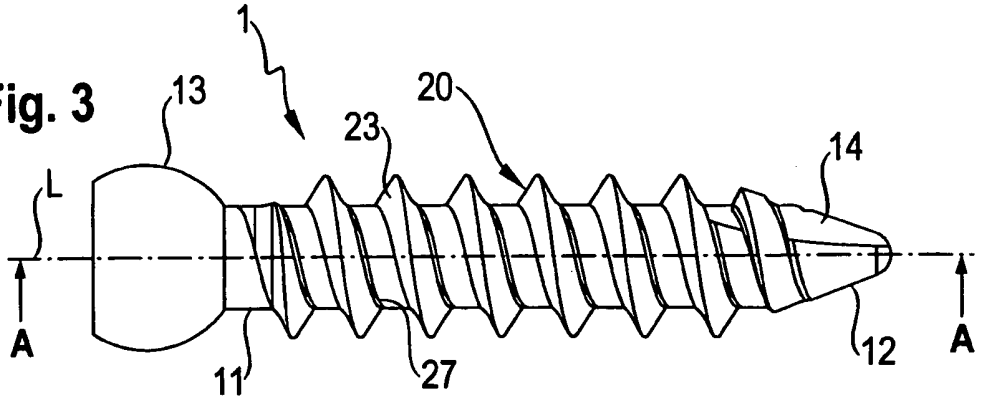


Fig. 4a

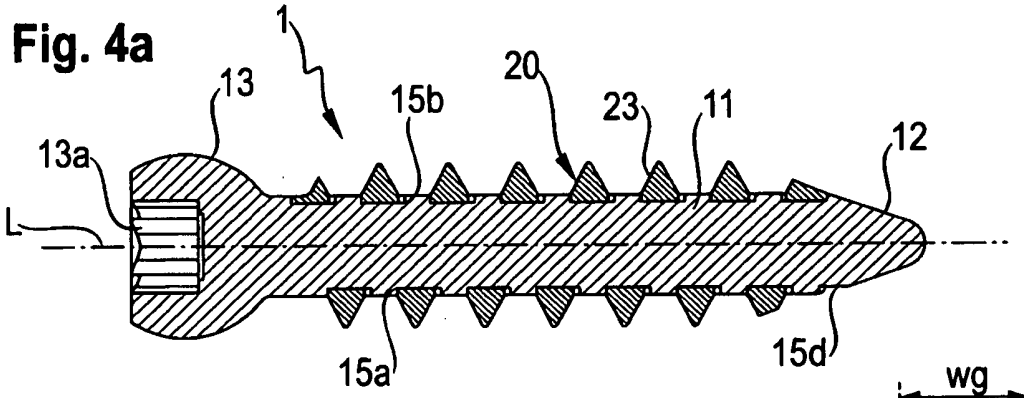


Fig. 4b

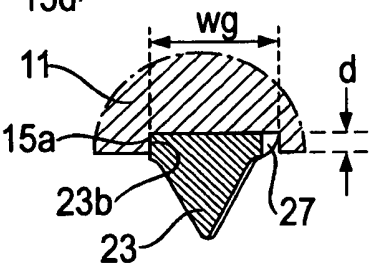


Fig. 5a

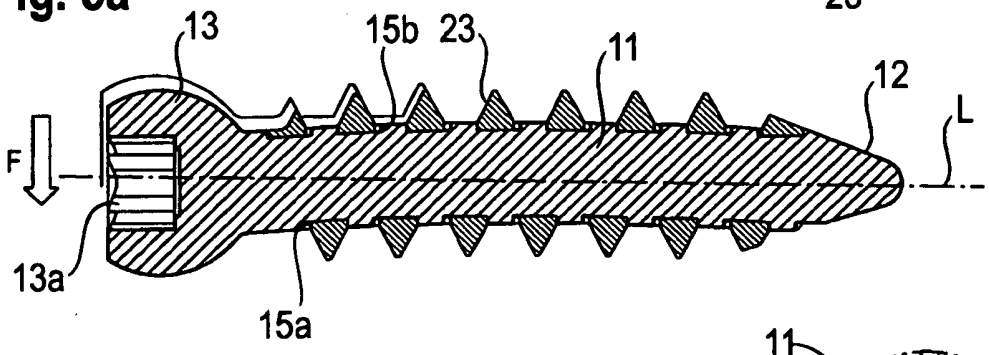


Fig. 5b

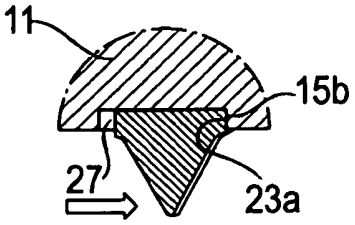


Fig. 6

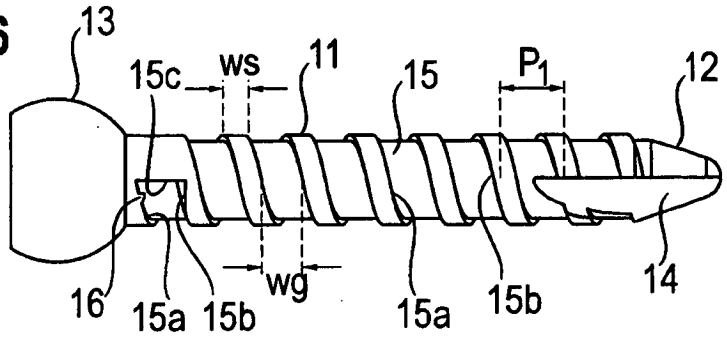
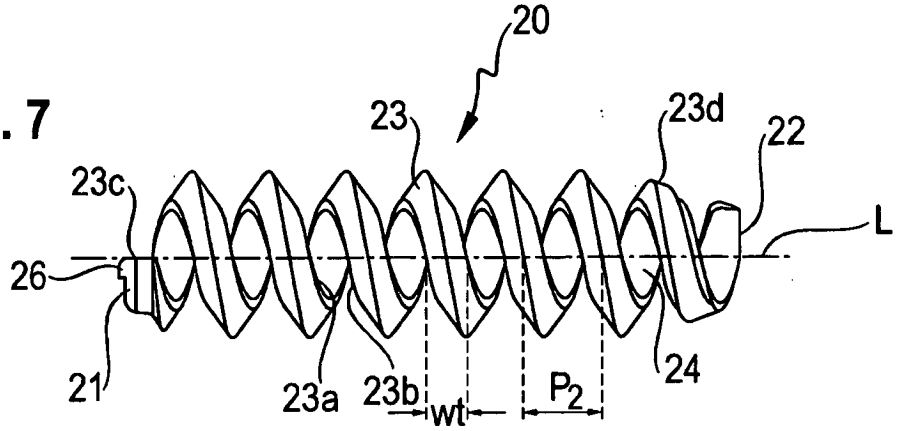


Fig. 7



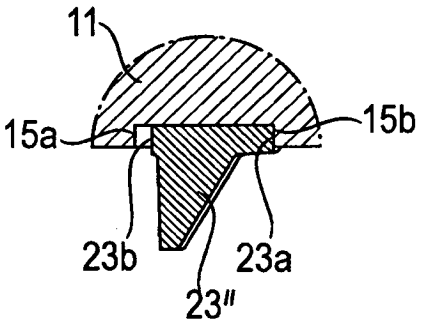
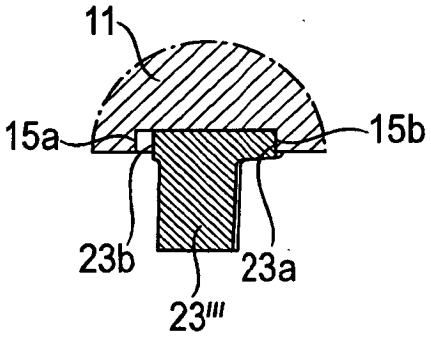


Fig. 8a



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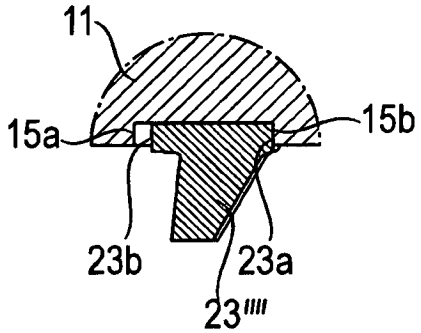


Fig. 8c

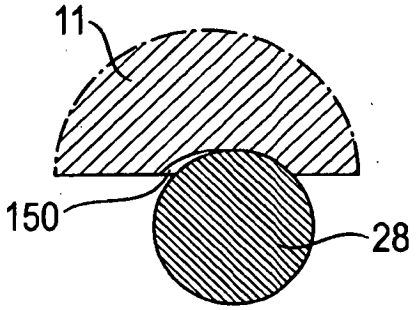
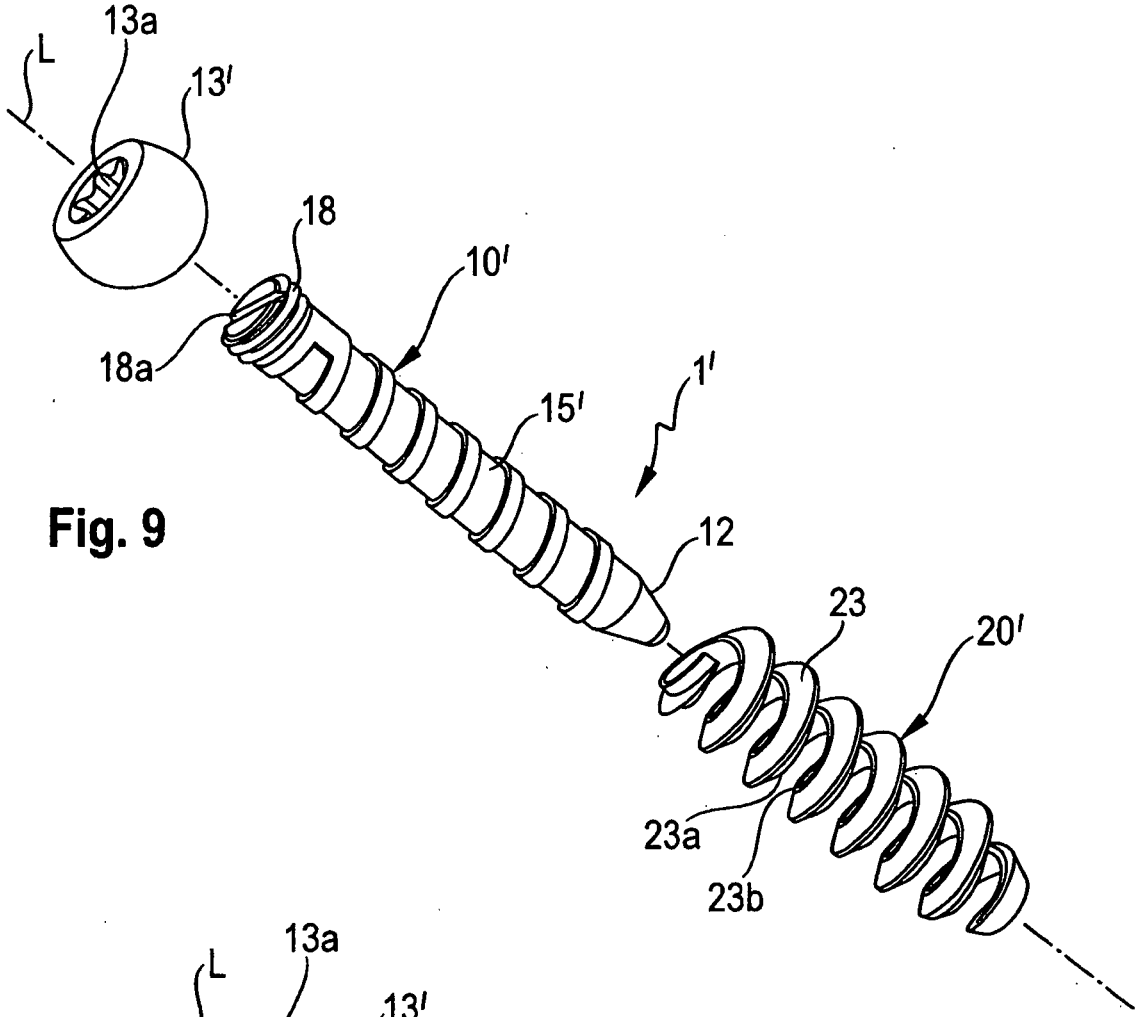


Fig. 8d



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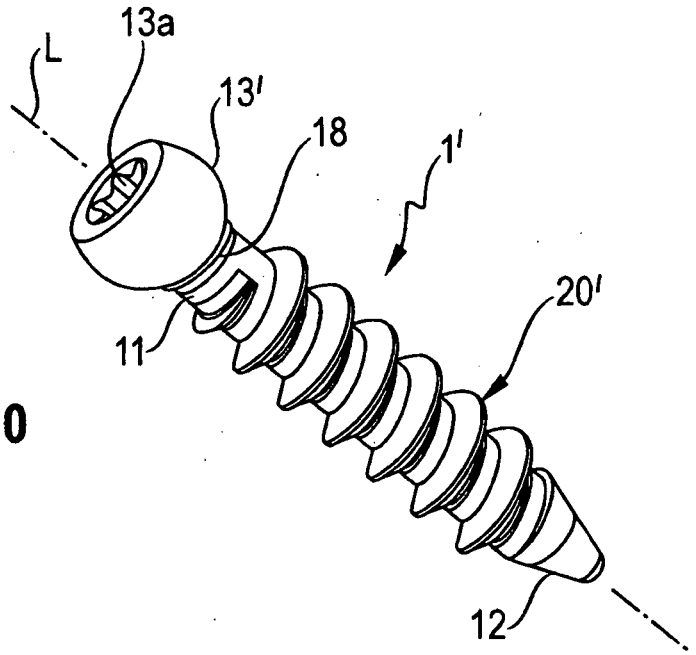


Fig. 10

Fig. 11

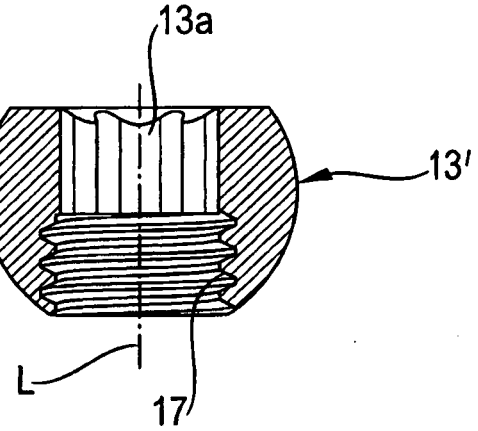


Fig. 12

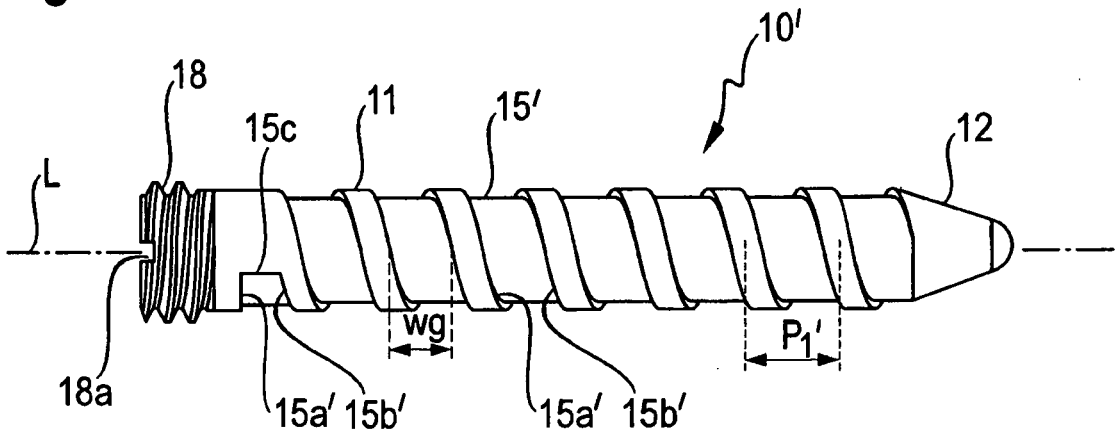
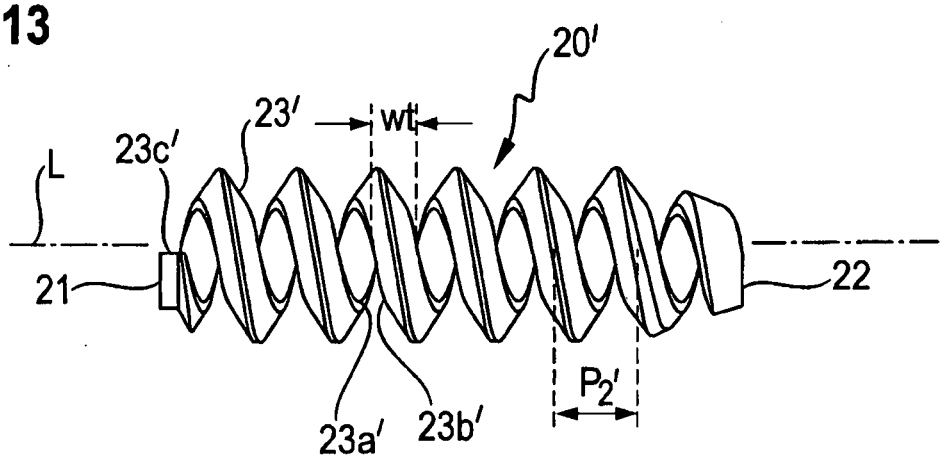


Fig. 13



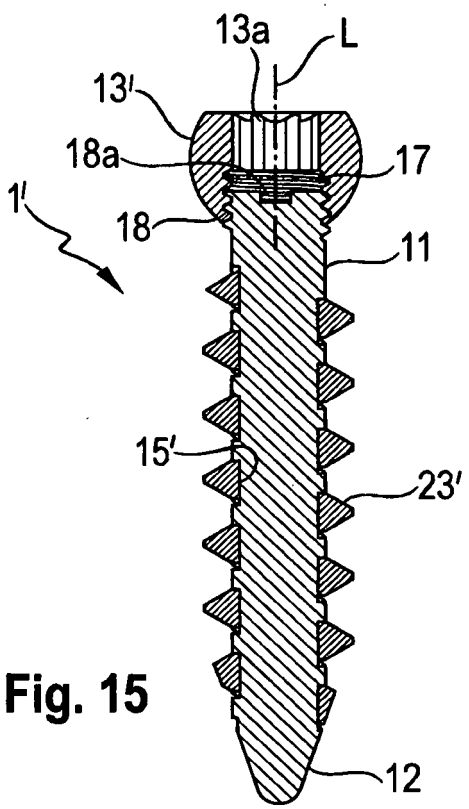


Fig. 15

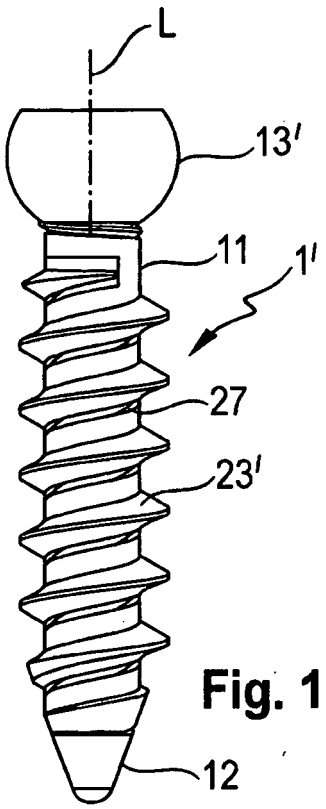


Fig. 14

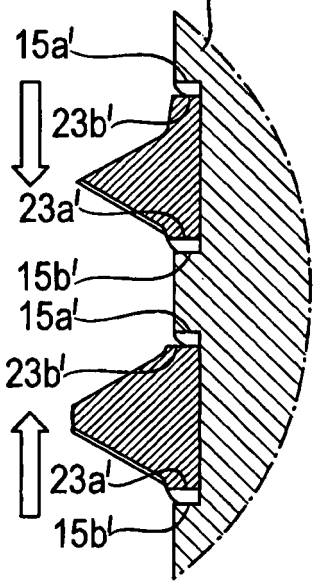


Fig. 17b

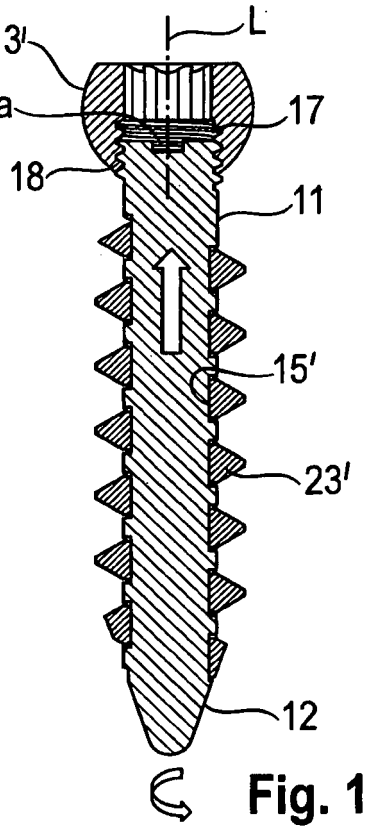


Fig. 17a

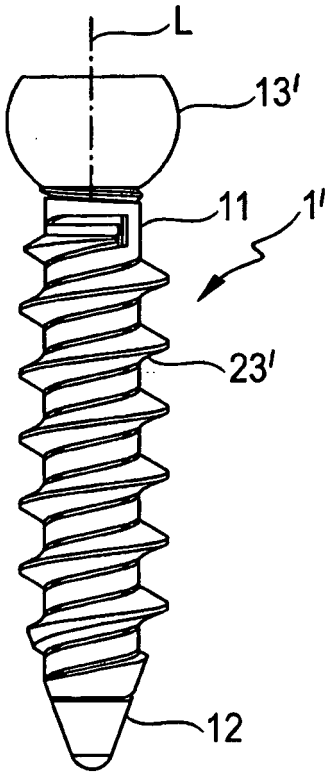


Fig. 16

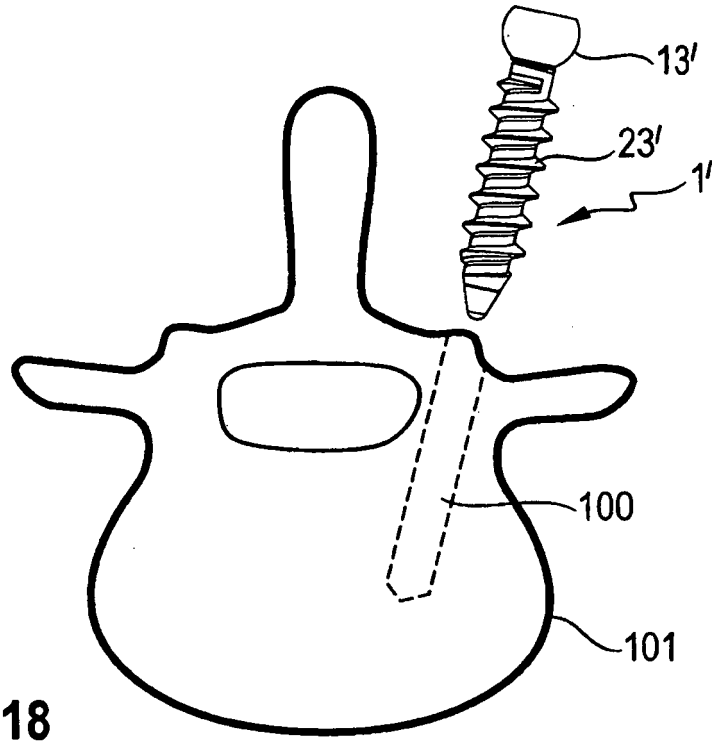


Fig. 18

Fig. 19b

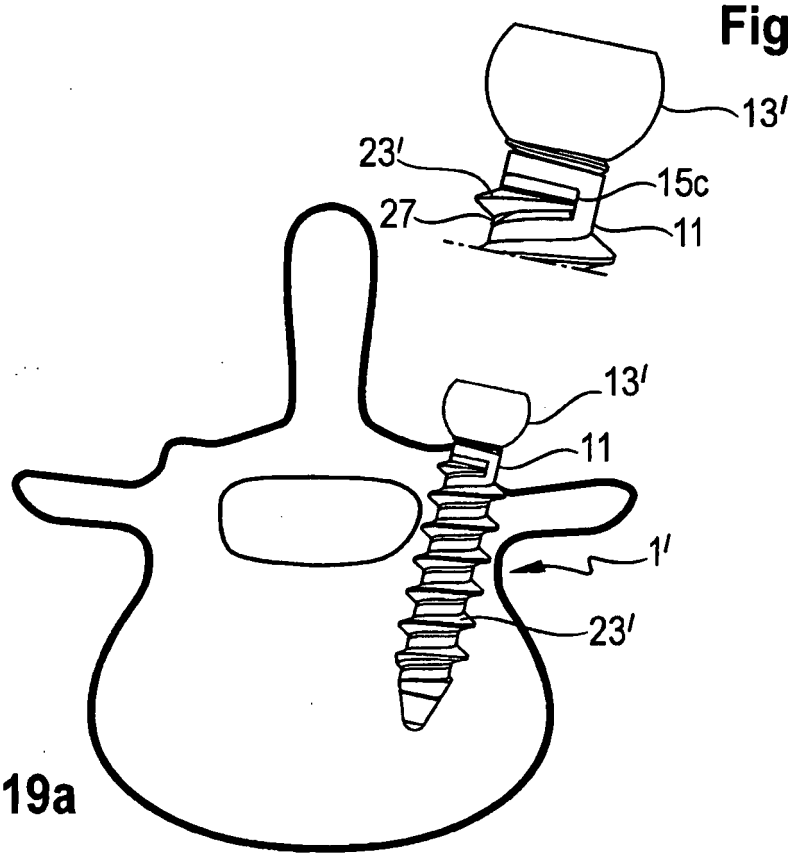


Fig. 19a

Fig. 20a

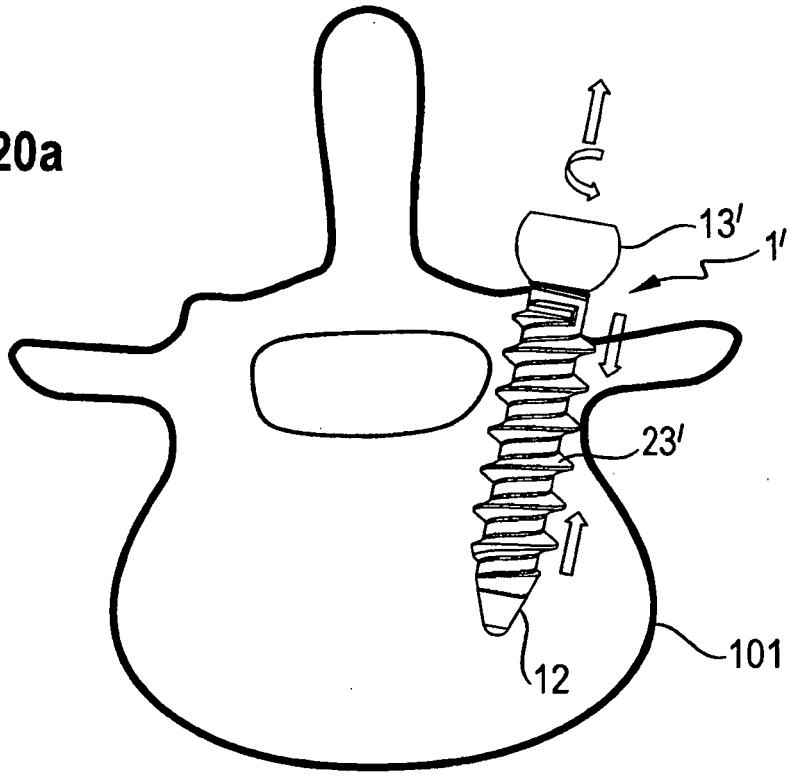
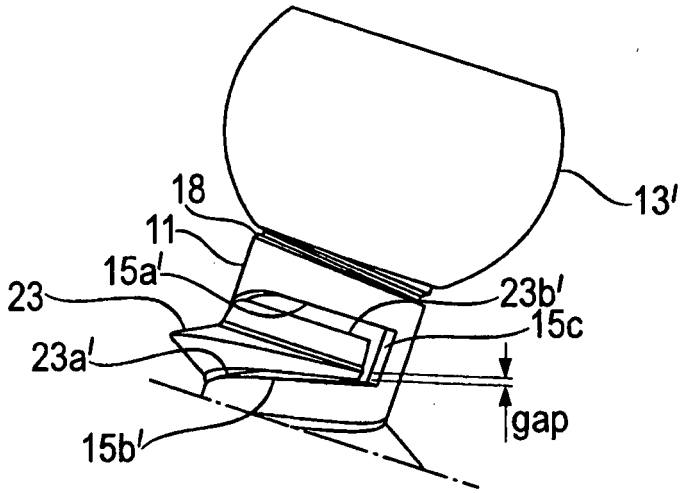


Fig. 20b



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EUROPEAN SEARCH REPORT

Application Number
EP 13 18 8243

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X	US 2003/123952 A1 (UNSWORTH JOHN DUNCAN [CA] ET AL) 3 July 2003 (2003-07-03) * paragraphs [0004], [0053], [0055]; figures 1-3,5,6 *	1-7,10, 13-15	INV. A61B17/86
X	US 7 935 138 B1 (RICHELSOPH MARC E [US]) 3 May 2011 (2011-05-03) * column 3, lines 27-35; figures 3,4 * * column 4, lines 15-41 *	1,2,7, 10,14,15	
X	WO 2012/158208 A2 (SPINAL VENTURES LLC [US]; ZWIRKOSKI PAUL [US]; ADAMS JOSEPH T [US]; AG) 22 November 2012 (2012-11-22) * paragraph [0050]; figures 21,22 *	1,2,14, 15	
X	US 4 811 618 A (TAKAYAMA SUI [JP]) 14 March 1989 (1989-03-14) * column 2, lines 1-38; figures 1,2,3a,3b *	1,2,7, 14,15	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	3 December 2013	Louka, Maria

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