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English translation of the International Patent Application No. PCT/CH01/00698
"Bone screw" in the name of Synthes AG Chur

Bone screw

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The invention relates to a bone screw for connecting two bone fragments as claimed in the precharacterising part of claim 1, to a device for implanting such a bone screw as claimed in the precharacterising part of claim 8, and to a method for the reduction, compression and/or fixation of bone fragments as
10 claimed in the precharacterising part of claim 4.

Bone screws are widely used in osteosynthesis, for example for the reduction of bone fragments, as compression bone screws, or for the fixation of bone fragments.

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A bone screw including two threaded segments formed axially in the end portions thereof and an unthreaded intermediate segment is known from US 5,019,079. The diameter of the intermediate segment corresponds essentially to the outside diameter of the external screw thread formed in the
20 threaded distal segment but is superior to the core diameter of the external screw thread formed in the threaded proximal segment, so that the intermediate segment may be used for laterally stabilizing the two bone fragments at the fracture site. A disadvantage of this embodiment of bone screws consists in the fact that the two external screw threads have different thread pitches, so that
25 the different implantation steps, i.e. the reduction of the bone fragments, the compression of the bone fragments, and the countersinking of the screw head, cannot be carried out separately from each other.

The invention is intended to provide a remedy for this. It is accordingly an object
30 of the invention to create a bone screw which makes it possible, during the implantation, to carry out the reduction of bone fragments, the compression of

bone fragments and the countersinking of the screw head independently from each other.

5 According to the invention, this object is achieved by means of a bone screw that shows the characteristics of claim 1, by means of a device for implanting such a bone screw that shows the characteristics of claim 3, and by means of a method for the reduction, compression and/or fixation of bone fragments which comprises the steps laid down in claim 4.

10 The bone screw according to the invention comprises essentially two threaded segments arranged coaxially to the longitudinal axis on either extremity of the bone screw, the thread pitches S_V and S_H of the threaded front segment and the threaded rear segment being identical. Thus, it can be achieved that after the reduction and compression of the two bone fragments, which may be done by
15 simply screwing the threaded front segment into the distal bone fragment whereas the threaded rear segment is screwed for example into an implantation instrument and is not yet screwed into the proximal bone fragment, the bone screw may be screwed further into the bone fragments until the threaded rear segment is also entirely countersunk into the proximal bone fragment without
20 changing, in doing so, the position of the bone fragments relative to each other and without changing the degree of compression exerted on the two bone fragments. The two threaded segments are realised in such a way that the outside diameter of the threaded front segment is smaller than the core diameter of the external screw thread formed in the threaded rear segment.

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The advantages achieved by the present invention consist essentially in the fact that the bone screw according to the invention and the device according to the invention make it possible, due to the identical thread pitches of the external

screw threads formed in the threaded front segment and in the threaded rear segment, to carry out the operation steps of

- reducing the bone fragments;
- 5 - compressing the bone fragments; and
- countersinking the screw head

independently from each other and in a controlled manner.

10 The core diameter of the threaded rear segment being superior to the outside diameter of the threaded front segment, the threaded rear segment may be prevented from interacting with the screw thread previously tapped into the bone fragments for receiving the threaded front segment.

15 Preferably, the external screw threads formed in the threaded front and rear segments are realised as self-tapping screw threads.

20 In the preferred embodiment of the bone screw according to the invention, said bone screw comprises an unthreaded intermediate segment provided between the two threaded segments and having an outside diameter smaller than, or equal to the core diameter of the threaded front segment. The advantage thus achieved resides in the fact that the threaded front segment may be screwed completely into the distal bone fragment and that it is not necessary, for carrying out a reduction and compression of the bone fragments, to enlarge the bore formed in the proximal bone fragment with respect to the bore in the distal bone
25 fragment Compared to an embodiment of the bone screw, in which the threaded front segment is axially in direct neighbourhood of the threaded rear segment and in which the bore in the proximal bone fragment would have to be enlarged for the threaded front segment to be screwable only into the distal bone segment, the bone screw of the invention permits to achieve a better stability of
30 the connection between the bone screw and the proximal bone fragment.

The device according to the invention serves for the reduction, compression and fixation of bone fragments by means of a bone screw and comprises essentially a surgical implantation instrument which has a central bore penetrating the implantation instrument coaxially so as to enable a screwdriver to be passed therethrough. In addition, the central bore has an enlarged portion extending from the front end portion of the implantation instrument to a depth T, thus forming a shoulder at the depth T. An internal screw thread is formed in the enlarged portion of the central bore which is complementary to the external screw thread of the threaded rear segment of the bone screw, thus enabling the threaded rear segment of the bone screw to be screwed into the central bore to a depth T. The depth T is selected in such a way that $T \geq L$, L being the length of the threaded rear segment of the bone screw. The advantage thus achieved is that the threaded rear segment of the bone screw may be completely screwed into the central bore of the implantation instrument.

Further advantageous embodiments of the invention will be characterised in the dependent claims.

In the following, the invention and improvements 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 view of one embodiment of the bone screw according to the invention; and

Fig. 2 is a longitudinal section of the device according to the invention and includes a bone screw according the embodiment shown in Fig. 1, an implantation instrument, and a screwdriver.

Fig. 1 shows the preferred embodiment of the bone screw 1 according to the invention. It comprises a threaded rear segment 7 with an external screw thread 9 having a core diameter D_{KH} , an outside diameter D_{HS} , and a thread pitch S_H , an unthreaded intermediate segment 6 with an outside diameter D_{MS} which extends coaxially to the longitudinal axis 2 and adjoins the threaded rear segment 7, and a threaded front segment 5 with an external screw thread 8 having a core diameter D_{KV} , an outside diameter D_{VS} , and a thread pitch S_V . The two threaded segments 5;7 have different diameters, i.e. the core diameter D_{KH} of the threaded rear segment 7 is greater than, or equal to the outside diameter D_{VS} of the threaded front segment 5. The thread pitches of the two external screw threads 8;9 are, however, identical. The outside diameter D_{MS} of the intermediate segment 6 is smaller than, or equal to the core diameter D_{KV} of the threaded front segment 5. In addition, the front end portion 3 of the bone screw 1 and the transition portion between the threaded rear segment 7 and the intermediate segment 6 are provided with a plurality of indentations 23 arranged in axial orientation about the circumferences of the two threaded segments 5;7, and having cutting edges 12 arranged essentially parallel to the longitudinal axis 2, so that the two external screw threads 8;9 are self-tapping. On the rear end portion 4 of the bone screw 1, means 11 for receiving a screwdriver such as a hexagon socket, Torx or Phillips recess are provided. In addition, the bone screw 1 is provided with a central bore 10 extending therethrough from the front end portion 3 to the rear end portion 4 which may serve for receiving a guide wire (not shown).

Fig. 2 shows the device according to the invention used in combination with the embodiment of the inventive bone screw 1 shown in Fig. 1, the threaded rear segment 7 of which is completely screwed into the implantation instrument 15 and the threaded front segment 5 is completely screwed into the distal bone fragment 14. The implantation instrument 15 comprises a continuous central bore 17 which is enlarged from the front end 18 to a depth T and this enlarged portion 24 is provided with an internal screw thread 20 which is complementary to the external screw thread 9. At the depth T, a shoulder is arranged between

the enlarged portion 24 of the central bore 17 and the narrower part 25 of the central bore 14, on which the rear end portion 4 of the bone screw 1 abuts as the threaded rear segment 7 is completely screwed into the implantation instrument 15. A screwdriver 17 may be passed from the rear end 19 of the implantation instrument 15 through the narrower portion 25 of the central bore 17, thus permitting the screwdriver 16 to be introduced into the means 11 for receiving a screwdriver provided on the rear end portion 4 of the bone screw 1, so that by means of the screwdriver 16, the bone screw 1 is rotatable relative to the implantation instrument 15.

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For realising the reduction, compression and fixation of the two bone fragments 13;14, first a bore 21 is made which penetrates the proximal bone fragment 13 and extends into the distal bone fragment 14, the diameter of said bore 21 corresponding to the core diameter D_{KV} (Fig. 1) of the external screw thread 8 of the threaded front segment 5 of the bone screw 1.

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At the beginning of the implantation process, the threaded rear segment 7 of the bone screw 1 is completely, and to a depth T , screwed into the internal screw thread 20 formed in the central bore 17 of the implantation instrument 15. The bone screw 1 is then screwed into the predrilled bores 21 formed in the two bone fragments 13;14 by rotating the implantation instrument 15 about the longitudinal axis 2. Since the threaded rear segment 7 of the bone screw 1 is entirely contained by the implantation instrument 15, the external screw thread 9 of the threaded rear segment 7 cannot engage with the proximal bone fragment 13, so that on rotating the implantation instrument 15 only the threaded front segment 5 of the bone screw 1 is screwed into the distal bone fragment 14. At this stage, the front end portion 18 of the implantation instrument 15 assumes the function of a screw head, so that once the bone screw 1 has been inserted to such a degree into the two bone fragments 13;14 that the front end portion 18 of the implantation instrument 15 abuts on the proximal bone fragment 14, any further rotation of the implantation instrument 15 will cause the two bone fragments 13;14 to move towards each other.

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Compression of the two bone fragments 13;14 sets in as soon as the two bone fragments 13;14 come into contact with each other. Once the desired degree of compressive force to be exerted on the two bone fragments 13;14 has been reached by further rotating the implantation instrument 15, the
5 screwdriver 16 is passed through the central bore 17 formed in the implantation instrument 15 and inserted into the means 11 for receiving the screwdriver, and the screwdriver 16 is used to further rotate the bone screw 1 so that, while the implantation instrument 15 is held and prevented from turning, the bone screw 1 is turned out of the internal screw thread 20 formed in the front end portion 18 of
10 the implantation instrument 15 and the threaded rear segment 7 thereof is screwed into the proximal bone fragment 13 until it has been driven entirely under the surface of the proximal bone fragment 13. Since the two bone fragments 13;14 are not moved relative to each other during this last step, the degree of compressive force exerted on the proximal bone fragment 13 after the
15 countersinking of the threaded rear segment 7 remains unchanged.

The bone screw 1 is preferably used where the presence of a screw head would be problematic, for example in the case of fractures occurring in the vicinity of an articulation, intra-articular fixations as required in scaphoid fractures, small-
20 sized fragments, fixations of ligaments and nerves, and fixations to be realised in the vicinity of blood vessels.

Claims

1. Bone screw (1) for connecting two bone fragments, including
 - A) a longitudinal axis (2), a front end portion (3), a rear end portion (4), and means (11) for receiving a screwdriver (16) on the rear end portion (4); further including
 - B) a threaded front segment (5) extending coaxially to the longitudinal axis (2) and located axially in the front end portion, comprising an external screw thread (8) having a core diameter D_{KV} , an outside diameter D_{VS} , and a thread pitch S_V ;
 - C) a threaded rear segment (7) extending coaxially to the longitudinal axis (2) and located axially in the rear end portion, comprising an external screw thread (9) having a core diameter D_{KH} , an outside diameter D_{HS} , and a thread pitch S_H ;
 - D) the outside diameter D_{VS} of the threaded front segment (5) is smaller than, or equal to the core diameter D_{KH} of the threaded rear segment (7); and
 - E) the thread pitch S_V of the threaded front segment (5) and the thread pitch S of the threaded rear segment (4) are identical,

characterised in that

 - F) the bone screw (1) comprises an intermediate segment (6) arranged between the two threaded segments (5;7) and equally extending coaxially to the longitudinal axis (2), having a constant outside diameter D_{MS} ; whereby
 - G) said outside diameter D_{MS} is smaller than, or equal to the core diameter of the external screw thread (8) formed in the threaded front segment (5); and whereby
 - H) said intermediate segment (6) has no thread.

2. A device for the reduction, compression, and fixation of bone fragments with at least a bone screw (1) according to claim 1
characterized in that

A) said device comprises a cylindrical or prismatic, surgical implantation instrument (15) which comprises a coaxial, continuous central bore (17), a front end portion (18), and a rear end portion (19); and

B) the central bore (17) has an enlarged portion (24) extending from the front end portion (18) of the instrument (15) to a depth T and provided with an internal screw thread (20) which is complementary to the external screw thread (9) formed in the rear segment (7) of the bone screw (1), whereby the depth T is $\geq L$, L being the length of the threaded rear segment (7) of the bone screw (1).

3. A device for the reduction, compression, and fixation of bone fragments by means of a bone screw (1) as claimed in claim 1 or 2, comprising

a) a cylindrical or prismatic, surgical implantation instrument (15) which comprises a coaxial, continuous central bore (17), a front end portion (18), and a rear end portion (19),

characterised in that

b) the central bore (17) has an enlarged portion (24) extending from the front end portion (18) of the instrument (15) to a depth T and provided with an internal screw thread (20) which is complementary to the external screw thread (9) formed in the rear segment (7) of the bone screw (1); and

c) the depth T is $\geq L$, L being the length of the threaded rear segment (7) of the bone screw (1).

4. Method for the reduction, compression and/or fixation of bone fragments including the following steps:

A) drilling a bore (21) into the bone fragments (13;14) to be surgically treated;

B) screwing the threaded rear segment (7) of the bone screw (1) into the internal screw thread (20) of the central bore (17) of the implantation instrument (15) until the threaded rear segment (7) is entirely contained by said central bore (17) and the rear end portion (4) of the bone screw (1) abuts on the shoulder (22) formed in the central bore (17) of the implantation instrument (15);

C) screwing the part of the bone screw (1) which protrudes from the implantation instrument (15) into the bore (21) until the threaded front segment (5) is screwed into the distal bone fragment (14) and until the front end portion (18) of the implantation device (15) abuts on the surface of the proximal bone fragment (13);

D) further rotating the implantation instrument (15) until the two bone fragments (13;14) have been reduced to a sufficient extent;

E) inserting a screwdriver (16) through the central bore (17) of the implantation instrument (15) so that it engages with the means (11) for receiving the screwdriver in the bone screw (1); and

F) screwing the bone screw (1) further into the bore (21) by rotating the screwdriver (16) until the threaded rear segment (7) has been turned out of the implantation instrument (15) and screwed into the proximal bone fragment (13).

5. Method as claimed in claim 4, characterised in that it comprises, in addition to the reduction as described in step D, the step of further rotating the implantation

instrument (15) so as to achieve the desired degree of compression to be exerted on the two bone fragments (13;14).

6. Method as claimed in claim 4 or 5, characterised in that it comprises in addition securing the implantation instrument (15) against rotation, while the bone screw (1) is screwed into the bore (21) by means of the screwdriver (16).

Abstract

Bone screw including two threaded segments (5;7) formed axially in the end portions thereof and an intermediate segment (6), the outside diameter D_{VS} of the threaded front segment (5) being smaller than the core diameter D_{KH} of the threaded rear segment (7) and the outside diameter D_{MS} of the intermediate segment (6) being smaller than the core diameter D_{KV} of the threaded front segment (5).

Device for the reduction, compression, and fixation of bone fragments, comprising

- a) an implantation instrument (15) comprising a central bore (17) extending coaxially therethrough, so that
- b) a screwdriver (16) may be passed through said central bore (17) from the rear end (19) of the instrument (15),
- 15 c) the central bore (17) being provided with an internal screw thread (20) formed in the front end portion (18) of the instrument (15), which is complementary to the external screw thread (9) formed in the threaded rear segment (7) of the bone screw (1) and which extends from the front end portion (18) of the implantation instrument (15) to a depth T ; and
- 20 e) the depth T is $\geq L$, L being the length of the threaded rear segment (7) of the bone screw (1).