ABSTRACT
A bone fixation assembly and associated method. The bone fixation assembly includes a bone fastener having a head and a bone-engaging portion, a receiver defining an opening along a first axis for receiving the bone fastener at a variable angle, and at least one supporting augment coupled to the bone fastener. The receiver has an inner articulation surface at a lower portion of the opening and matingly articulates with the supporting augment.
BONE FIXATION ASSEMBLY

[0001] Various internal fixation devices are known for correcting and/or stabilizing malformation or other condition of bones, including long bones and the spine. Such fixation devices can include elongated rods affixed with bone screws at desired orientations relative to the bone or spine. Some known bone fixation devices utilize poly-axial or multi-axial screws for adjusting the fixation device at a desired orientation.

[0002] Although the existing fixation devices can be satisfactory for their intended purposes, there is still a need for modular bone screw assemblies that can provide variable angle orientation, and which are easy to assemble.

SUMMARY

[0003] The present teachings provide a bone fixation assembly. The bone fixation assembly includes a bone fastener having a head and a bone-engaging portion, a receiver defining an opening along a first axis for receiving the bone fastener at a variable angle, and at least one supporting augment coupled to the bone fastener. The receiver has an inner articulation surface at a lower portion of the opening and matingly articulates with the supporting augment.

[0004] The present teachings also provide a method for bone fixation. The method includes providing a receiver defining an opening along a first axis for receiving a bone fastener at a variable angle, inserting the head of the bone fastener into the opening, and inserting at least one supporting augment into the opening. The at least one supporting augment is articulable with an inner articulation surface of the receiver. The method further includes coupling the at least one supporting augment to the head of the bone fastener, and varying the angle of the bone fastener relative to the first axis by articulating the at least one supporting augment relative to the articulation surface.

[0005] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0007] FIG. 1 is a side view of a bone fixation assembly according to the present teachings shown with an elongated fixation member;

[0008] FIG. 1A is a side view of a bone fixation assembly according to the present teachings similar to FIG. 1, illustrating a variable angle orientation;

[0009] FIG. 2 is a sectional view of the bone fixation assembly of FIG. 1 taken along the axis 2—2 of FIG. 1;

[0010] FIG. 3 is an enlarged view of detail A of FIG. 2 shown additionally in exploded view;

[0011] FIG. 4 is an enlarged perspective view of a receiver of the bone fixation assembly of FIG. 3;

[0012] FIG. 5 is an enlarged perspective view of a bone fastener of the bone fixation assembly of FIG. 3;

[0013] FIG. 6 is an enlarged perspective view of a supporting augment of the bone fixation assembly of FIG. 3;

[0014] FIG. 7 is an enlarged perspective view of a cap ring of the bone fixation assembly of FIG. 3;

[0015] FIG. 8 is an enlarged perspective view of a cap of the bone fixation assembly of FIG. 3;

[0016] FIG. 9 is an enlarged perspective view of a fastener ring of the bone fixation assembly of FIG. 3; and

[0017] FIG. 10 is an end view of the bone fixation device of FIG. 2.

DESCRIPTION OF VARIOUS ASPECTS

[0018] The following description is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0019] Referring to FIGS. 1, 1A, and 2, an exemplary variable angle bone fixation assembly 100 is illustrated according to the present teachings. The bone fixation assembly 100 can include a receiver 102 defining an opening 118 along a first axis “X”, and a bone fastener 104. The bone fastener 104 can be assembled on the receiver 102 for variable angle angulation relative to the first axis X on an angulation cone of angle α, as illustrated in FIG. 1A. The bone fastener 104 can include a head 108 and a bone-engaging portion 106, which can be shaped as a screw or other anchor, as shown in FIG. 5. The bone-engaging portion 106 can include, for example, a plurality of threads 107 and an anchoring tip 109. The head 108 can include a circumferential exterior groove 111 for engaging a retention member, such as a fastener ring 112, shown in FIG. 9, as discussed below.

[0020] Referring to FIGS. 3-10, the receiver 102 can include two substantially parallel arms 126 extending in a direction away from the fastener 104. The arms define a channel 128 along a second axis “Y” generally perpendicular to the first axis X. The channel 128 can be shaped to receive an elongated fixation member 130, such as, for example, a spinal fixation rod or other fixation bar, as shown in FIG. 1. The interior surface of the arms 126 can include a thread pattern or other interlocking form 132, such as a helically-wound interlocking form similar to the one disclosed and described in U.S. Pat. No. 6,726,689, filed Sep. 2, 2002, the disclosure of which is incorporated herein by reference. It will be appreciated that other thread forms can also be used. The interlocking form 132 can mate with a closure member (not shown) having a corresponding interlocking form for securing the fixation member 130 in the receiver 102 such that radial splaying of the arms 126 can be operatively resisted.

[0021] Referring to FIGS. 3-6, the receiver 102 can include an articulation surface 120 at a lower portion of the opening 118 and adjacent a lower end 122 thereof. The articulation surface 120 can articulate with a corresponding curved exterior surface 124 of one or more discrete supporting augments 110. The conforming articulating surfaces 120, 124 can be portions of generally spherically surfaces or other surfaces that can provide desired variable angle fixation. Each supporting augment 110 can include a curved
interior surface 125 which can be shaped to conform to at least a portion of the head 108 of the bone fastener 104. Referring to FIG. 6, in one aspect, each supporting augment 110 can include upper and lower substantially planar surfaces 143a, 143b, first and second oppositely inclined substantially planar end surfaces 140a, 140b, and an upper curved cutout or notch 136 adjacent to first end surface 140a. The upper surface 143a can define a sharp corner 145a with the second end surface 140b, and a blunt or rounded corner 145b with the first end surface 140a.

[0022] The supporting augments 110 can be positioned relative to each other such that upon assembly each of the first and second end surfaces 140a, 140b of one supporting augment 110 can mate with the second and first end surfaces 140b, 140a, respectively, of the other supporting augment 110, thereby completing an annular curved surface with a 360-degree circumference. The shape of the supporting augments 110 can be defined for ease of assembly and angulation during assembly. For example, during assembly, the supporting augments 110 can be positioned such that the sharp corner 145a of each supporting augment 110 rides on the notch 136 of the other supporting augment 110, such that the supporting augments 110 overlap partially, and the overall size/volume of the resulting configuration is smaller during assembly than the size of the assembled supporting augments 110.

[0023] Referring to FIGS. 3, 6 and 9, each supporting augment 110 can also include a circumferential interior groove 134 shaped for partially receiving the fastener ring 112. The fastener ring 112 can be a substantially flat and compliant split ring with an outer boundary 113 and an inner boundary 115. In assembly, at least a portion of the outer boundary 113 of the fastener ring 112 can be engaged with the interior groove 134 of the supporting augment 110. The inner boundary 115 of the fastener ring 112 can engage the exterior groove 111 of the head 108 of the bone fastener 104.

[0024] Referring to FIGS. 3, 7, and 8, the bone fixation assembly 100 can also include a cap 116, which can engage an upper portion of the head 108. The cap 116 can include a circumferential external cap groove 117 for engaging a cap ring 114. The cap ring 114 can be a compliant split ring and can be positioned in engagement between the cap groove 117 and an interior groove or slot 119 defined in the receiver 102. Pressing the cap 116 against the head 108 of the bone fastener 104 with the fixation member 130 can prevent angulation of the bone fastener 104 relative to the receiver 102, thereby retaining the fastener 104 in a fixed orientation.

[0025] The bone fixation assembly 100 can be assembled during or before the surgical procedure. Generally, the head 108 of the bone fastener 104 can be inserted first into the opening 118. At least one supporting augment 110 can be inserted into the opening 118, and coupled to the head 108 of the bone fastener 104. The angle α of the bone fastener 104 relative to the first axis X can then be varied by articulating the supporting augment 110 relative to the articulation surface 120.

[0026] In one exemplary aspect, the fastener ring 112 can be assembled on the exterior groove 111 of the head 108 of the bone fastener 104. The head 108 with the fastener ring 112 thereon can be inserted into the receiver 102 through the lower end 122 of the opening 118, and can be pushed above its final seating position to facilitate assembly, as necessary. The supporting augments 110 can then be inserted from an upper end 123 of the receiver 102 and can be pushed toward the fastener ring 112 while the bone fastener 104 is pulled down, until the supporting augments 110 engage the fastener ring 112 and the bone fastener 104 is seated in engagement with the receiver 102. In this position, the bone fastener 104 can freely angulate relative to axis X, but can not be removed from the receiver 102 either through the lower end 122 or through the upper end 123. For facilitating insertion the supporting augments 110 can be arranged with partial overlapping therebetween, as discussed above. In another aspect, the supporting augments 110 can be inserted into the receiver 102 through the lower end 122 of the opening 118, and manipulated into engagement with the fastener ring 112.

[0027] The cap 116 with the cap ring 114 can be inserted from the upper end 123 of the receiver 102 such that the cap ring 114 engages the interior slot 119 of the receiver 102. For a particular application, such as spinal fixation, a rod or other longitudinal fixation member 130 can be positioned along the channel 128 and pressed against the cap 116 with a compression member (not shown). Pressing the cap 116 against the head 108 with the compression member secures the bone fastener 104 in a desired orientation.

[0028] It will be appreciated that the modularity and shape of the various parts of the bone fixation assembly 100 can provide a compact (non-bulky) bone fixation device, which can be easily assembled during the surgical procedure, or can also be at least partially pre-assembled. Furthermore, the bone fixation assembly 100 can be easily configured for accommodating various surgical situations at the site of operation as desired by the surgeon.

[0029] The fixation assembly can be formed from biocompatible materials, such as, for example, metallic materials.

[0030] The foregoing discussion discloses and describes merely exemplary arrangements of the present invention. One skilled in the art will readily recognize from such discussion, and from the accompanying drawings and claims, that various changes, modifications and variations can be made therein without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A bone fixation assembly comprising:
   a bone fastener having a head and a bone-engaging portion;
   a receiver defining an opening along a first axis for receiving the bone fastener at a variable angle, the receiver having an inner articulation surface at a lower portion of the opening; and
   at least one supporting augment coupled to the bone fastener and matingly articulable with the articulation surface of the receiver.

2. The bone fixation assembly of claim 1, wherein the at least one supporting augment includes two separate supporting augments.

3. The bone fixation assembly of claim 1, wherein the articulation surface is substantially spherical and wherein the supporting augment has an outer mating surface that is substantially spherical.
4. The bone fixation assembly of claim 1, wherein a lower end of the opening is configured for receiving the head of the bone fastener therethrough.

5. The bone fixation assembly of claim 4, further comprising a fastener ring, the fastener ring couplable to the head of the bone fastener such that the fastener ring can be inserted assembled to the bone fastener from the lower end of the opening.

6. The bone fixation assembly of claim 5, wherein the fastener ring is supportable on a groove of the supporting augment.

7. The bone fixation assembly of claim 6, wherein the fastener ring is a split ring.

8. The bone fixation assembly of claim 6, wherein the supporting augment is shaped for allowing variable angulation of the fastener.

9. The bone fixation assembly of claim 2, wherein each supporting augment includes a notch on an upper surface of the augment.

10. The bone fixation assembly of claim 8, wherein each supporting augment includes two oppositely inclined end surfaces.

11. The bone fixation assembly of claim 9, wherein each supporting augment is shaped for partial overlapping about the notch during assembly.

12. The bone fixation assembly of claim 8, wherein the supporting augment is further shaped for preventing removal of the fastener when the ring is coupled to the supporting augment and to the head of the fastener.

13. The bone fixation assembly of claim 1, further comprising a fastener cap for coupling the head of the fastener to an inner surface of the receiver.

14. The bone fixation assembly of claim 13, further comprising a cap ring for coupling the fastener cap and the receiver.

15. The bone fixation assembly of claim 14, wherein the receiver defines a channel extending along a second axis generally perpendicular to the first axis.

16. The bone fixation assembly of claim 15, wherein the channel is shaped for receiving a fixation rod above the fastener cap.

17. The bone fixation assembly of claim 14, wherein the cap ring is a split ring.

18. A method for spinal fixation comprising:

   providing a receiver defining an opening along a first axis for receiving a bone fastener at a variable angle, the receiver having an inner articulation surface at a lower portion of the opening;

   inserting the head of the bone fastener into the opening;

   inserting at least one supporting augment into the opening, the at least one supporting augment articulate with the articulation surface;

   coupling the at least one supporting augment to the head of the bone fastener; and

   varying the angle of the bone fastener relative to the first axis by articulating the at least one supporting augment relative to the articulation surface.

19. The method of claim 18, wherein coupling the at least one augment is performed after inserting the head of the bone fastener into the opening.

20. The method of claim 18, wherein inserting the head of the bone fastener into the opening includes inserting the head through a lower end of the opening.

21. The method of claim 20, wherein coupling the at least one supporting augment to the head of the bone fastener includes preventing the head of the bone fastener from withdrawal through the opening.

22. The method of claim 18, wherein coupling the at least one supporting augment to the head of the bone fastener includes coupling a retention member to the at least one supporting augment and to the head of the bone fastener.

23. The method of claim 20, further comprising inserting a cap through an upper end of the opening for engaging the head of the bone fastener.

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