US 20060253118A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2006/0253118 A1

Bailey (43) Pub. Date: Nov. 9, 2006

(54) SPINAL FIXATION SYSTEM

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(21) Appl. No.: **11/484,495**

(22) Filed: **Jul. 11, 2006**

Related U.S. Application Data

(63) Continuation of application No. 10/341,658, filed on Jan. 14, 2003, now Pat. No. 7,104,992.

Publication Classification

(51) **Int. Cl.**
A61B 17/70 (2006.01)

(52) **U.S. Cl.** **606/61**

(57) **ABSTRACT**

A clamp assembly for securing a bone anchor to a generally cylindrical rod. The clamp assembly includes a first portion, a second portion and a compressible ball carried by the second portion, the ball having a through hole for receiving the generally cylindrical rod. The first portion includes first and second flanges, each of the first and second flanges defining an aperture for receiving a portion of the bone anchor. The first and second flanges are movable from a first position in which the first and second flanges are separated by a gap to a second position in which the first and second flanges are drawn toward each other. The first and second flanges include first and second opposing surfaces, respectively, the first and second opposing surfaces being angled relative to one another in the first position.

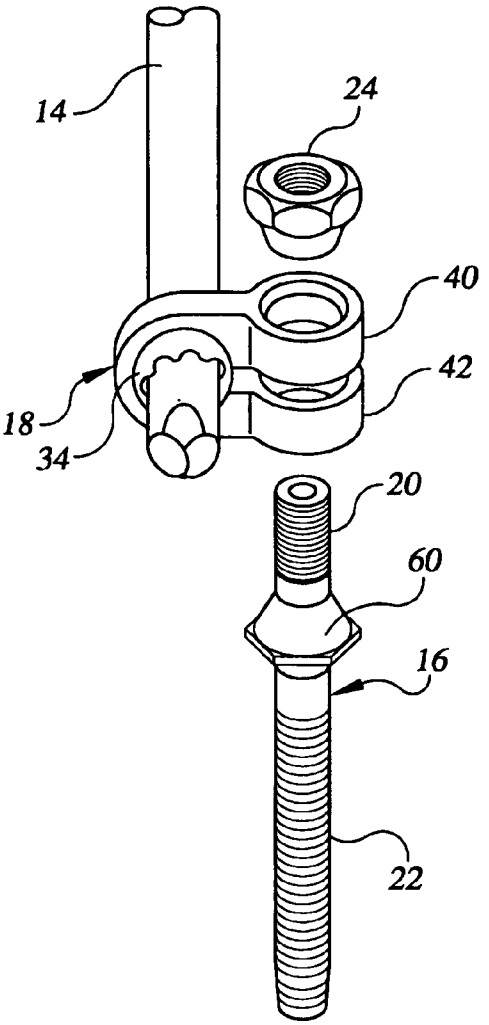


FIG.1

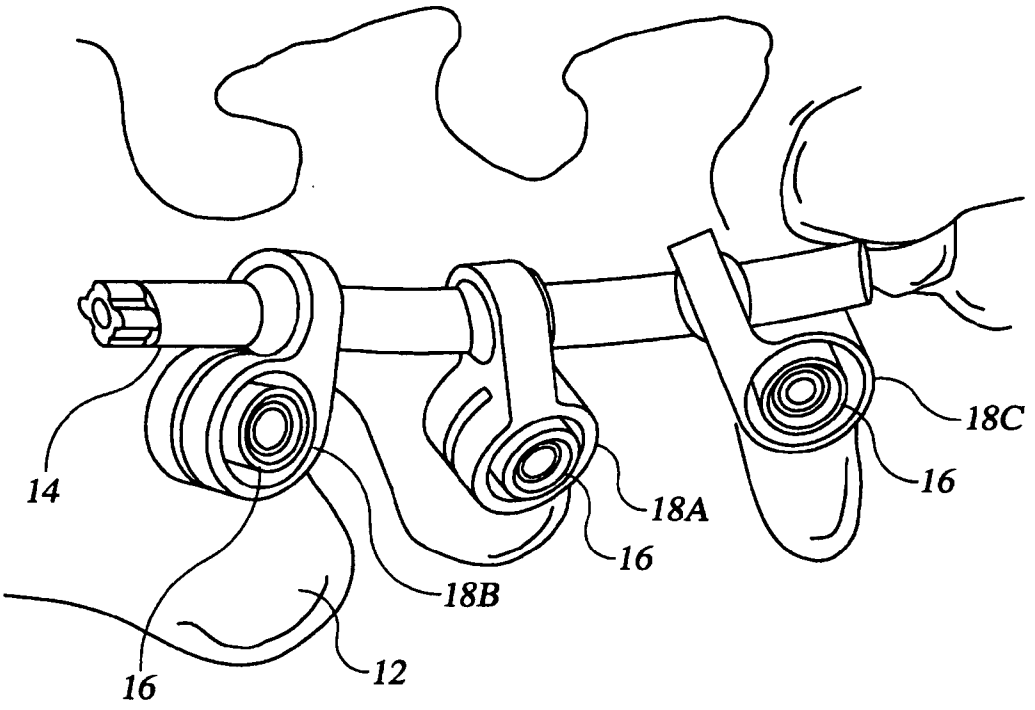


FIG.2

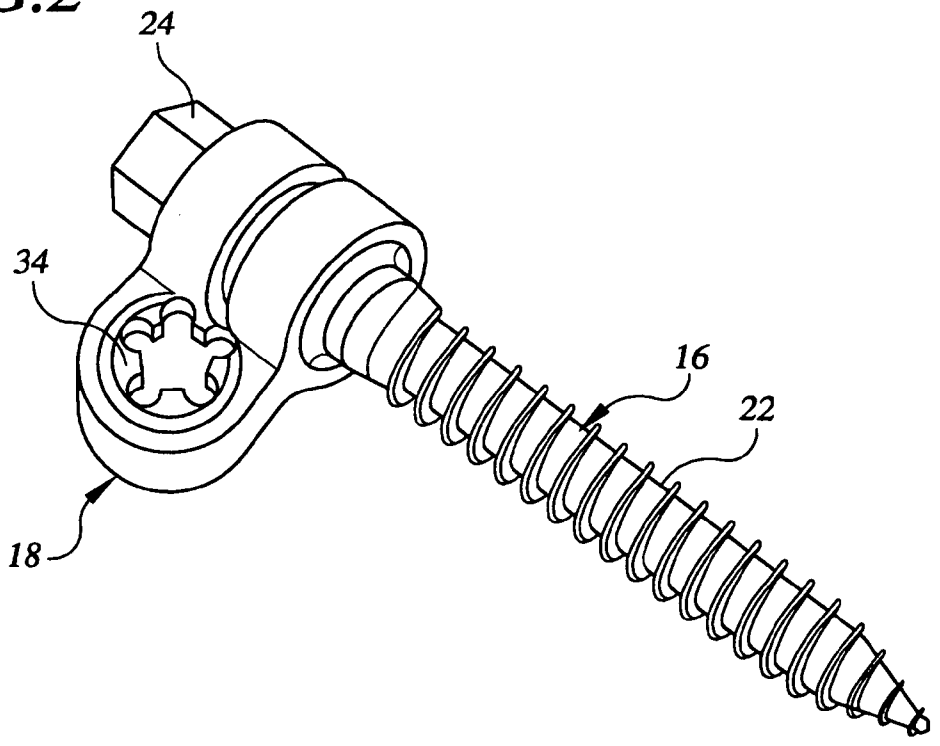


FIG.3

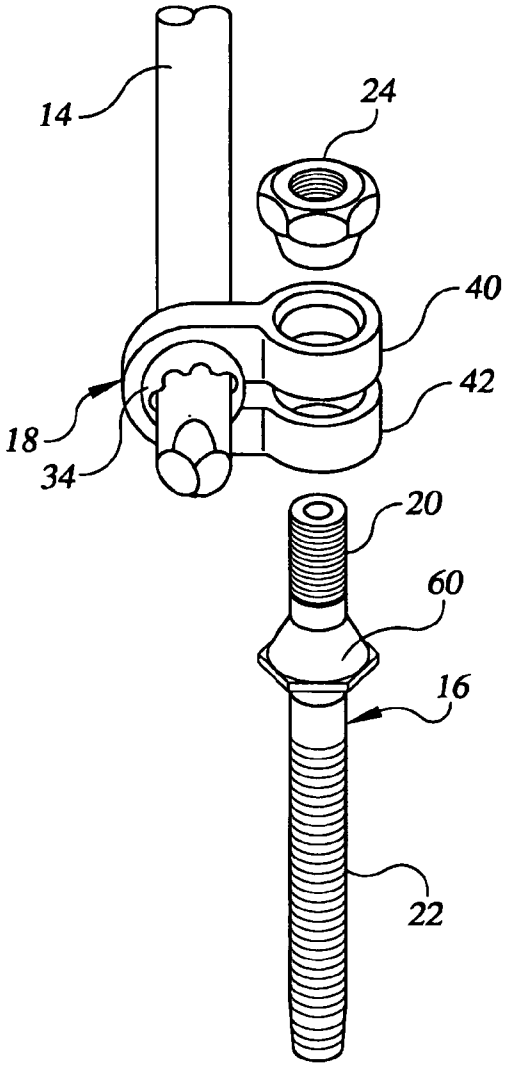


FIG.4

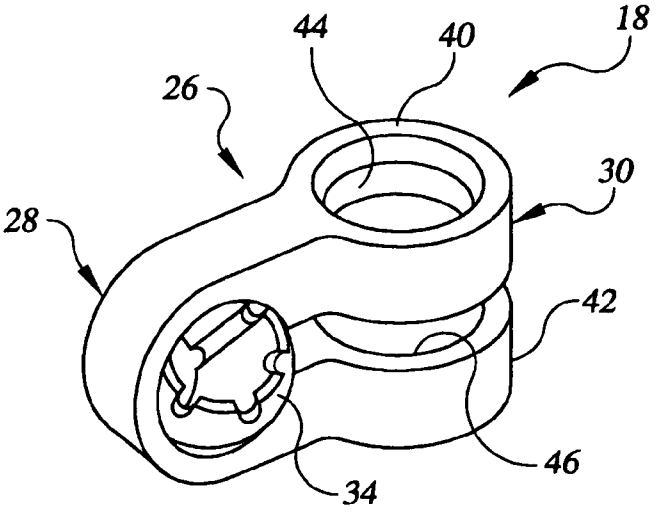


FIG.5A

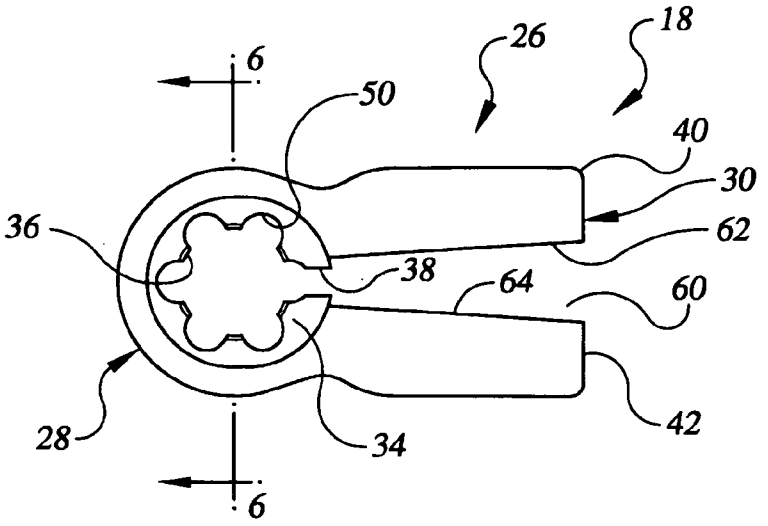


FIG.5B

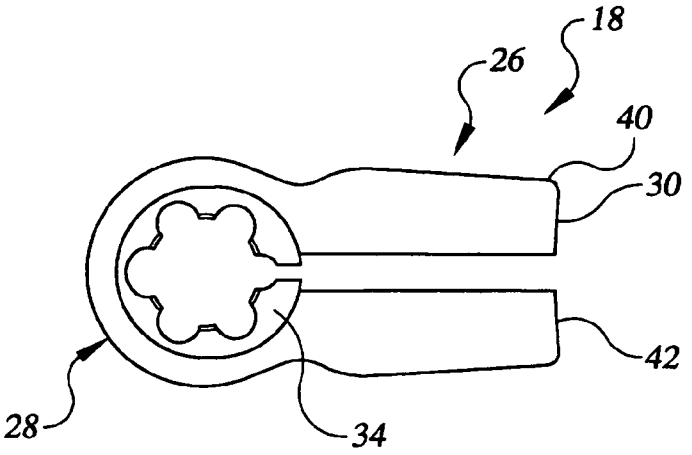
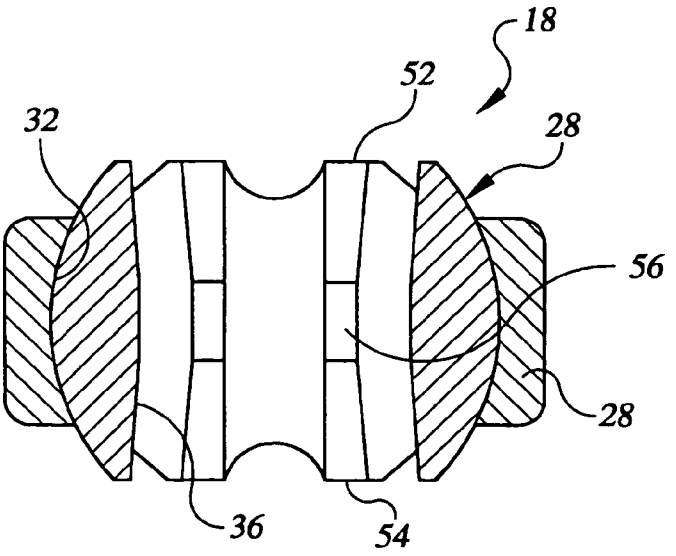


FIG.6



SPINAL FIXATION SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 10/341,658 filed on Jan. 14, 2003. The disclosure of the above application is incorporated herein by reference.

INTRODUCTION

[0002] The spinal column is a highly complex structure which houses and protects critical elements of the nervous system. In spite of these complexities, the spinal column is a highly flexible structure, capable of a high degree of curvature and twist through a wide range motion. Genetic or developmental irregularities, trauma, chronic stress, tumors, and disease, however, can result in spinal pathologies which either limit this range of motion, or threaten the critical elements of the nervous system housed within the spinal column.

[0003] A variety of systems has been disclosed in the art which achieve immobilization of portions of the spinal column by implanting artificial assemblies in or on the spinal column. These assemblies may be generally classified as anterior, posterior or lateral implants. Posterior implants are attached to the back of the spinal column generally by coupling to the pedicles with screws, or through hooks that attach under the lamina. In either case, the implants generally include elongate support rod elements which are coupled to the screws or hooks to immobilize two or more sequential vertebrae, for example to hold them stable so that adjacent bones may be fused with bone graft.

[0004] During implantation of a spinal fixation system of the type having an elongated support rod and anchors, it is important to provide adjustability between the support rod and the anchors. Adjustability facilitates ideal placement of the bone anchors relative to the spine. Preferably, the adjustability between the support rod and the anchors allows the supports rods to translate relative to the anchors and also allows for pivotal movement of the anchors relative to the support rod. The spinal system must also be able to arrest relative movement between the support rod and the anchors after implantation so that the spinal segments are post-operatively immobilized.

[0005] While known spinal fixation systems have proven to be useful for various applications, they are all associated with drawbacks. In this regard, the fixation screws or hooks of most known systems are difficult or impossible to adequately tighten to arrest relative movement between the anchors and support rod after implantation. Overcoming this limitation typically involves a complex clamping arrangement or an arrangement that requires undue tightening. Use of known systems is often a tedious process, which is inconsistent in result and adds unwanted time to a procedure.

[0006] Accordingly, it remains a need in the art to provide an improved spinal system clamping mechanism for coupling a rod and a bone anchor that overcomes the above discussed and other drawbacks of the prior art.

SUMMARY

[0007] The present teachings provide a clamp assembly for securing a bone anchor to a generally cylindrical rod. In one aspect, the clamp assembly includes a first portion, a second portion and a compressible ball carried by the second portion, the ball having a through hole for receiving the generally cylindrical rod. The first portion includes first and second flanges, each of the first and second flanges defining an aperture for receiving a portion of the bone anchor. The first and second flanges are movable from a first position in which the first and second flanges are separated by a gap to a second position in which the first and second flanges are drawn toward each other. The first and second flanges include first and second opposing surfaces, respectively, the first and second opposing surfaces being angled relative to one another in the first position.

[0008] Further areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

[0010] **FIG. 1** is a perspective view of a spinal fixation system constructed in accordance with the teachings of a preferred embodiment of the present invention, the spinal fixation system shown arranged in an exemplary construct and operatively attached to a human spinal column;

[0011] **FIG. 2** is a perspective view of one of the spinal anchors and an associated clamp assembly of **FIG. 1** removed from the construct of **FIG. 1** for purposes of illustration;

[0012] **FIG. 3** is a partially exploded side view of a portion of the construct of **FIG. 1**;

[0013] **FIG. 4** is a perspective view of the clamp assembly of **FIG. 2**;

[0014] **FIG. 5A** is a side view of the clamp assembly of **FIG. 4** shown with the first and second flanges normally spaced apart;

[0015] **FIG. 5B** is a view similar to **FIG. 5A** illustrating the first and second flanges drawn together; and

[0016] **FIG. 6** is a cross-sectional view taken along the line **6-6** of **FIG. 5A**.

DESCRIPTION

[0017] The following description of the preferred embodiments of the present invention is merely exemplary in nature and is in no way intended to limit the subject invention or its application or uses.

[0018] With general reference to the drawings, a spinal fixation system constructed in accordance with the teachings of the preferred embodiment of the present invention is illustrated and generally identified at reference character **10**. As shown in the environmental view of **FIG. 1**, components of the system **10** have been arranged in an exemplary construct for attachment to a portion of a spinal column **12** of a human patient. The components of the system **10** of the present invention used in the construct of **FIG. 10** generally include a linkage in the form of a generally cylindrical

support rod **14**, a plurality of spinal anchors **16** for engaging the spinal column **12**, and a plurality of clamp assemblies **18** securing the spinal anchors **16** to the cylindrical rod **14**.

[**0019**] The spinal anchors are illustrated throughout the drawings as bone screws **16**. Alteratively, it will be understood by those skilled in the art that other types of anchors known in the art may be employed for directly engaging the spine. For example, the anchors may alternatively be hooks that attach under the lamina of the spine.

[**0020**] With particular reference to **FIGS. 2 and 3**, one of the spinal anchors **16** and an associated one of the clamp assemblies **18** are illustrated in further detail. The spinal anchor **16** includes an upper threaded shaft portion **20** and a lower threaded shaft portion **22**. The upper threaded shaft portion **20** threadably engages a nut **24** when the spinal anchor **16** is secured to a linkage or rod **14** in a manner discussed below. The rod is preferably a generally cylindrical rod **14**.

[**0021**] The clamp assemblies **18** each adjustably interconnect one of the spinal anchors **16** that engage the spinal column **12** with the rod **14**. In the exemplary construct of **FIG. 1**, the system **10** of the present invention is illustrated to include three clamp assemblies **18**A, **18**B, **18**C. A first of the clamp assemblies **18**A is shown in further detail in **FIGS. 2-6** and is illustrated to generally include a body **26** having a first portion **28** for engaging the rod **14** and a second portion **30** for engaging the spinal anchor **16**. The body **26** of the clamp assembly **18**A is shown to generally have a C-shape with an intermediate portion or arm that defines an opening **32** for receiving the rod **14**. In the embodiment illustrated, the opening **32** is partially spherical and is adapted to adjustably receive a compressible locking member or ball **34**.

[**0022**] The compressible locking ball **34** is shown particularly in **FIGS. 5A and 5B** and the cross-sectional views of **FIG. 6**. As shown, the locking ball **34** is generally spherical in shape and includes an aperture or through hole **36** which passes therethrough for receiving the rod **14**. As will become more apparent below, the clamp body **26** and the ball **34** cooperate to form a ball and socket joint that allows pivotal movement of the rod **14** relative to the anchor **16**. This pivotal movement is about an imaginary center of the ball **34**. The locking ball **34** is normally permitted to universally move within the opening **32**. A slit **38** is provided in the locking ball **34** to facilitate compression of the ball and resulting clamping on the rod **14**.

[**0023**] The through hole **36** is defined by a generally cylindrical inner surface. The generally cylindrical inner surface preferably includes at least one relieved channel **50**. In the embodiment illustrated, the cylindrical inner surface is shown to include five relieved channels **50**. The particular number of relieved channels **50** will be understood to be a matter of design choice and may vary from that shown in the drawings. The relieved channels **50** allow for a more uniform collapse of the locking ball **34**. In this manner, the locking strength of the clamp assembly **18** is increased independent of the position of the ball **34** within the partially spherical opening defined by the clamp **34**.

[**0024**] As perhaps most particularly shown in the cross-section view of **FIG. 6**, at least a portion of the through hole **36** tapers from a first end **52** of the through hole **36** to a second end **54** of the through hole **36** toward a center of the locking ball **34**. As shown, the through hole **36** preferably tapers from the first end **52** towards the center and also from the second end **54** towards the center. A center portion **56** of the through hole **36** has a constant diameter. This configuration of the through hole **36** allows the locking ball **34** to be loaded and not impinge on a contoured rod.

[**0025**] In the embodiment illustrated, the through hole **36** passes through the center of the locking ball **34**. Alternatively, the through hole **36** may be eccentric to the sphere defined by the locking ball **34**. By orienting the through hole **36** eccentric to the sphere, adjustments can be made by rotating the locking ball **34** within the clamp body **26**.

[**0026**] The clamp body **26** further includes a first or upper flange **40** and a second or lower flange **42**. In the embodiment illustrated, the upper and lower flanges **40** and **42** are symmetrical about a plane extending therebetween. The upper and lower flanges **40** and **42** are shown to be generally circular in shape. The intermediate portion or arm of the clamp body **26** that extends between the flanges **40** and **42** is disposed radially relative to the upper and lower flanges **40** and **42**. The upper and lower flanges **40** and **42** define distinct but aligning apertures **44** and **46** (see **FIG. 4**), respectively. The apertures **44** and **46** are both associated with recesses **48** to receive either a nut **24** or a partially spherical shaped portion **60** of the screw **16**, respectively. In this manner, it is impossible to put the clamp assembly **18** on the rod **14** upside down.

[**0027**] As shown particularly in **FIG. 5A**, the first and second flanges **40** and **42** are normally spaced apart by a gap. The first and second flanges **40** and **42** include first and second opposing surfaces **62** and **64**, respectively. As shown in **FIG. 5A**, when the first and second flanges **40** and **42** are normally spaced apart, the opposing surfaces **60** and **64** are angled relative to one another.

[**0028**] Upon tightening of the nut **24**, movement of the clamp body **26** relative to the rod **14** is arrested. Explaining further, tightening of the nut **24** serves to draw the upper and lower flanges **40** and **42** together causing the intermediate portion of the clamp body **26** to compress squeeze the locking ball **34** and correspondingly clamp the rod **14**. Relative movement is also arrested between the locking ball **34** and the clamp body **26**.

[**0029**] Importantly, the clamp body **26** is formed to include sufficient spacing between the upper and lower flanges **40** and **42** so that the gap **60** is always maintained throughout the range of tightening. In this manner, clamping forces are more efficiently transferred to the locking ball **34**. The clamp body **26** is illustrated in a fully clamped condition in **FIG. 5B**. As shown, the opposing surfaces **62** and **64** are oriented generally parallel to one another.

[**0030**] With particular reference to **FIGS. 1**, the clamp assemblies **18**B and **18**C will be understood to be identical. The clamp assemblies **18**B and **18**C differ from the clamp assembly **18**A in that the second portion **30** is tangentially oriented relative to the first and second flanges **40** and **42**. In other words, the intermediate portion or arm that connects the first and second flanges **40** and **42** is offset to one side from a radial position. This offset allows the rod **14** to be positioned closer to the anchor **16** and reduces the medial lateral profile of the construct. Otherwise, it will be understood that the clamp assemblies **18**A-**18**C are identical.

[0031] 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 clamp assembly for securing a bone anchor to a generally cylindrical rod, the clamp assembly comprising:

a first portion including first and second spaced apart flanges, the first and second spaced apart flanges both defining apertures for receiving a portion of the bone anchor, wherein the first and second flanges include first and second opposing surfaces, respectively, the first and second opposing surfaces being angled relative to one another before the first and second flanges are drawn toward one another;

a second portion; and

a compressible ball carried by the second portion, the ball having a through hole for receiving the generally cylindrical rod.

2. The clamp assembly of claim 1, wherein the through hole defined by a generally cylindrical inner surface has at least one relieved channel.

3. The clamp assembly of claim 1 in combination with the bone anchor, the bone anchor having an upper threaded portion extendable through the apertures of the first and second flanges and engaging a nut such that tightening of nut draws the first and second flanges toward one another and the second portion compresses the ball.

4. The clamp assembly of claim 3, wherein the first and second opposing surfaces are generally parallel to one another when the nut is tightened.

5. The clamp assembly of claim 4, wherein the second portion circumferentially surrounds the ball substantially completely when the first and second flanges are drawn together.

6. The clamp assembly of claim 1, wherein the generally cylindrical surface includes a plurality of relieved channels.

7. The clamp assembly of claim 6, wherein the plurality of relieved channels extend generally parallel to an elongated axis of the rod.

8. The clamp assembly of claim 1, wherein the compressible ball and the second portion of the clamp assembly define a ball and socket joint such that the rod is permitted to pivot relative to the clamp assembly about a center of the ball.

9. A clamp assembly for securing a bone anchor to a generally cylindrical rod, the clamp assembly comprising:

a first portion including first and second flanges, each of the first and second flanges defining an aperture for receiving a portion of the bone anchor, the first and second flanges movable from a first position in which the first and second flanges are separated by a gap to a second position in which the first and second flanges are drawn toward each other, the first and second flanges including first and second opposing surfaces, respectively, the first and second opposing surfaces being angled relative to one another in the first position;

a second portion; and

a compressible ball carried by the second portion, the ball having a through hole for receiving the generally cylindrical rod.

10. The clamp assembly of claim 9, in which the first and second opposing surfaces are generally parallel to one another in the second position.

11. The clamp assembly of claim 10, wherein the second portion circumferentially surrounds the ball substantially completely when the first and second flanges are in the second position.

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