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Weaver et al.

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(54) **BONE PLATING SYSTEM**

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Related U.S. Application Data

(63) Continuation of application No. 09/660,287, filed on Sep. 12, 2000, now Pat. No. 6,623,486.

(60) Provisional application No. 60/153,239, filed on Sep. 13, 1999.

(51) **Int. Cl.**
A61B 17/58 (2006.01)

(52) **U.S. Cl.** **606/69**

(58) **Field of Classification Search** 606/69, 606/70, 71, 73

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,552,389	A	1/1971	Allgower et al.	
3,630,261	A *	12/1971	Gley	411/315
3,668,972	A	6/1972	Allgower et al.	
3,716,050	A	2/1973	Johnston	
3,779,240	A	12/1973	Kondo	
RE28,841	E	6/1976	Allgower et al.	
4,219,015	A	8/1980	Steinemann	
4,408,601	A	10/1983	Wenk	
RE31,628	E	7/1984	Allgower et al.	
4,493,317	A	1/1985	Klaue	
4,513,744	A	4/1985	Klaue	

(Continued)

FOREIGN PATENT DOCUMENTS

CH	611147	5/1979

(Continued)

OTHER PUBLICATIONS

ACE Symmetry™ Titanium Upper Extremity Plates, Ace Medical Company.

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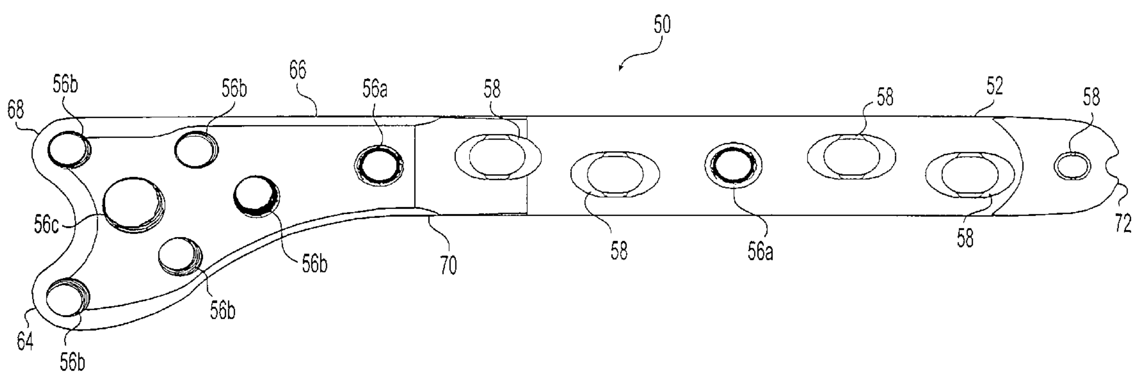
(57) **ABSTRACT**

The present invention relates to a bone plating system and method for fracture fixation of bone. The bone plating system includes a bone plate, at least one locking screw, and at least one non-locking screw. The bone plate has locking holes with threads and non-locking holes. The locking screws have a shaft with a thread for engaging bone and a head with a thread configured and dimensioned to mate with the thread of the locking holes. The non-locking screws have a thread for engaging bone and a non-threaded head. Both the locking and non-locking screws remain seated in their respective holes for substantially as long as the bone plate is implanted. The non-locking screws compress the bone plate against the bone and hold fracture reduction while the locking screws are secured to the plate at a fixed angular relationship. The mixed fixation achieved by this bone plating system and method is particularly useful for treatment of per-articular fractures.

55 Claims, 9 Drawing Sheets



U.S. PATENT DOCUMENTS

4,565,193	A		1/1986	Streli	
4,838,252	A		6/1989	Klau	
4,867,144	A	*	9/1989	Karas et al.	606/69
4,927,421	A		5/1990	Goble et al.	
4,957,497	A		9/1990	Hoogland et al.	
4,988,350	A		1/1991	Herzberg	
5,002,544	A		3/1991	Klaue et al.	
5,006,120	A		4/1991	Carter	
5,041,114	A		8/1991	Chapman et al.	
5,085,660	A		2/1992	Lin	
5,129,901	A		7/1992	Decoste	
5,151,103	A		9/1992	Tepic et al.	
5,190,544	A	*	3/1993	Chapman et al.	606/69
5,197,966	A		3/1993	Sommerkamp	
5,269,784	A		12/1993	Mast	
5,275,601	A		1/1994	Gogolewski et al.	
5,304,180	A		4/1994	Slocum	
5,324,290	A		6/1994	Zdeblick et al.	
5,364,398	A		11/1994	Chapman et al.	
5,364,399	A		11/1994	Lowery et al.	
5,429,641	A		7/1995	Gotfried	
5,514,138	A		5/1996	McCarthy	
5,591,168	A		1/1997	Judet et al.	
5,601,553	A	*	2/1997	Trebing et al.	606/61
5,607,428	A	*	3/1997	Lin	606/69
5,674,222	A	*	10/1997	Berger et al.	606/69
5,702,399	A		12/1997	Kilpela et al.	
5,709,686	A	*	1/1998	Talos et al.	606/69
5,741,258	A		4/1998	Klaue et al.	
5,749,872	A	*	5/1998	Kyle et al.	606/69
5,772,662	A		6/1998	Chapman et al.	
5,810,823	A		9/1998	Klaue et al.	
5,938,664	A		8/1999	Winquist et al.	
5,954,722	A	*	9/1999	Bono	606/61
5,968,047	A		10/1999	Reed	
6,022,352	A		2/2000	Vandewalle	
6,096,040	A		8/2000	Esser	
6,129,730	A		10/2000	Bono et al.	
6,183,475	B1		2/2001	Lester et al.	
6,206,881	B1		3/2001	Frigg et al.	
6,228,085	B1		5/2001	Theken et al.	
6,306,136	B1	*	10/2001	Baccelli	606/61
6,322,562	B1		11/2001	Wolter	
6,364,882	B1		4/2002	Orbay	
6,440,135	B1		8/2002	Orbay et al.	
6,454,770	B1		9/2002	Klaue	
6,527,776	B1		3/2003	Michelson	
D479,331	S		9/2003	Pike et al.	
6,623,486	B1		9/2003	Weaver et al.	
6,669,701	B1		12/2003	Steiner et al.	

FOREIGN PATENT DOCUMENTS

DE	43 41 980	A1	6/1995
DE	43 43 117	A1	6/1995
DE	4438264	A1	3/1996
DE	93 21 544	U1	10/1999
EP	0 207 884	A2	1/1987
EP	1 468 655	A2	10/2004
FR	2233973		1/1975
FR	2405062		5/1979
FR	2405705		5/1979
FR	2405706		5/1979
FR	2496429		5/1979
RU	SU 1279626	A1	12/1986
WO	WO 97/09000		3/1997
WO	WO 00/53110		9/2000
WO	WO 00/53111		9/2000

* cited by examiner

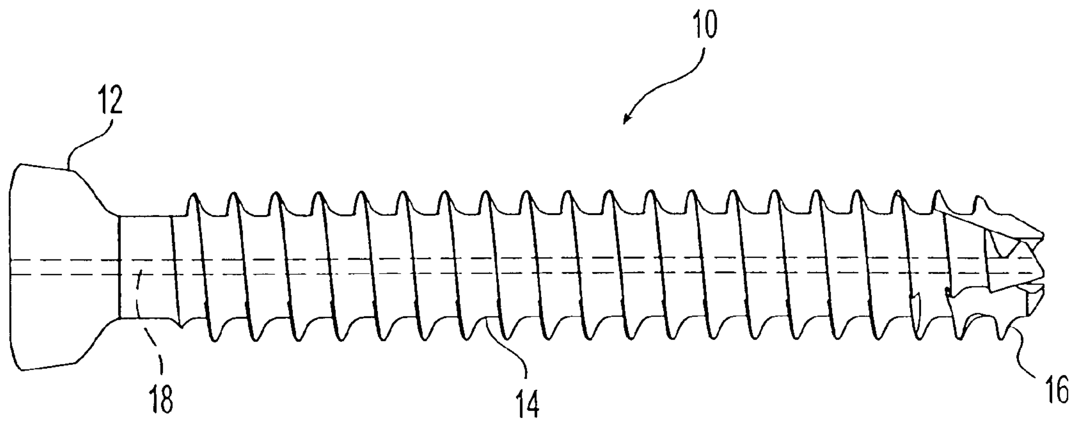


Fig. 1

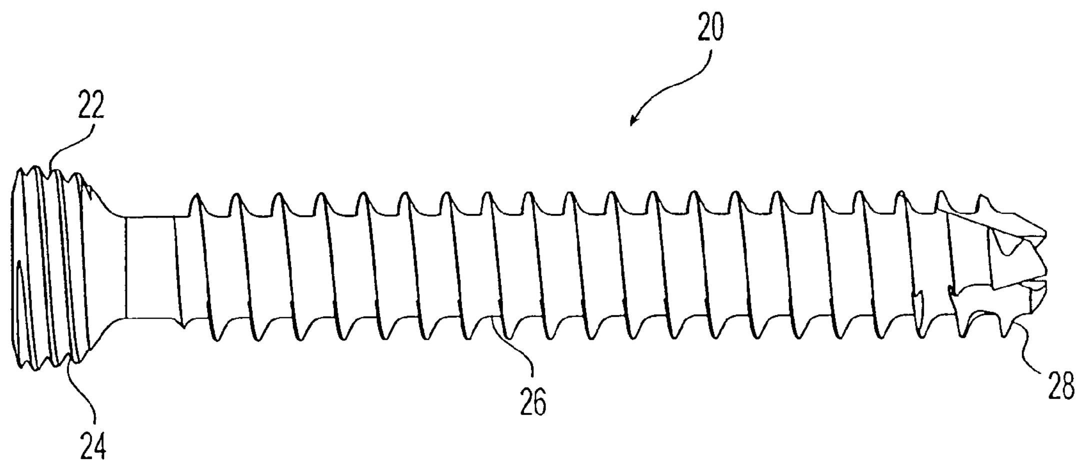


Fig. 2

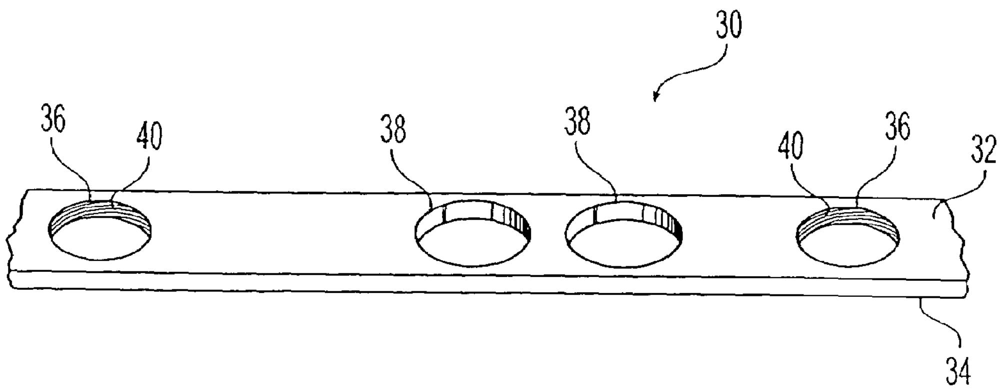


Fig. 3

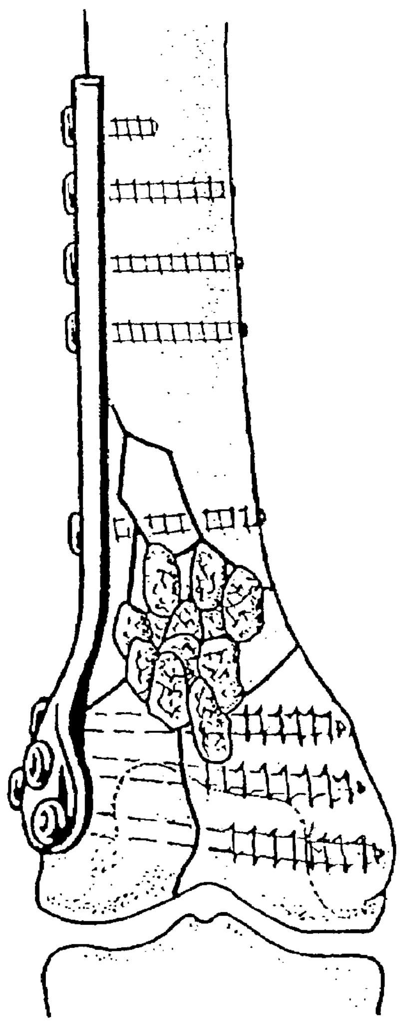
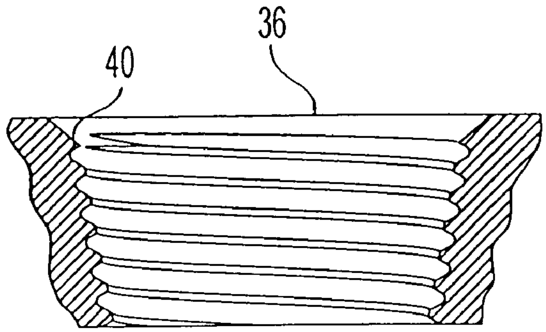


Fig. 9



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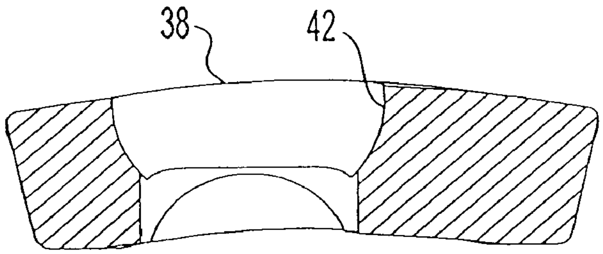

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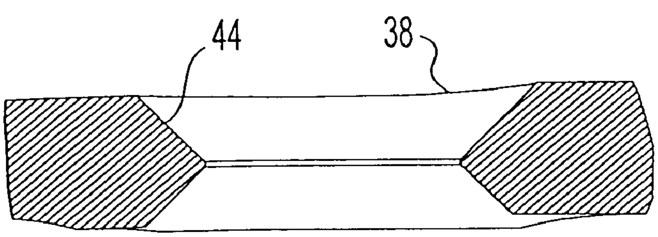

Fig. 6

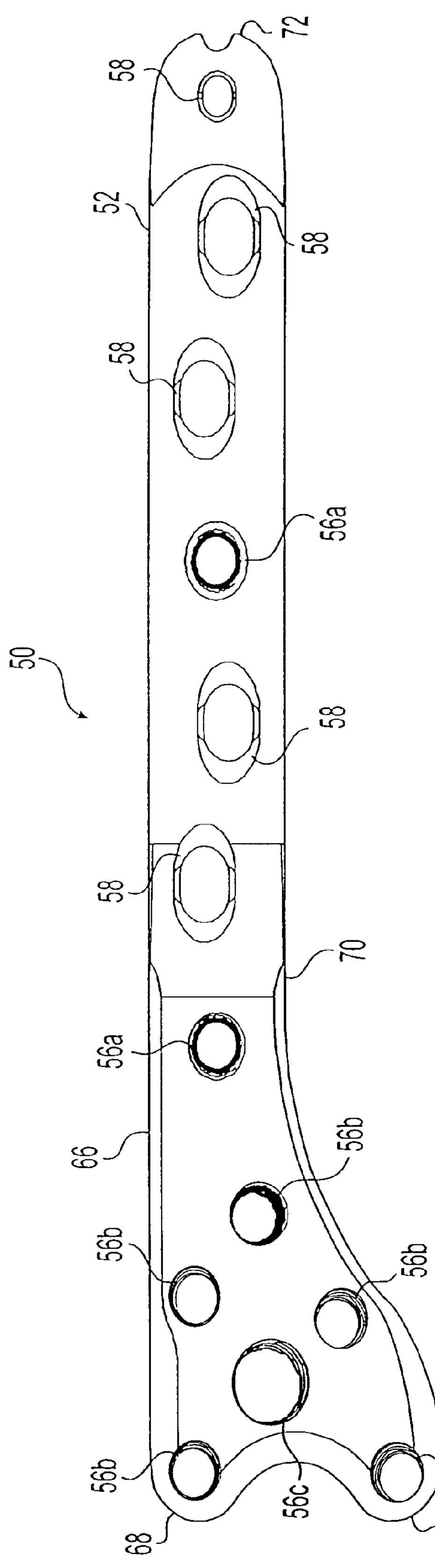
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Fig. 7

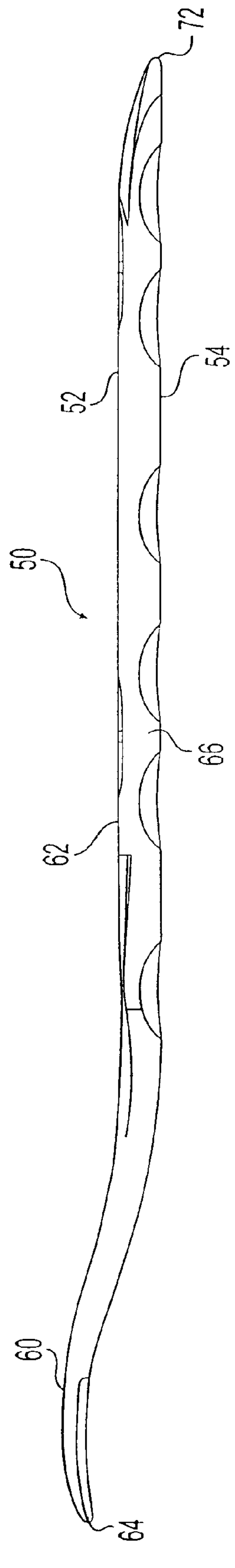
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Fig. 8

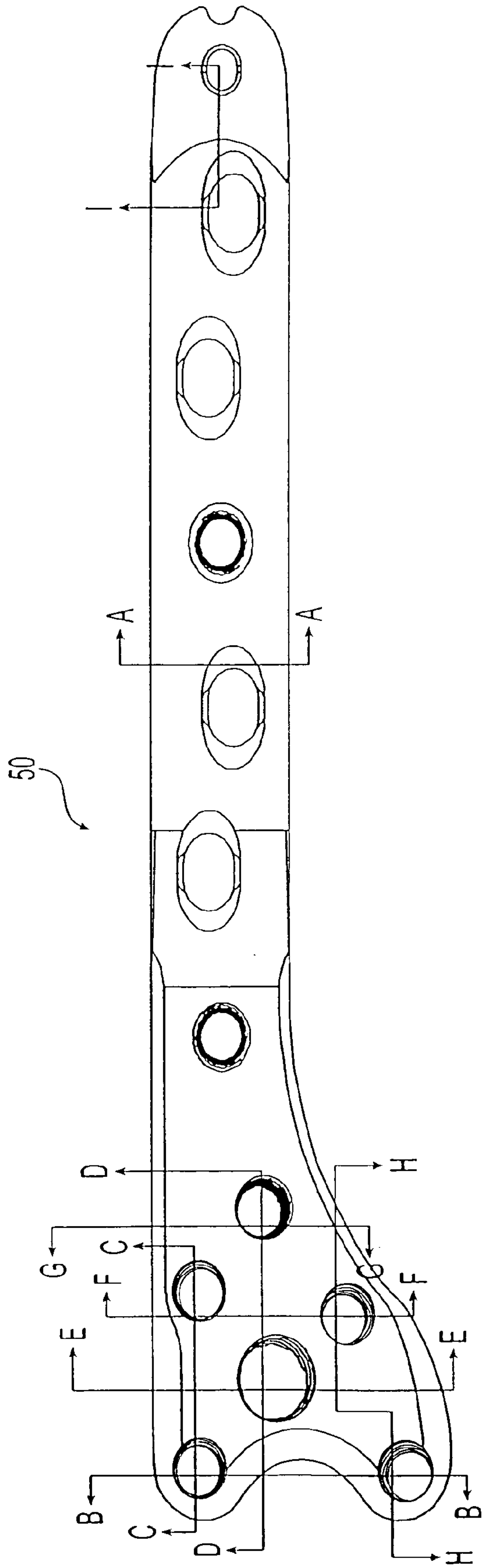
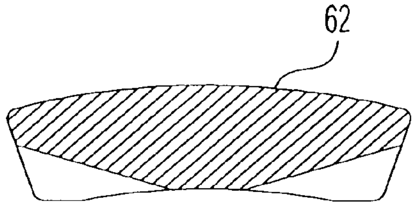


Fig. 10



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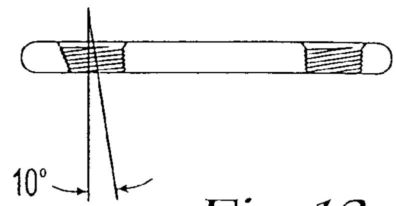


Fig. 12

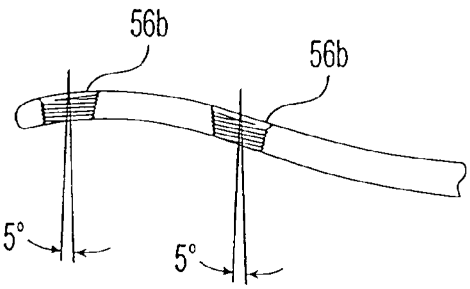
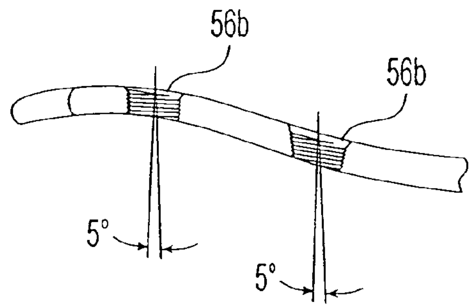


Fig. 13



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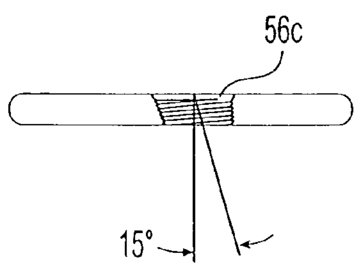

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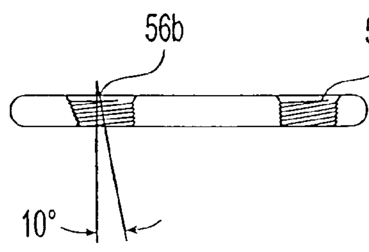

Fig. 16

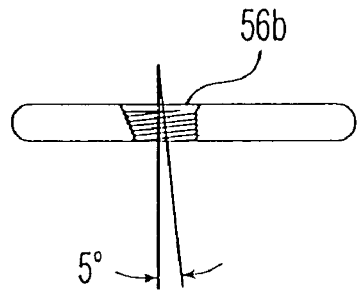

Fig. 17

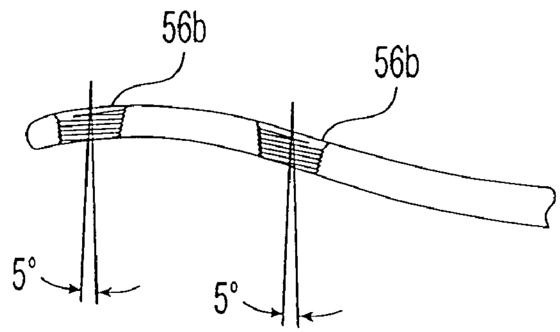

Fig. 18

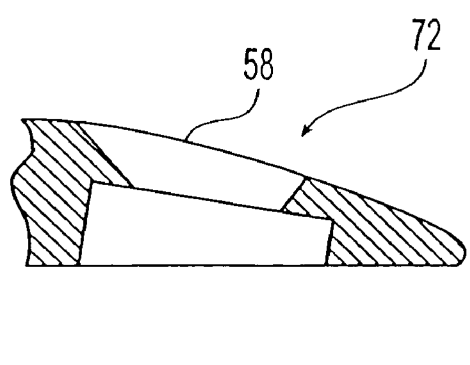

Fig. 19

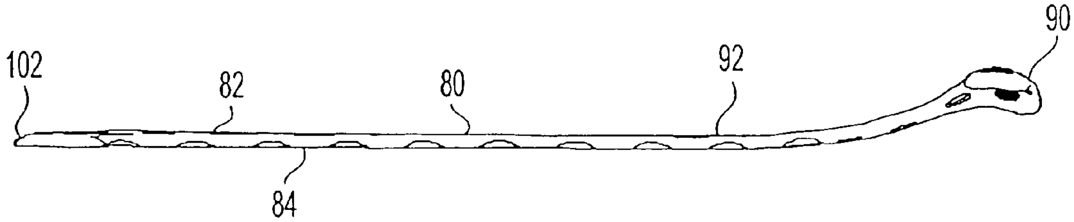

Fig. 20

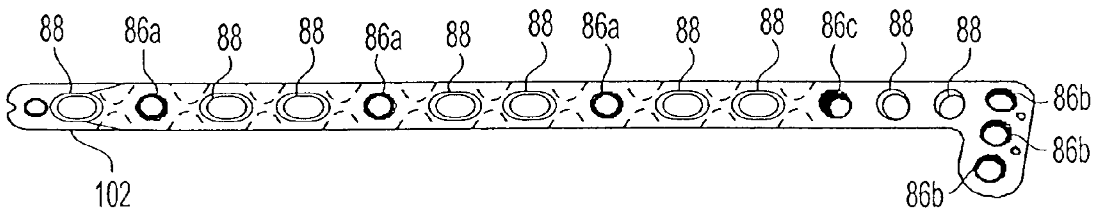

Fig. 21

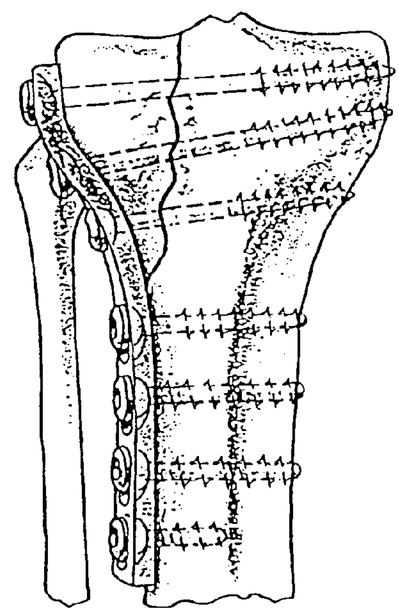

Fig. 22

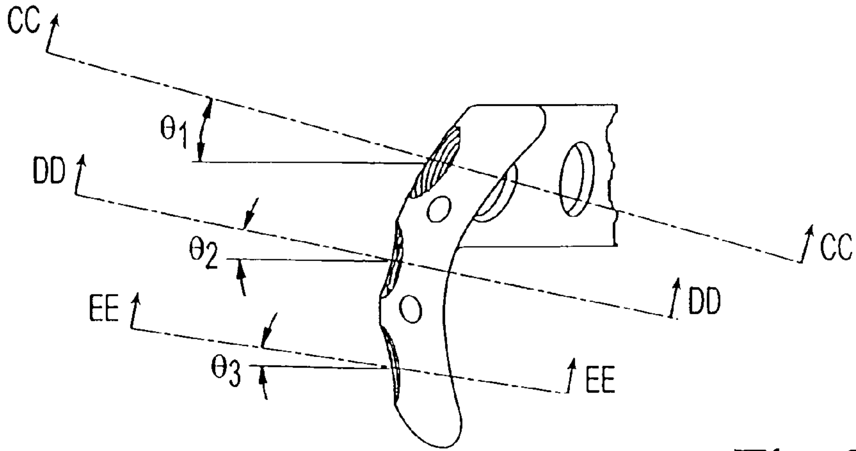

Fig. 23

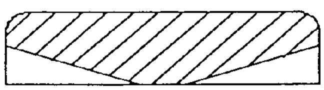

Fig. 24

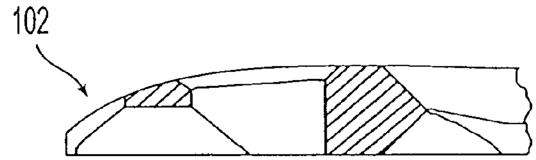

Fig. 25

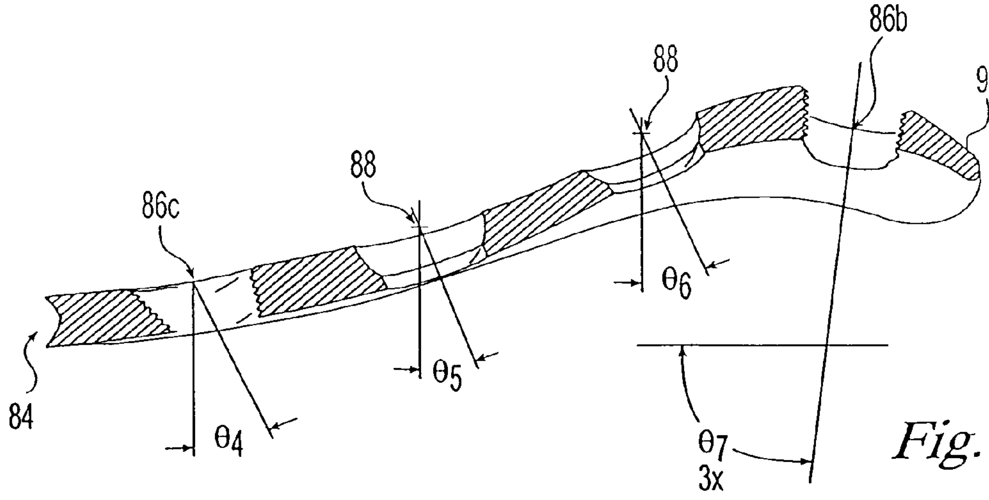

Fig. 26

BONE PLATING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 09/660,287, filed on Sep. 12, 2000 now U.S. Pat. No. 6,626,486, which claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional Application No. 60/153,239, filed on Sep. 13, 1999.

FIELD OF THE INVENTION

The present invention is directed to a bone plating system for fracture fixation, and in particular to a system including a bone plate having plate holes for both locking and non-locking screws.

BACKGROUND OF THE INVENTION

The clinical success of plate and screw systems for internal fixation of fractures is well-documented. However, treatment of certain fractures, such as peri-articular fractures, which require a fixed angular relationship between the bone plate and screws, remains problematic. Fixed angle devices for treatment of these fractures are available and include the Dynamic Condylar Screw System commercially available from Synthes (USA) of Paoli, Pa. and a wide variety of blade plates. All of these devices require a high level of surgical skill, suitable bone quantity and quality, and a fracture pattern compatible with the device.

In cases in which these requirements are not satisfied, e.g. severely comminuted bone or missing bone segments, conventional bone plate and screw systems must be used. Although these conventional systems are particularly well-suited to promoting healing of the fracture by compressing the fracture ends together and drawing the bone into close apposition with other fragments and the bone plate, the angular relationships between the plate and screws are not fixed and can change postoperatively. This can lead to mal-alignment and poor clinical results.

The primary mechanism for the change in angular relationship is related to energy storage. As previously noted, threading a bone screw into bone compresses the bone against the plate. The compression results in high strain in the bone, and, consequently, energy storage. With the dynamic loading resulting from physiological conditions, loosening of the plate and screw and loss of the stored energy can result.

Securing the screws to the plate provides a fixed angle relationship between the plate and screw and reduces the incidence of loosening. One method of securing the screw to the plate involves the use of so-called "locking screws." A locking screw has threading on an outer surface of its head that mates with corresponding threading on the surface of a plate hole to lock the screw to the plate. Bone plates having threaded holes for accommodating locking screws are known. For example, German Patent Application No. 43 43 117 discloses a bone plate with threaded holes for locking screws. As the relationship between the locking screws and the plate is fixed, locking screws provide a high resistance to shear or torsional forces. However, locking screws have a limited capability to compress bone fragments.

In summary, conventional bone screws, i.e. screws that are not secured to a plate so that a fixed angular relationship between the plate and screw is maintained (hereinafter "non-locking screws") effectively compress bone fragments,

but possess a low resistance to shear force that can lead to loosening of the screw. Locking screws have a high resistance to shear force that ensure stability at the bone screw/plate hole interface, but possess a limited ability to compress bone fragments. Thus, a bone plating system that combines non-locking screws with locking screws would be ideal for certain clinical situations.

U.S. Pat. No. 5,601,553 discloses a locking plate and bone screw. The plate has a plurality of threaded plate holes for receiving locking screws. The plate also has non-threaded plate holes for receiving temporary screws that keep the plate in place while the locking screws are inserted. After the locking screws are inserted, the temporary screws are removed. Thus, the long term benefits of combining non-locking screws with locking screws are not obtained. U.S. Pat. No. 5,709,686 discloses a bone plate with partially threaded plate holes. The partially threaded holes allow either non-locking or locking screws to be used. Because the plate holes are only partially threaded, the locking screws used may not be able to maintain the fixed angular relationship between the screws and plate under physiological loads. Specifically, the locking screws within the plate are only partially captivated and thus only partially surrounded by threads. Under high stress and loading conditions, the locking plate hole may distort and allow the fixed angular relationship between the locking screw and plate to change. This can result in loss of fixation or loss of established intraoperative plate orientation. Additionally, because of the plate hole geometry, translation of the plate with the non-locking screws is limited to one direction only. This may be a disadvantage in reduction and manipulation of fragments.

Thus, there exists a need for an improved bone plating system that overcomes the deficiencies of the prior art.

SUMMARY OF THE INVENTION

The bone plating system for fixation of bone according to the present invention includes a bone plate having an upper surface, a bone-contacting surface, at least one first hole passing through the upper and bone-contacting surfaces and having a thread, and at least one second hole passing through the upper and bone-contacting surfaces. The bone plating system also includes a first screw having a shaft with a thread for engaging bone and a head with a thread configured and dimensioned to mate with the thread of the first hole, and a second screw having a shaft with a thread for engaging bone and a head. The first and second screws remain seated in their respective holes for substantially as long as the bone plate is implanted. Preferably, the bone plate includes a plurality of first and second holes, and a corresponding plurality of first and second screws are provided.

In order to facilitate insertion, the first and second screws can be a self-tapping screws. These screws can also be self-drilling screws. Additionally, the first and second screws can be cannulated for insertion of a guide wire to guide screw placement. The first plate hole can have a substantially conical shape with a double-lead thread.

In one embodiment, the bone plate has a trapezoidal shaped cross section in regions between the first and second plate holes for minimizing contact between bone and the bone-contacting surface. Additionally, at least one of the second plate holes is longitudinally elongated and has an edge inclined at an angle to the upper surface toward the bone-contacting surface for displacing the bone plate when engaged by the head of a second bone screw.

In an exemplary embodiment, the bone plate includes a head portion configured and dimensioned to conform to a metaphysis of a bone and a shaft portion configured and dimensioned to conform to a diaphysis of a bone. The head portion has only first plate holes and the shaft portion has both first and second plate holes. In one embodiment, the head portion has a curved surface, includes an anterior fork substantially parallel to an anterior side of the shaft portion, and includes a posterior fork extending out from a posterior side of the shaft portion. In another embodiment, the head portion flares outward from the shaft portion and is curved, tapered, and twisted. The head portion can also be provided with suture holes from suture anchoring of the bone plate.

The method for fracture fixation of bone according to the present invention comprises the steps of reducing the fracture to bring bone fragments in close apposition; compressing a bone plate against the bone with at least one first fastener to hold the fracture reduction; and securing at least one second fastener at a fixed angular relationship to the bone plate. The first fasteners are inserted before the second fasteners and both the first and second fasteners remain in bone for substantially as long as the bone plate is implanted.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of one embodiment of a non-locking screw according to the present invention;

FIG. **2** is a side view of one embodiment of a locking screw according to the present invention;

FIG. **3** is a perspective view of a portion of a bone plate according to the present invention;

FIG. **4** shows a cross-sectional view of one of the first plate holes through line **4**—**4** of FIG. **3**;

FIG. **5** shows a cross-sectional view of one of the second plate holes through line **5**—**5** of FIG. **3**;

FIG. **6** shows another cross-sectional view of the second plate hole of FIG. **5** through line **6**—**6** of FIG. **3**;

FIG. **7** shows a top view of an embodiment of a bone plate according to the present invention designed for use in the distal femur;

FIG. **8** shows a side view of the bone plate of FIG. **7**;

FIG. **9** shows a perspective view of the bone plate of FIG. **7** implanted in a distal femur;

FIG. **10** shows a top view of the bone plate of FIG. **7** with various cross sections labeled;

FIG. **11** shows a cross-section of the bone plate of FIG. **7** through line A—A;

FIG. **12** shows a cross-section of the bone plate of FIG. **7** through line B—B;

FIG. **13** shows a cross-section of the bone plate of FIG. **7** through line C—C;

FIG. **14** shows a cross-section of the bone plate of FIG. **7** through line D—D;

FIG. **15** shows a cross-section of the bone plate of FIG. **7** through line E—E;

FIG. **16** shows a cross-section of the bone plate of FIG. **7** through line F—F;

FIG. **17** shows a cross-section of the bone plate of FIG. **7** through line G—G;

FIG. **18** shows a cross-section of the bone plate of FIG. **7** through line H—H;

FIG. **19** shows a cross-section of the bone plate of FIG. **7** through line I—I

FIG. **20** shows a side view of an embodiment of a bone plate according to the present invention designed for use in the proximal tibia;

FIG. **21** shows a top view of the bone plate of FIG. **20**;

FIG. **22** shows a perspective view of the bone plate of FIG. **20** implanted in a proximal tibia;

FIG. **23** shows an end view of the bone plate of FIG. **20** with various cross sections labeled;

FIG. **24** shows a cross-section of the bone plate of FIG. **21** through line A—A;

FIG. **25** shows a cross-section of the bone plate of FIG. **21** through line I—I; and

FIG. **26** shows a cross-section of the bone plate of FIG. **21** through line D—D.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The bone plating system according to the present invention includes a bone plate, non-locking screws, and locking screws. FIG. **1** shows an example of a non-locking screw **10** that can be used with the present invention. In general and as described in more detail below, any surgical screw that has a non-threaded head **12** of an appropriate size and geometry for select plate holes of the bone plate can be used. Non-locking screw **10** has a shaft **14** that is at least partially threaded for attachment to bone. The length of shaft **14** and the shaft thread configuration can be selected for the particular application. As is well known in the art, the threads and a tip **16** can be made to be self-tapping and/or self-drilling to facilitate implantation. Shaft **14** can also be cannulated with a channel for receiving a guide wire to aid in proper placement.

FIG. **2** shows an example of a locking screw **20** that can be used with the present invention. In general and as described in more detail below, any surgical screw that has a head **22** with threads **24** can be used as long as head **22** is of an appropriate size and geometry for select plate holes of the bone plate and threads **24** mate with the threads of the plate holes. Locking screw **20** has a shaft **26** that is at least partially threaded for attachment to bone. The length of shaft **26** and the shaft thread configuration can be selected for the particular application. As is well known in the art, the threads and a tip **28** can be made to be self-tapping and/or self-drilling to facilitate implantation. Shaft **26** can be cannulated for receiving a guide wire.

FIG. **3** shows a portion of a bone plate **30** according to the present invention. Bone plate **30** can be made in different shapes and sizes for use in a wide variety of clinical applications. Bone plate **30** includes an upper surface **32** and a bone contacting surface **34**. Bone plate **30** has a plurality of first plate holes **36** and a plurality of second plate holes **38**. Each of first and second plate holes **36**, **38** passes through upper **32** and bone-contacting surfaces **34**. Each first plate hole **36** has a thread **40** that mates with thread **24** on head **22** of locking screw **20** to secure locking screw **20** to bone plate **30** at a temporally fixed angular orientation. Second plate holes **38** are not threaded and receive non-locking screws **10** with non-threaded heads **12**. Insertion of non-locking screws **10** in second plate holes **38** draws the bone toward bone-contacting surface **34** to compress the bone. Thus, seating of non-locking screws **10** in second plate holes **38** compresses the bone against bone-contacting surface **34** and seating of locking screws **20** in first plate holes **36** secures heads **22** to bone plate **30** for maintaining a fixed angular relationship between locking screws **20** and bone plate **30**. Simultaneous use of bone plate **30** with both non-locking and locking screws **10**, **20** for as long as bone plate **30** is implanted provides stability between both the screw and bone plate and between the bone plate and bone.

As non-locking screws **10** are generally secured in cancellous bone, the threads on shaft **14** are typically larger than the threads on shaft **26** of locking screws **20**.

First plate holes **36** are preferably conical in shape. As shown in FIG. **4**, threads **40** on first plate holes **36** are also preferably double lead threads. The double lead conical threads enables multiple threads to engage while maintaining a low profile. Additionally, the double lead conical threads are less susceptible to cross-threading compared to other threads, e.g. cylindrical threaded arrangements.

As seen best in FIGS. **5** and **6**, second plate holes **38** are preferably dynamic compression unit (DCU) screw holes substantially similar to those disclosed in reissued U.S. Pat. No. Re. 31,628 to Allgower et al., the contents of which are incorporated herein by reference. The DCU screw holes promote healing of the bone by compressing the fracture ends together. Briefly, second plate holes **38** have an edge **42** which includes an oblique portion or ramp **44** having an inclination such that when ramp **44** is engaged by the underside of head **12** of non-locking screw **10**, bone plate **30** is displaced in a direction to move ramp **44** away from non-locking screw **10** and to cause bone plate **30** to apply a pressure to hold the fracture ends in tight engagement.

Bone-contacting surface **34** on bone plate **30** can be shaped to minimize contact with bone. Limiting contact between the bone plate and bone has a number of biological and mechanical advantages including reduced damage to blood supply and easier plate removal. Providing bone plate **30** with a trapezoidal cross section (FIG. **11**) in the regions between first and second plate holes **34**, **36** is one way to minimize contact. Other ways are disclosed in U.S. Pat. Nos. 5,151,103; 5,053,036; 5,002,544; and 4,838,252. The contents of these patents are incorporated herein by reference.

By combining locking screws and non-locking screws on the same bone plate, the present invention provides a novel mixed fixation. With the non-locking screws, fracture reduction is held by friction between the bone plate and bone. This friction is generated by tightening the non-locking screws in bone. However, micromotion between the non-locking screws and bone leads to bone resorption, and loss of reduction. Additionally, insertion of the non-locking screws requires bone to withstand the stresses of tightening of the screws. This results in high stress in bone surrounding the non-locking screws. Ordinarily, the high stress can cause the non-locking screw threads to strip (threads in bone fail in shear) and/or creep in bone (since bone is a viscoelastic material). Either one of these phenomenon also results in loss of reduction.

By adding at least one locking screw, loss of reduction is minimized or eliminated by the present invention. Specifically, by securing the locking screws to the bone plate and not the bone, the effect of the viscoelastic behavior of bone is reduced, the threads do not strip, and micromotion is prevented. The attachment between the locking screws and bone plate is a high strength connection in which the locking screw must cut sideways through bone to fail.

As management of certain peri-articular fractures typically involves insertion of screws at various angles with respect to the bone plate and it is highly desirable to maintain the initial angular relationships between the individual screws and the bone plate, the bone plating system according to the present invention is particularly well-suited for these clinical applications. FIGS. **7**–**19** show a bone plate **50** according to the present invention specifically designed for use in the distal femur. Bone plate **50** would be used primarily for, but not limited to, severely comminuted fractures including Hoffa type fractures.

Bone plate **50** has an upper surface **52** and a bone-contacting surface **54**. Bone plate **50** has a plurality of threaded plate holes **56***a*, **56***b*, **56***c* (collectively referred to as threaded plate holes **56**) for receiving locking screws **20** and a plurality of non-threaded plate holes **58** for receiving non-locking screws **10**. Each of threaded and non-threaded plate holes **56**, **58** passes through upper **52** and bone-contacting surfaces **54**. As was the case for bone plate **30**, the thread on threaded plate holes **56** mates with threaded head **22** of locking screw **20** to secure locking screw **20** to bone plate **50** at a temporally fixed angular orientation and insertion of non-locking screws **10** in non-threaded plate holes **58** draws the bone toward bone-contacting surface **54** to compress the bone.

Bone plate **50** includes a head portion **60** configured and dimensioned to conform to the metaphysis of the distal femur and a shaft portion **62** configured and dimensioned to conform to a diaphysis of a bone. As best seen in FIG. **8**, bone contacting surface **54** of head portion **60** is a curved surface to fit the contours of the distal femur. Head portion **60** includes an anterior fork **64** substantially parallel to an anterior side **66** of shaft portion **62** and a posterior fork **68** extending laterally out from a posterior side **70** of shaft portion **62**.

The non-threaded plate holes **58** are preferably dynamic compression unit (DCU) screw holes substantially similar to second plate holes **38**. Shaft portion **62** has both threaded plate holes **56***a* and non-threaded plate holes **58** so that both locking and non-locking screws can be used in shaft portion **62**. The ability to use locking screws in shaft portion **62** is particularly useful when the far cortex of part of the diaphysis is missing or severely damaged since fixation with non-locking screws is problematic because of the condition of the far cortex. As best seen in FIG. **11**, the regions between threaded and non-threaded plate holes **56***a*, **58** have a trapezoidal cross section that limits contact between bone-contacting surface **54** of shaft portion **62** and the femur. Shaft portion **62** terminates in a tapered tail **72** (FIG. **19**).

In contrast to shaft portion **62**, head portion **60** contains only threaded holes **56**. Specifically, threaded plate holes **56***b* that surround a centrally located threaded plate hole **56***c*. Threaded plate hole **56***c* has a larger diameter than threaded plate holes **56***b* to accommodate a locking screw with a larger diameter, e.g. threaded plate hole **56***b* have a diameter of 5.0 mm and threaded plate hole **56***c* has a diameter of 7.3 mm. FIGS. **12**–**18** show the various angular orientations of the individual threaded holes **56***b*, **56***c*. In generally, threaded holes **56***b*, **56***c* are arranged so that the inserted locking screws converge towards each other. It should be noted that, if a surgeon elects, non-locking screws can be used in any of threaded plate holes **56**. Finally, it should also be noted that bone plate **50** has several structural differences from the condylar buttress plate commercially available from Synthes (U.S.A.) of Paoli, Pa. For example, the head of the condylar buttress plate is contoured in both the longitudinal and transverse directions while head portion **60** of bone plate **50** is contoured only in the longitudinal direction for a more anatomical fit. Additionally, tail **72** has an elevated end to get under tissue.

FIGS. **20**–**26** show a bone plate **80** according to the present invention specifically designed for use in the proximal tibia. Bone plate **80** would be primarily used for, but not limited to fractures of the lateral proximal tibial plateau. Bone plate **80** has an upper surface **82** and a bone-contacting surface **84**. Bone plate **80** has a plurality of threaded plate holes **86***a*, **86***b* and **86***c* (collectively referred to as threaded plate holes **86**) for receiving locking screws **20** and a plurality of non-threaded plate holes **88** for receiving non-locking screws **10**. Each of threaded and non-threaded plate holes **86** and **88** pass through upper **82** and bone-contacting surfaces **84**. As was the case for bone plate **30**, the threads on threaded plate holes **86** mate with the threaded head **22** of locking screw **20** to secure locking screw **20** to bone plate **80** at a fixed angular orientation. Insertion of non-locking screws **10** in non-threaded plate holes **88** draws the bone-contacting surface **84** toward the bone to compress the plate to the bone.

Bone plate **80** includes a head portion **90** configured and dimensioned to conform to the metaphysis of the lateral proximal tibia and a shaft portion **92** configured and dimensioned to conform to a diaphysis of the lateral proximal tibia. As seen in FIGS. **20** and **26**, bone contacting surface **84** of head portion **90** is a curved, tapered, and twisted to fit the contours of the lateral proximal tibial plateau. Head portion **90** also features sutures holes for suture anchoring and for provisional fixation of bone plate **80**.

The non-threaded plate holes **88** are preferably dynamic compression unit (DCU) screw holes substantially similar to second plate holes **38**. Shaft portion **92** has both threaded plate holes **86***a* and non-threaded plate holes **88** so that both locking and non-locking screws can be used in shaft portion **92**. The ability to use locking screws in shaft portion **92** is particularly useful when the far cortex of part of the diaphysis is missing or severely damaged since fixation with non-locking screws is problematic because of the condition of the far cortex. As best seen in FIG. **24**, the regions between threaded and non-threaded plate holes **86***a* and **88** have a rectangular cross section that limits contact between bone-contacting surface **84** of shaft portion **92** and the tibia. Shaft portion **92** terminates in a tapered tail **102** (FIG. **25**).

In similar fashion to shaft portion **92**, head portion **90** contains threaded holes **86** and non-threaded holes **88**. Head portion **90** features threaded plate holes **86***b* and **86***c*. Holes **86***b* and **86***c* have a diameter of 5.0 mm and are oriented as shown in FIGS. **23** and **26**. In general, threaded holes **86***b*, **86***c* are arranged so that the inserted locking screws converge towards each other. As shown in FIG. **23**, plate holes **86***b* are oriented to converge at a predetermined distance from plate surface **84** to optimize the position of locking screws **20** within the tibia plateau. As shown in FIG. **26**, plate hole **86***c* is oriented to converge with plate hole **86***b* at predetermined distance to provide additional stability to the locked fixed-angle construct. It should be noted that if a surgeon elects, non-locking screws can be used in any of threaded plate holes **86**.

While it is apparent that the illustrative embodiments of the invention herein disclosed fulfill the objectives stated above, it will be appreciated that numerous modifications and other embodiments may be devised by those skilled in the art. For example, for some fractures only one first plate hole and one second plate hole are needed, although at least two of each is advantageous. Furthermore, additional plate holes without screws can be present in the plate, if desired to allow the surgeon further flexibility in use. Therefore, it will be understood that the appended claims are intended to cover all such modifications and embodiments which come within the spirit and scope of the present invention.

What is claimed:

1. A bone plating system for improving the stability of a bone fracture in a long bone comprising:

a bone plate having:

an upper surface;

a lower surface;

a shaft portion having a width and a central longitudinal axis, the shaft portion configured and dimensioned to extend along at least a portion of a diaphysis of the bone and the lower surface of the shaft portion having a plurality of arched cut-outs extending transverse to the longitudinal axis; and

a head portion that flares outward from the shaft portion so as to have a width that is greater than the width of the shaft portion, the head portion curving upward from the shaft portion and having at least three bone anchor holes, the bone anchor holes being conically tapered from the upper surface to the lower surface, the at least three bone anchor holes having at least a portion that has a thread to engage a thread on a head of a bone anchor,

wherein the head portion has only bone anchor holes having the threaded portion, the shaft portion having a plurality of holes having at least a portion that has a thread to contact the thread on the head of a bone anchor.

2. The bone plating system of claim **1**, wherein the threaded holes in the shaft portion are offset from the central longitudinal axis of the shaft portion.

3. The bone plating system of claim **2**, wherein the threaded holes in the shaft portion alternate sides from the central longitudinal axis of the shaft, such that the holes in the shaft portion form a staggered arrangement.

4. The bone plating system of claim **1**, wherein there are at least five holes in the shaft portion.

5. The bone plating system of claim **1**, wherein at least two of the holes in the head portion have diameters different from each other.

6. The bone plating system of claim **1**, wherein the internal surface of at least one of the holes in the shaft portion has at least a portion which is smooth.

7. The bone plating system of claim **6**, wherein the smooth portion of the threaded hole is at the upper portion of the hole.

8. The bone plating system of claim **7**, wherein the smooth upper portion of the hole tapers inward in a direction from the upper surface of the plate to the lower surface of the plate.

9. The bone plating system of claim **1**, wherein at least a portion of the head portion is thinner than at least a portion of the shaft portion.

10. The bone plating system of claim **1**, wherein the head portion lies in a plane different from the plane in which the shaft portion lies.

11. The bone plating system of claim **1**, wherein the shaft portion of the bone plate has a thinner cross section in regions between the plate holes.

12. The bone plating system of claim **11**, wherein the shaft portion of the bone plate has a trapezoidal shaped cross section in regions between the plate holes for minimizing contact between the bone and the lower surface.

13. The bone plating system of claim **1**, wherein the lower surface of the shaft portion of the bone plate is curved along a direction transverse to the longitudinal axis of the shaft portion.

14. The bone plating system of claim **1**, wherein the bone plate includes at least one hole for provisional fixation of the bone plate.

15. The bone plating system of claim **14**, wherein the at least one provisional fixation hole is an unthreaded suture hole.

16. The bone plating system of claim **15**, wherein the suture hole is located in the head portion.

17. The bone plating system of claim 1, wherein the threaded portion of each bone-anchor hole has a multiple-lead thread.

18. The bone plating system of claim 1, wherein the bone plate is configured and dimensioned for use with the tibia.

19. The bone plating system of claim 1, wherein the bone plate is configured and dimensioned for use with the femur.

20. The bone plating system of claim 1, wherein the head portion is curved in at least two planes.

21. The bone plating system of claim 1, wherein the bone plate has a portion that is curved.

22. The bone plating system of claim 1, wherein the holes have a diameter between approximately 5 mm and approximately 7 mm.

23. The bone plating system of claim 1, wherein the holes in the head portion are arranged and positioned so that the inserted anchors converge towards each other.

24. A bone plating system for improving the stability of a bone fracture in a long bone comprising:

a bone plate having:

an upper surface;

a lower surface;

a shaft portion having a width and a central longitudinal axis, the shaft portion configured and dimensioned to extend along at least a length of a diaphysis of the bone and the lower surface of the shaft portion having a plurality of arched cut-outs extending transverse to the longitudinal axis; and

a head portion having a width that is greater than the width of the shaft portion and which curves upward from the shaft portion, the head portion having a plurality of conically tapered holes having at least a portion that has a thread to contact a bone anchor,

wherein the shaft portion has a plurality of conically tapered holes having at least a portion that has a thread to contact a thread on the head of a bone anchor, and the shaft portion of the bone plate has a thinner cross section in regions between the plate holes.

25. The bone plating system of claim 24, wherein the conically tapered holes in the shaft portion are offset from the central longitudinal axis of the shaft portion.

26. The bone plating system of claim 25, wherein the conically tapered holes in the shaft portion alternate sides from the central longitudinal axis of the shaft, such that the holes in the shaft portion form a staggered arrangement.

27. The bone plating system of claim 24, wherein at least one of the holes in the head portion has a non-perpendicular angular orientation with respect to the plane defined by the upper surface of the plate.

28. The bone plating system of claim 27, wherein the hole angle is between approximately 0° and approximately 15°.

29. The bone plating system of claim 24, wherein the shaft portion further comprises a plurality of holes without threads.

30. The bone plating system of claim 24, wherein there are at least three holes in the head portion.

31. The bone plating system of claim 24, wherein there are at least five holes in the shaft portion.

32. The bone plating system of claim 24, wherein all of the holes located in the head portion for receiving bone anchors have at least a portion that is threaded.

33. The bone plating system of claim 24, wherein at least two of the holes in the head portion have diameters different from each other.

34. The bone plating system of claim 24, wherein the internal surface of at least one of the threaded holes in the shaft portion has at least a portion which is smooth.

35. The bone plating system of claim 34, wherein the smooth portion of the threaded hole is at the upper portion of the hole.

36. The bone plating system of claim 35, wherein the smooth upper portion of the hole tapers inward in a direction from the upper surface of the plate to the lower surface of the plate.

37. The bone plating system of claim 24, wherein at least a portion of the head portion is thinner than at least a portion of the shaft portion.

38. The bone plating system of claim 24, wherein the head portion lies in a plane different from the plane in which the shaft portion lies.

39. The bone plating system of claim 24, wherein the shaft portion of the bone plate has a trapezoidal shaped cross section in regions between the plate holes for minimizing contact between bone and the lower surface.

40. The bone plating system of claim 24, wherein the lower surface of the shaft portion of the bone plate is curved along a direction transverse to the longitudinal axis of the shaft portion.

41. The bone plating system of claim 24, wherein the bone plate includes at least one hole for provisional fixation of the bone plate.

42. The bone plating system of claim 41, wherein the at least one provisional fixation hole is an unthreaded suture hole.

43. The bone plating system of claim 42, wherein the suture hole is located in the head portion.

44. The bone plating system of claim 24, wherein the threaded portion has a multiple-lead thread.

45. The bone plating system of claim 24, wherein the bone plate is configured and dimensioned for use with the tibia.

46. The bone plating system of claim 24, wherein the bone plate is configured and dimensioned for use with the femur.

47. The bone plating system of claim 24, wherein the head portion is curved in at least two planes.

48. The bone plating system of claim 24, wherein the bone plate has a portion that is curved.

49. The bone plating system of claim 24, wherein the holes have a diameter between approximately 5 mm and approximately 7 mm.

50. The bone plating system of claim 24, wherein the holes in the head portion are arranged and positioned so that the inserted anchors converge towards each other.

51. The bone plating system of claim 50, wherein at least one of the holes in the head portion has a non-perpendicular angular orientation with respect to the plane defined by the upper surface of the plate.

52. The bone plating system of claim 51, wherein the hole angle is between approximately 0° and approximately 15°.

53. A bone plating system for improving the stability of a bone fracture in a long bone comprising:

a bone plate having:

an upper surface;

a lower surface;

a shaft portion having a width and a longitudinal axis, the lower surface of the shaft portion having a plurality of arched cut-outs extending transverse to the longitudinal axis; and

a head portion having a width that is greater than the width of the shaft portion, the head portion having a plurality of conically tapered holes having at least a portion that has a thread to contact a bone anchor,

wherein the shaft portion has a plurality of conically tapered holes having at least a portion that has a thread to contact a thread on the head of a bone anchor, and the shaft portion of the bone plate has a thinner cross section in at least one region between at least two holes in the shaft portion.

54. The bone plating system of claim **53**, wherein the bone plate includes at least one non-threaded screw hole.

55. The bone plating system of claim **53**, wherein the bone plate includes at least one non-threaded suture hole.

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