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Bonutti

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[54] **BONE SUTURE**

[76] Inventor: **Peter M. Bonutti**, 1303 West Evergreen Plaza, Effingham, Ill. 62401

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[52] **U.S. Cl.** **606/60**; 606/57; 606/215

[58] **Field of Search** 606/57, 60, 215, 606/216, 232

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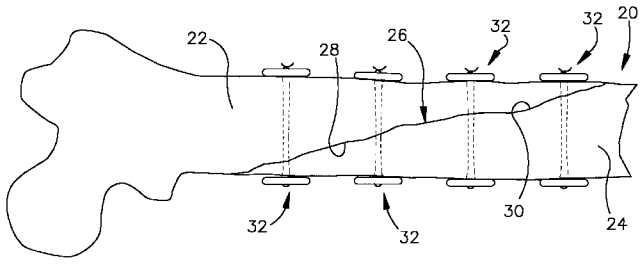
Primary Examiner—Gary Jackson

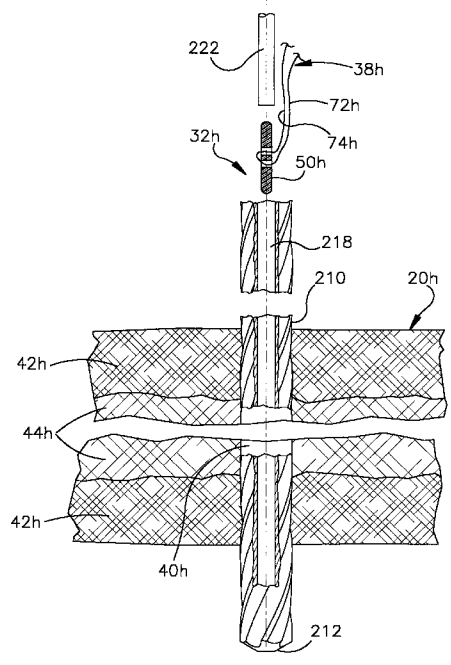
Attorney, Agent, or Firm—Tarolli, Sundheim, Covell, Tummino & Szabo

[57] **ABSTRACT**

An anchor connected with a suture is moved through a passage between opposite sides of a bone. The anchor is then pivoted to change its orientation. A second anchor is connected with the suture. While tension is maintained in the suture, the suture is secured against movement relative to the anchors. This may be done by tying the suture or by using a suture retainer to hold the suture. A suture retainer may be used in place of the second anchor. The passage may extend across a fracture in the bone. The passage may have either a nonlinear or linear configuration. The passage may be formed by first moving a thin elongated member through the bone. The thin elongated member is then used as a guide for a drill. The thin elongated member is withdrawn from the drill and the suture anchor is moved through a passage in the drill.

84 Claims, 5 Drawing Sheets





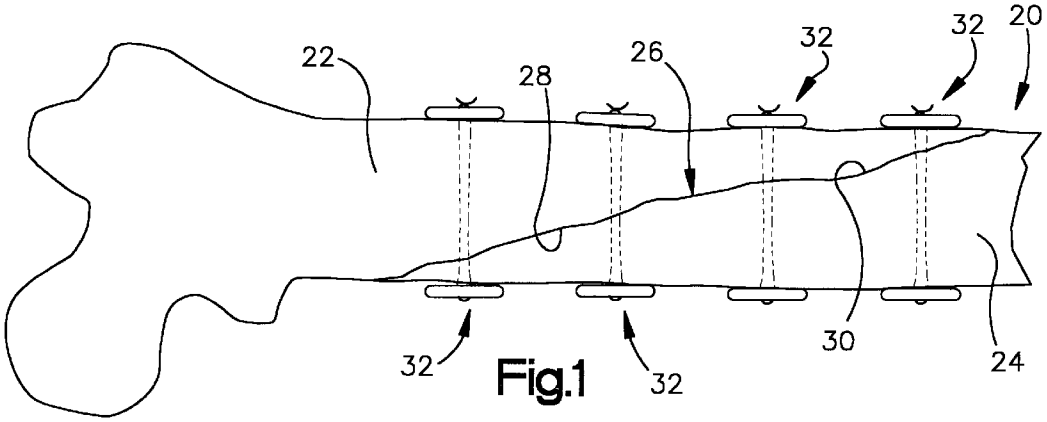

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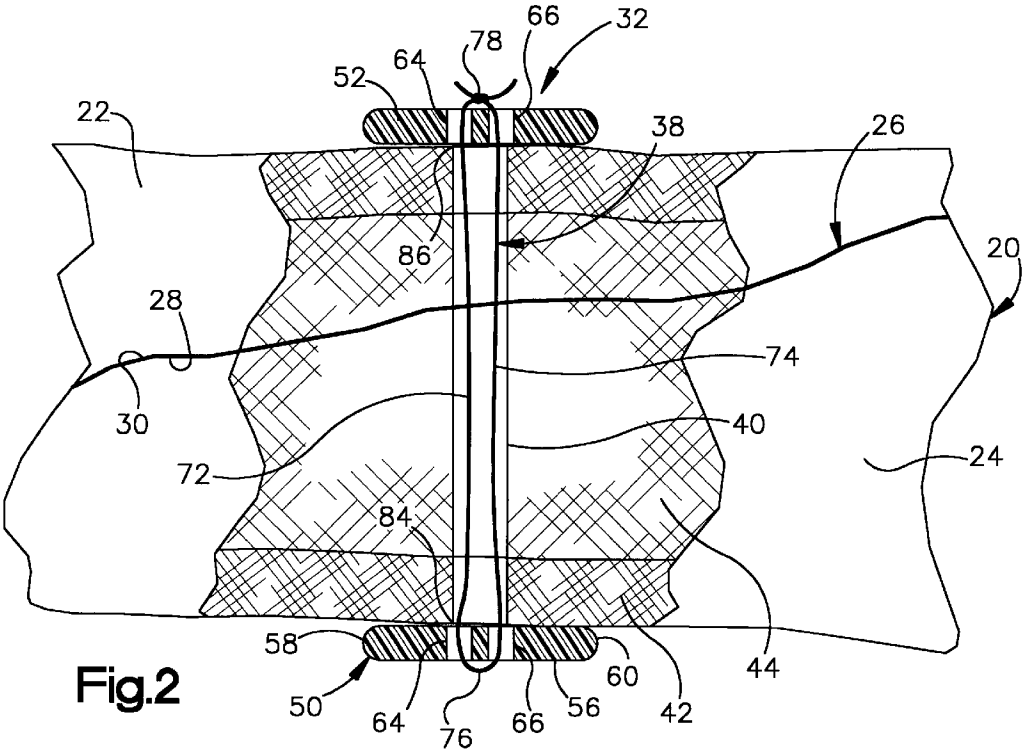
Fig.1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22
38
26
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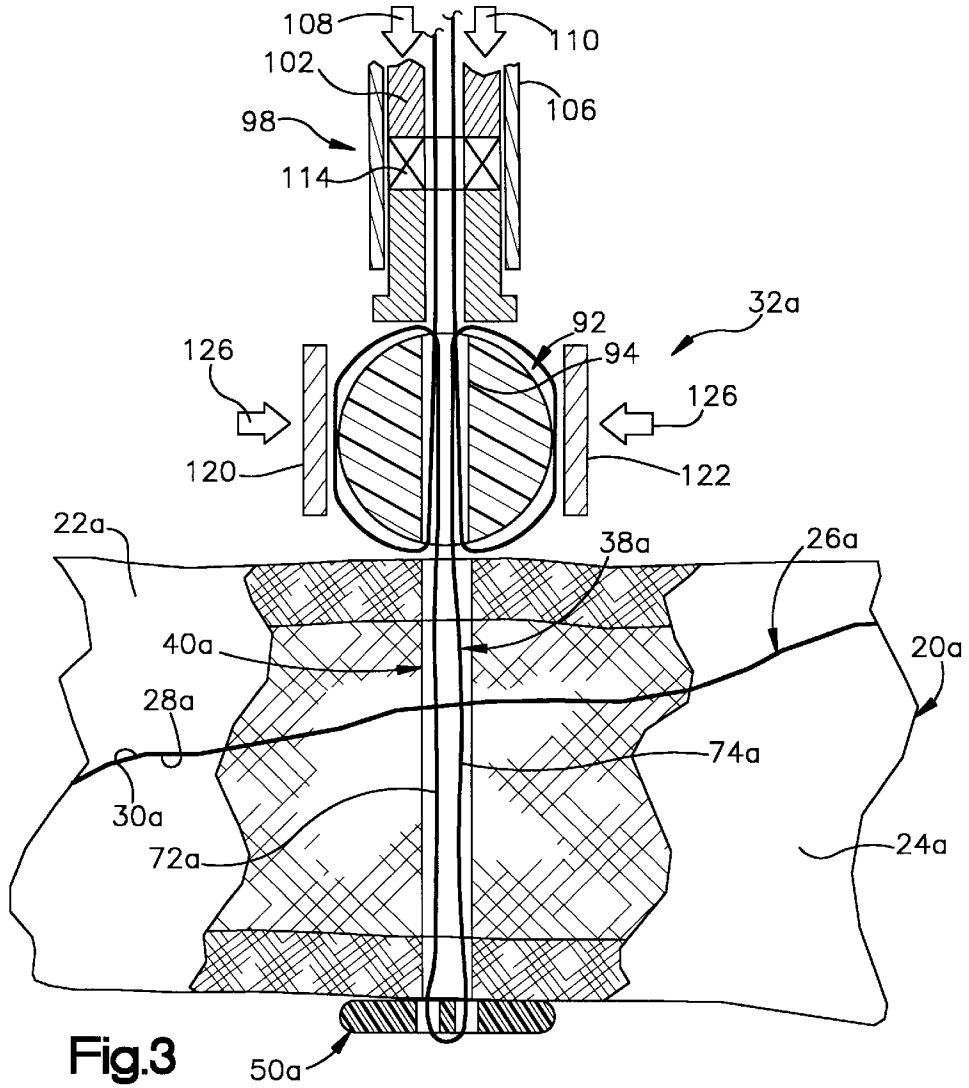
64
76
66
56
42

Fig.2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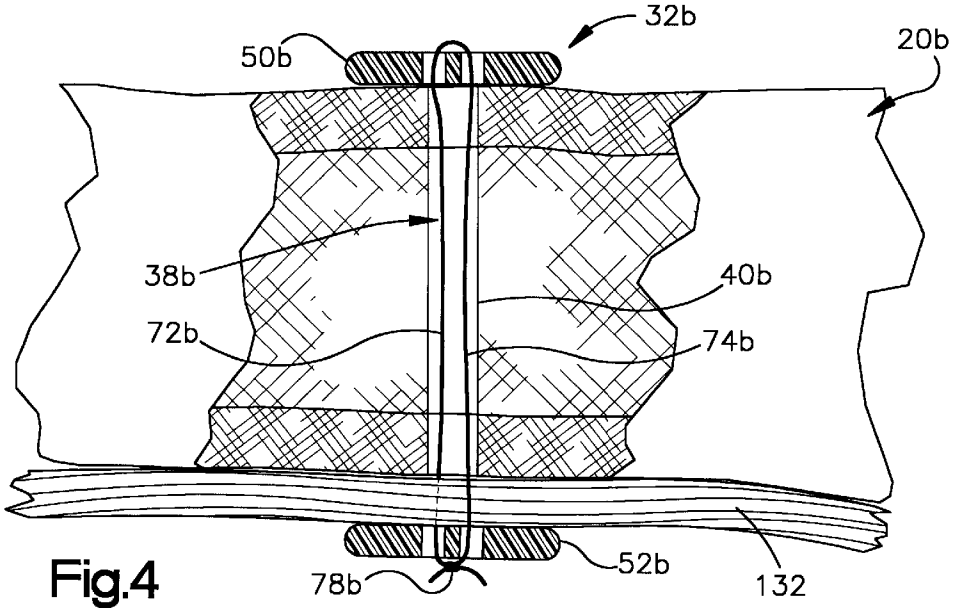
28a
74a
30a
72a
24a
50a

Fig.3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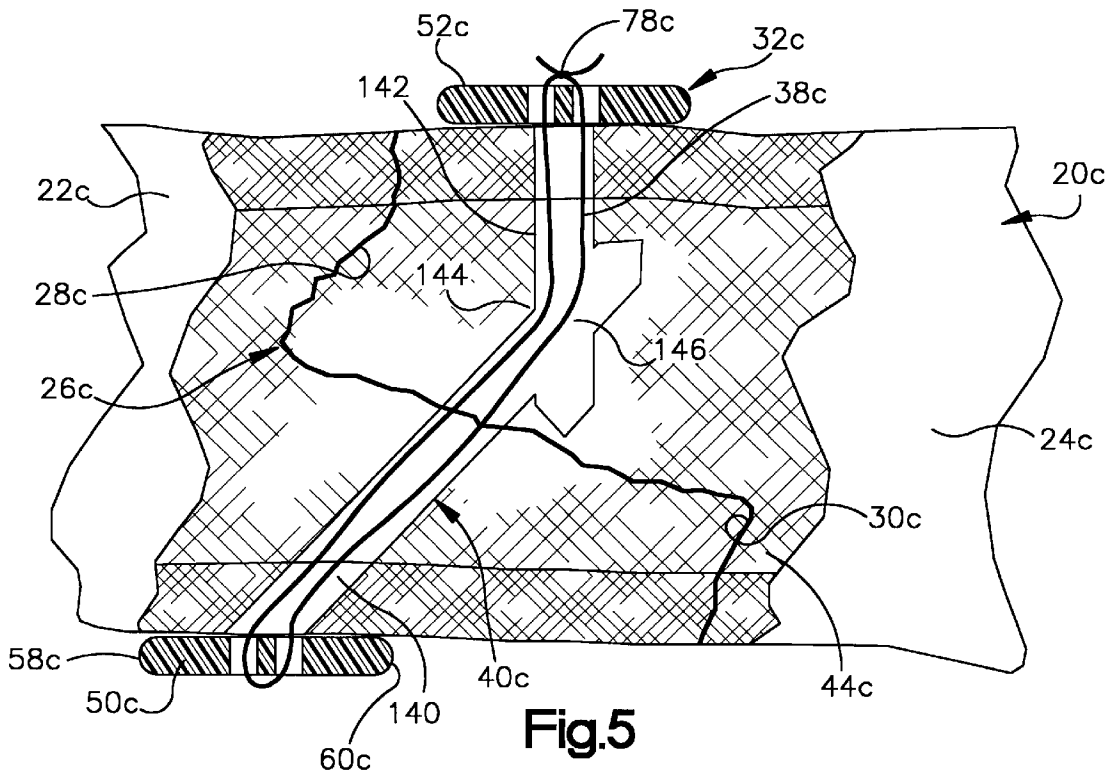
50b
20b
38b
40b
72b
74b
52b
78b
132

Fig.4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26c
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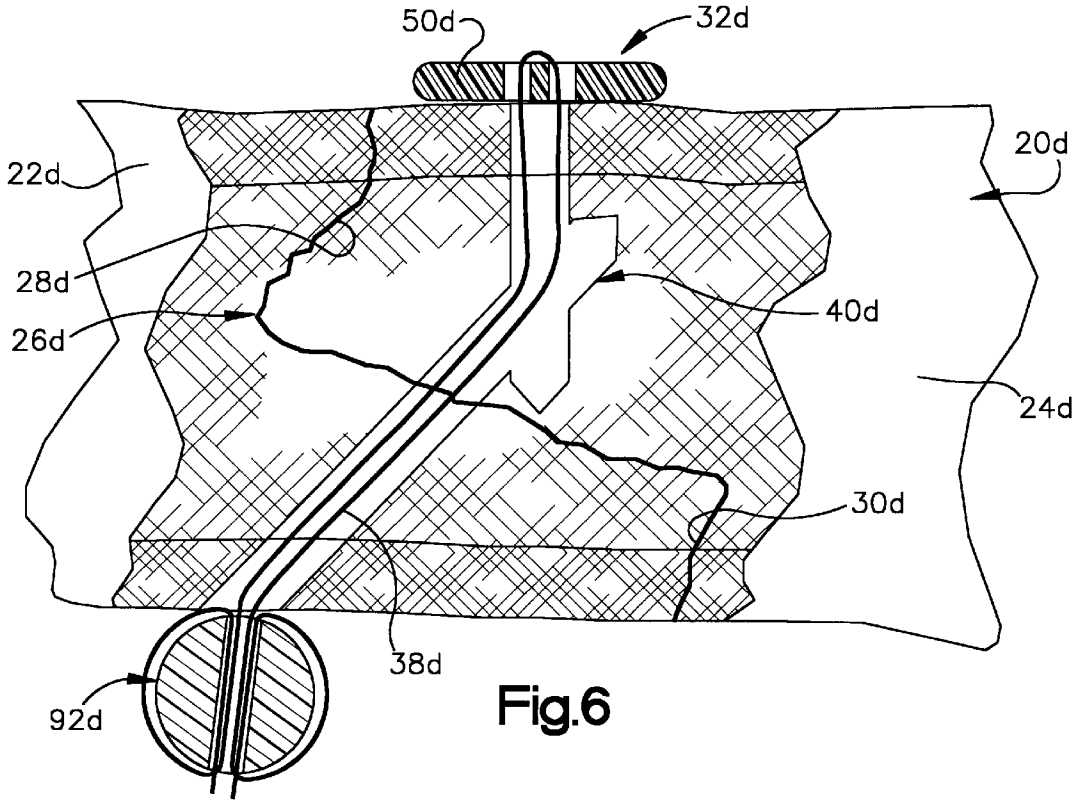
50c
140
60c

Fig.5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28d
40d
26d
24d
30d
38d
92d

Fig.6

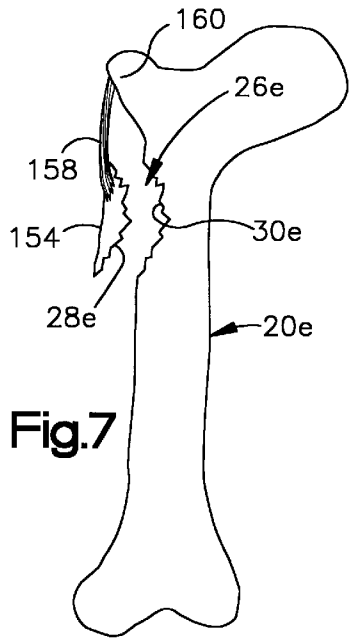

Fig.7

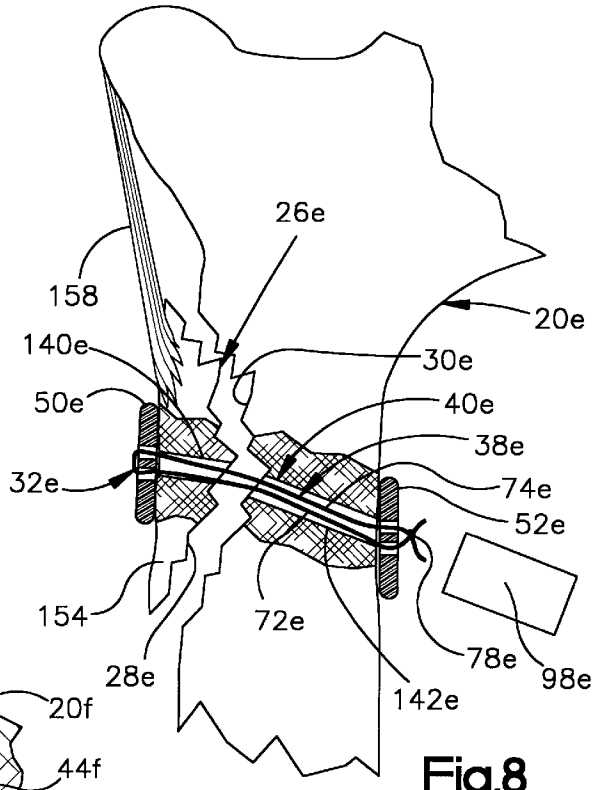

Fig.8

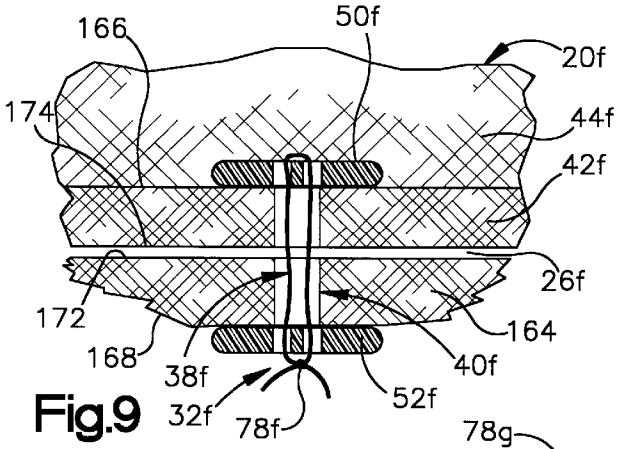

Fig.9

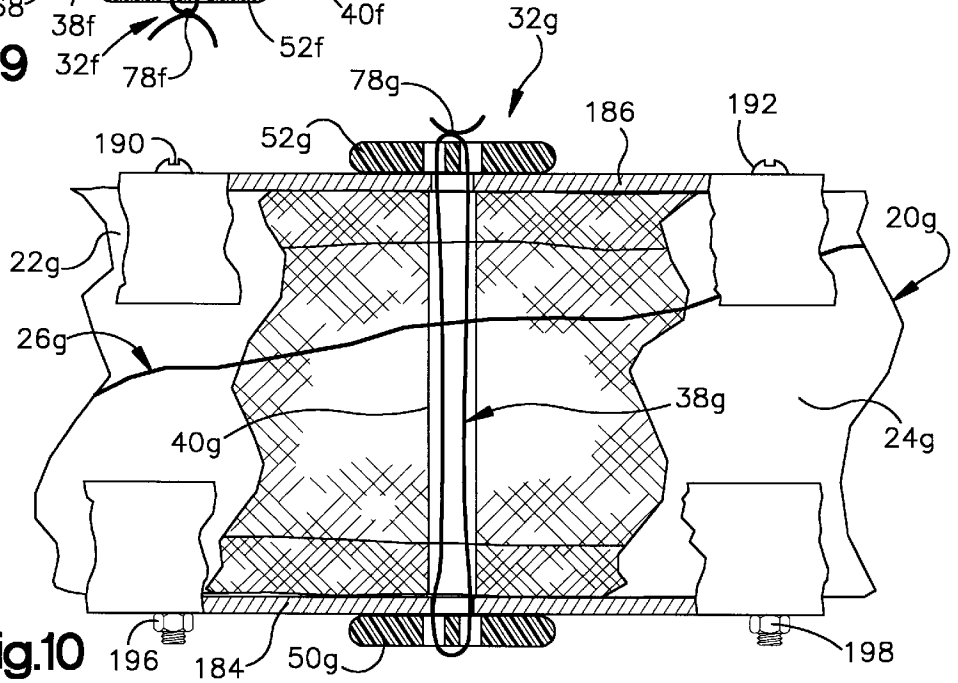

Fig.10

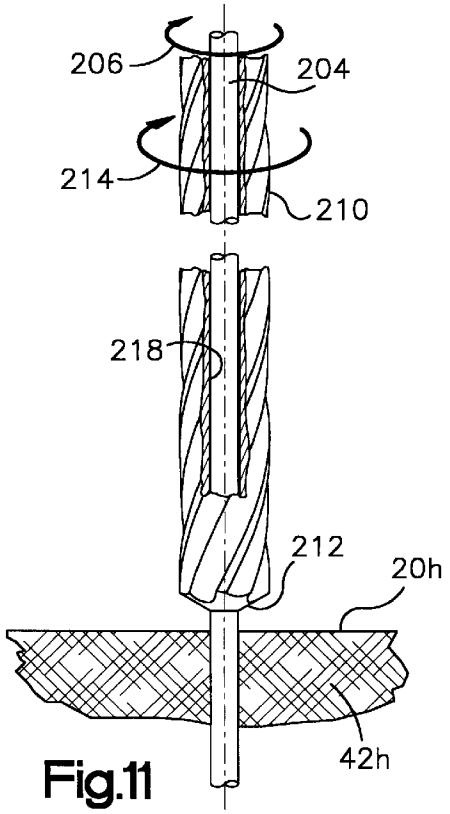
206
204
214
210
218
212
20h
42h

Fig.11

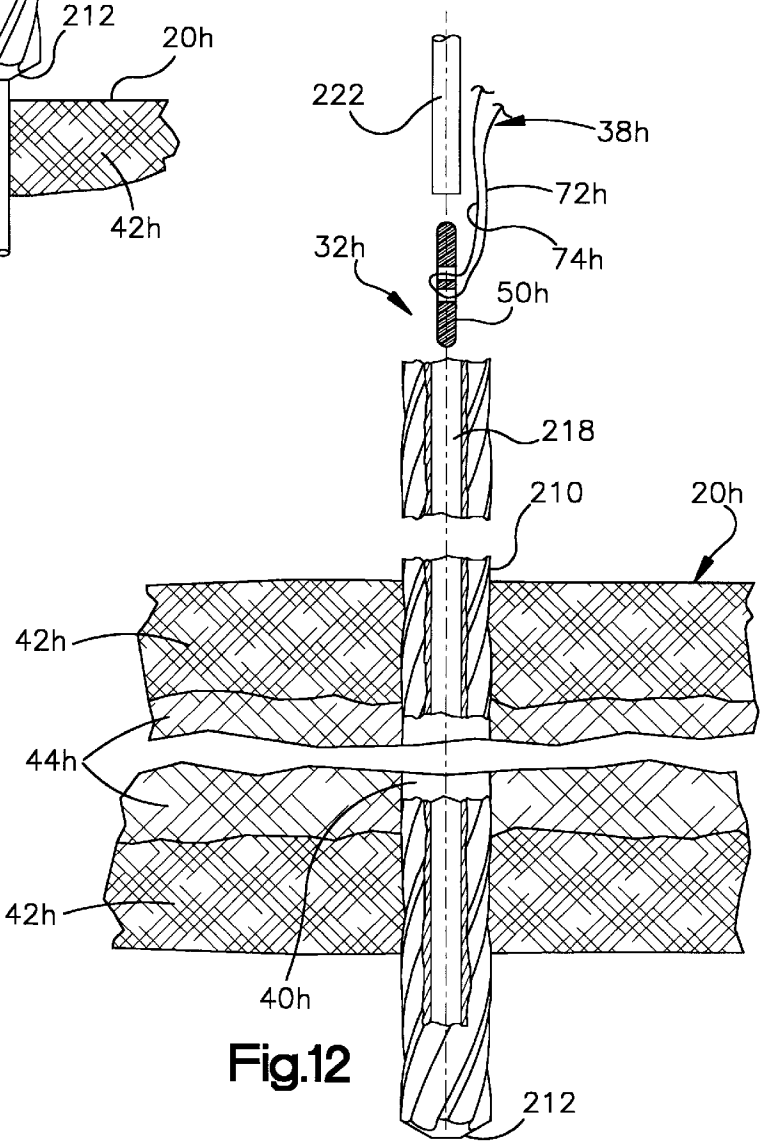
222
38h
72h
74h
32h
50h
218
210
20h
42h
44h
42h
40h
212

Fig.12

BONE SUTURE

BACKGROUND OF THE INVENTION

The present invention relates to a new and improved method and apparatus for securing sections of a fractured bone and/or securing body tissue to bone.

When a bone is broken or fractured, it is necessary to press sections of the bone on opposite sides of the fracture together in order to promote healing of the bone. Bone screws have been used with or without metal plates to hold the sections of the fractured bone against movement relative to each other. In addition, it has been suggested that avulsion fractures could be treated by using wire sutures between sections of bone in a matter similar to that disclosed in U.S. Pat. No. 5,474,554. It has also been suggested that an anchor could be retained in a bone is a manner disclosed in U.S. Pat. Nos. 5,527,343 and 5,534,012.

SUMMARY OF THE INVENTION

The present invention relates to a method of securing sections of a fractured bone and/or of securing body tissue to bone which may or may not have been fractured. Sections of a fractured bone are held against movement relative to each other by a suture which extends through a passage in the bone. Body tissue may be held against movement relative to bone by a suture which extends through a passage in the bone. Since the suture is flexible, the passage in the bone may have a linear or nonlinear configuration. Tension is maintained in the suture to press surfaces on the fracture together and/or to hold body tissue by securing anchors and/or suture retainers to opposite ends of the suture.

The linear or nonlinear passage through bone may be formed in any one of many different ways. One specific way of forming the passage is moving a thin elongated member through the bone. A drill is then moved along the thin elongated member to enlarge a passage formed through the bone by the thin elongated member. The thin elongated member is then withdrawn from the drill and a suture anchor connected with a suture is moved through the drill.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features of the invention will become more apparent upon a consideration of the following description taken in connection with the accompanying drawings wherein:

FIG. **1** is a schematic illustration of a bone having a fracture which has been treated with sutures and suture anchors;

FIG. **2** is an enlarged fragmentary schematic sectional view of a portion of the bone of FIG. **1** and illustrating the manner in which a suture extends across the fracture and interconnects suture anchors on opposite sides of the fracture;

FIG. **3** is a schematic illustration, generally similar to FIG. **2**, illustrating the manner in which a suture retainer is used to maintain tension in a suture which extends across a fracture to a suture anchor;

FIG. **4** is a schematic illustration, generally similar to FIGS. **2** and **3**, illustrating the manner in which body tissue is connected with a bone using a suture and suture anchors;

FIG. **5** is a schematic illustration, generally similar to FIGS. **2–4**, illustrating the manner in which a suture extends between suture anchors through a nonlinear passage;

FIG. **6** is a schematic illustration, generally similar to FIG. **5**, illustrating the manner in which a suture extends between a suture anchor and a suture retainer through a nonlinear passage;

FIG. **7** is a schematic illustration depicting a bone which has been fractured in such a manner as to have a bone fragment connected with the bone by muscle or other fibrous tissue;

FIG. **8** is a schematic illustration depicting the manner in which the bone fragment of FIG. **7** is connected to the bone by a suture and a pair of suture anchors;

FIG. **9** is a schematic illustration depicting the manner in which a bone fragment is connected with a bone by a suture which extends between an anchor within the bone and an anchor which engages the bone fragment;

FIG. **10** is a schematic illustration, generally similar to FIGS. **2–4** and illustrating in the manner in which plates and rigid fasteners are used in association with a suture and anchors to treat a bone fracture;

FIG. **11** is a schematic illustration depicting the manner in which a thin elongated member is moved through bone and the manner in which a drill is moved along the thin elongated member to enlarge a passage formed in the bone by the thin elongated member; and

FIG. **12** is a schematic illustration depicting the manner in which an anchor is moved through a passage in the drill of FIG. **11** after the thin elongated member has been removed from the passage in the drill.

DESCRIPTION OF SPECIFIC PREFERRED EMBODIMENTS OF THE INVENTION

A bone **20** which has been fractured is illustrated in FIG. **1**. The bone **20** is divided into two sections **22** and **24** by a fracture **26**. Opposite side surfaces **28** and **30** of the fracture **26** are pressed together by bone suture assemblies **32**.

It should be understood that the bone suture assemblies **32** may be utilized in the treatment of any one of many different types of fractures. The fractures may or may not result in the formation of one or more bone fragments. In FIG. **1**, the bone suture assemblies **32** have been illustrated as interconnecting sections **22** and **24** of a complete bone fracture of the spiral type. However, the bone suture assemblies **32** could be utilized to connect a fragment of a bone to the main portion of the bone from which the fragment was broken off.

Each of the bone suture assemblies **32** has the same construction. However, the bone suture assemblies **32** could have different constructions if desired. The construction of one of the identical bone suture assemblies **32** is illustrated in FIG. **2**.

The bone suture assembly **32** (FIG. **2**) includes a flexible suture **38** which extends across the fracture **26**. The suture **38** is disposed in a straight cylindrical passage **40** which extends diametrically across a generally cylindrical portion of the bone **20**. The passage **40** extends through hard compact tissue of an outer layer **42** of the bone and through spongy or cancellous bone tissue **44** which is enclosed by the hard outer layer. Although the passage **40** has a linear configuration, the passage could have a nonlinear configuration if desired.

The suture **38** extends between a first suture anchor **50** disposed on one side of the fracture **26** and a second suture anchor **52** disposed on the opposite side of the fracture. Tension is maintained in the suture **38** to press the suture anchors **50** and **52** against opposite sides of the bone **20** with a predetermined force. This force presses the side surfaces **28** and **30** of the fracture **26** firmly together to promote healing of the fracture. If desired, buttons or other force distributing members could be provided between the anchors **50** and **52** and the bone **20**. Body tissue could be disposed between the anchors **50** and **52** and the bone **20**.

The suture **38** and/or suture anchors **50** and **52** may be formed of any desired natural or artificial material. For example, the suture **38** may formed of either a polymeric material or a metal. The suture **38** may be biodegradable. Any known suture material may be utilized to form the suture **38**.

The suture anchors **50** and **52** have the same construction. However, the anchor **50** could have a construction which is different than the construction of the anchor **52**. The anchor **50** has a cylindrical outer side surface **56** which extends between smooth rounded end portions **58** and **60**. A pair of parallel cylindrical openings **64** and **66** extend diametrically through the anchor **50**. The anchor **50** is free of sharp corners or projections to avoid cutting or abrading of body tissue disposed adjacent to the anchor.

The suture anchor **50** is made of a biocompatible material. Suitable materials include stainless steel or titanium, cobalt chrome and other biocompatible metals. Polymeric material may also be used, suitable polymeric materials includes polyethylene and biodegradable material such as PLA and PGA. It is believed that it may be preferred to form the suture anchors **50** and **52** from biodegradable or bioerodible copolymers. If desired, the anchor **50** could be formed of body material or hydrophilic materials.

It is contemplated that the anchor **50** may have any desired configuration. For example, the anchor **50** could have any one of the configurations disclosed in U.S. Pat. No. 5,522,846 issued Jun. 4, 1996 and entitled "Suture Anchor". Alternatively, the suture anchor **50** could have the configuration disclosed in U.S. Pat. No. 5,534,012 issued Jul. 9, 1996 and entitled "Method and Apparatus for Anchoring a Suture".

Although the anchor **50** may have any desired configuration, the cross-sectional size of the anchor is such as to enable the anchor to be moved through the passage **40**. In addition, the length of the anchor **50** is such as to enable it to span an opening at an end of the passage **40** and transmit force from the suture **38** to a substantial area on the outer layer **42** of the bone **20**. It is believed that it will be preferred to form the anchor **50** in such a manner as to eliminate any sharp corners or projections.

In the illustrated embodiment of the invention, the anchor **50** has a cylindrical configuration. This particular anchor has an axial length of about two millimeters and a diameter of about one millimeter. The openings **64** and **66** have a diameter of about one-half millimeter.

It should be understood that the foregoing dimensions have been set forth herein for purposes of clarity of description and it is contemplated that the size of the anchor **50** may vary as a function of the size of the bone being treated. Thus, relatively small anchors may be used in association with treatment of small bones in a wrist, hand, foot or ankle of a patient. Relatively large anchors may be used in association with treatment of larger bones in an arm, shoulder, leg or hip of a patient. It should be understood that the bone suture assembly **32** may be used in conjunction with many different bones other than the specific bones previously mentioned.

Only a single anchor **50** or **52** has been shown at opposite ends of the passage **40**. It is contemplated that a plurality of anchors could be provided at each end of the passage **40**. For example, a pair of separate or interconnected anchors, could be provided in a manner similar to that disclosed in the aforementioned U.S. Pat. No. 5,534,012.

In the embodiment of the invention illustrated in FIG. **2**, the suture **38** has a pair of limbs or sections **72** and **74** which extend through the openings **64** and **66** in the suture anchors **50** and **52**. A connector section **76** interconnects the two limbs **72** and **74** of the suture **38** and engages a portion of the anchor **50**. A knot **78** is formed in the opposite ends of the limbs **72** and **74** to interconnect the two limbs of the suture **38**.

When the knot **78** is formed, a predetermined tension is present in the limbs **72** and **74** of the suture **38**. This results in the suture anchors **50** and **52** being pressed firmly against the bone **20** with a predetermined force. This predetermined force is maintained during and after tying of the knot **78**.

When the bone suture assembly **32** is to be used to treat the fracture **26** in the bone **20**, the two sections **22** and **24** of the bone are pressed together at the fracture **26** to align the side surfaces **28** and **30** of the fracture. A drill is then used to form the passage **40** which extends diametrically through the generally cylindrical bone **20**. Of course, the passage **40** could be formed by the use of a tool other than a drill. If desired, the passage **40** could have a noncircular cross-sectional configuration.

Once the passage **40** has been formed in the two sections **22** and **24** of the bone **20**, a tubular cylindrical member is inserted into the passage **40** and extends diametrically through the bone **20**. The leading end of the tubular cylindrical member is aligned with a circular outlet **84** from the passage **40**. The opposite end of the tubular member is aligned with a circular inlet **86** to the passage **40**. The tubular member has a thin cylindrical wall which engages the sections **22** and **24** of the bone **20**. A cylindrical inner side surface of the tubular member defines a passage having a diameter which is only slightly less than the diameter of the passage **40**.

By inserting the tubular member into the passage **40**, the portions of the passage disposed on opposite sides of the fracture **26** are maintained in alignment. The tubular member may be flexible to enable the tubular member to be inserted into a nonlinear passage **40** through the bone **20**. The tubular member may be formed of metal or a polymeric material. If the tubular member is formed of a polymeric material, it may be preferred to form the tubular member from a biodegradable or bioerodible copolymer.

The suture **38** is formed into a loop which extends through the openings **64** and **66** in the anchor **50**. At this time, the suture **38** has a length which is substantially greater than the length illustrated in FIG. **2**. The cylindrical anchor **50**, with the suture **38** connected thereto, is then positioned in axial alignment with the tubular member which extends through the passage **40**. Thus, the anchor **50** is moved to an orientation in which a longitudinal central axis of the anchor is coincident with the longitudinal central axis of the cylindrical passage in the tubular member which extends through the passage **40** in the bone **20**.

The leading end **58** of the anchor **50** is then moved into the cylindrical tubular member which forms a liner for the passage **40**. A pusher member pushes the anchor **50** from an upper (as viewed in FIG. **2**) end of the tubular member along the passage **40** in the bone **20** and through the outlet **84** from the passage. As the anchor **50** moves through the passage **40**, the suture **38** is pulled through the passage **40** by the anchor.

The orientation of the anchor **50** is then changed from an orientation in which the longitudinal central axis of the anchor **50** is aligned with the longitudinal central axis of the passage **40** to an orientation in which the longitudinal central axis of the anchor **50** extends generally perpendicular to the longitudinal central axis of the passage **40**, i.e., the orientation shown in FIG. **2**. To pivot the anchor **50** to the orientation shown in FIG. **2**, as the anchor emerges from the

outlet **84**, the suture **38** is tensioned. The combination of the tension in the suture **38** and force applied against the trailing end **60** of the anchor by the pusher member causes the anchor to pivot about the trailing end **60** of the anchor. The pusher member is then withdrawn and the suture tensioned to move the anchor to the position shown in FIG. **2** in a manner similar to that described in the aforementioned U.S. Pat. Nos. 5,527,343 and 5,534,012.

Although it is believed that it may be preferred to change the orientation of the anchor **50** after it has emerged from the passage **40**, the anchor could be blocked from reentering the passage in other ways if desired. Thus, the anchor could expand after emerging from the passage **40**. This could be accomplished by having spring biased arms held in a retracted position by engagement of spring biased arms with the inner side surface of the tubular cylindrical member which lines the passage **40**. Upon emerging from the passage, the arms would move outward under the influence of spring forces and extend radially outward beyond the edge of the exit from the passage **40**. If desired, the anchor **50** could be constructed so as to expand in a manner similar to that disclosed in U.S. Pat. No. 5,397,331 and/or U.S. Pat. No. 4,409,974.

Rather than expanding under the influence of stored energy, such as spring force, the anchor **50** could expand by absorbing body fluids. Thus, the anchor **50** may be compressed when it moves through the passage **40** and will expand and absorb body fluids after emerging from the passage **40**. It is contemplated that the anchor **50** could be constructed so as to expand in any one of the ways disclosed in U.S. patent application Ser. No. 08/699,553 filed Aug. 19, 1996 by Peter M. Bonutti and entitled "Suture Anchor".

The cylindrical tubular member is then withdrawn from the passage **40**. It should be understood that the cylindrical tubular member is used to line the passage **40** in the bone **20** during movement of the anchor **50** through the passage. The use of the tubular member to line the passage **40** may be omitted if desired. However, if the use of the tubular member to line the passage **40** is omitted, the anchor **50** and pusher member would be exposed to the cancellous bone tissue **44** during movement of the anchor through the passage.

The limbs **72** and **74** of the suture **38** are then threaded through openings **64** and **66** in the second suture anchor **52**. The limbs **72** and **74** of the suture **38** are tensioned and the second anchor **52** is pressed against the outer side surface of the bone **20**. While a predetermined tension force is maintained in the limbs **72** and **74** of the suture **38**, the knot **78** is tied in the suture to interconnect the two suture anchors **50** and **52** with the suture **38**. The suture **38** is then trimmed to the desired length.

Once the knot **78** has been tied between the limbs **72** and **74** of the suture **38**, the tension in the suture **38** presses the side surfaces **28** and **30** of the fracture **26** together. This pressure between the side surfaces **28** and **30** of the fracture **26** is maintained by the suture **38** and suture anchors **50** and **52** until the fracture heals. It is believed that it may be preferred to form the suture **38** and suture anchors **50** and **52** of a biodegradable material which, after the fracture **26** has healed, will dissolve in the patient's body.

The cylindrical tubular member which is inserted into the passage **40** through the bone **20** performs the dual functions of lining the inside of the passage **40** and maintaining the two sections **22** and **24** of the bone in alignment. The cylindrical tubular member could have a slot formed in a side wall of the tubular member to facilitate insertion of the tubular member into the passage **40**. It is contemplated that the cylindrical tubular member could be left in the passage **40** after the bone suture assembly **32** has been installed. If the slotted or unslotted cylindrical tubular member is to be left in the passage **40**, the cylindrical tubular member may be formed of a biodegradable or bioerodible copolymer. When the cylindrical tubular member remains in the passage **40**, the suture **38** extends through the tubular member.

Although only a knot **78** has been shown in FIG. **2** adjacent to the second anchor **52**, a suture retainer could be provided to further hold the limbs **72** and **74** of the suture **38**. If a suture retainer is to be used in association with the knot **78**, the suture retainer will be moved along the limbs of the suture **38** toward the knot before the limbs **72** and **74** of the suture are trimmed to the short length shown in FIG. **2**. The suture retainer would then be plastically deformed to grip the limbs **72** and **74** of the suture **38**. Thereafter, the suture limbs **72** and **74** would be trimmed to a desired length.

Bone Suture Assembly—Second Embodiment

In the embodiment of the invention illustrated in FIG. **2**, a pair of suture anchors **50** and **52** are connected with the suture **38** to maintain tension in the suture and pressure against opposite side surfaces **28** and **30** of the fracture **26**. In the embodiment of the invention illustrated in FIG. **3**, a suture retainer is used in place of one of the suture anchors. Since the embodiment of the invention illustrated in FIG. **3** is generally similar to the embodiment of the invention illustrated in FIG. **2**, similar numerals will be utilized to designate similar components, the suffix letter "a" being associated with the embodiment of the invention illustrated in FIG. **3** to avoid confusion.

A bone **20***a* has sections **22***a* and **24***a* which are separated by a fracture **26***a*. The fracture **26***a* has side surfaces **28***a* and **30***a* which are pressed together by a bone suture assembly **32***a*. A suture **38***a* extends through a cylindrical passage **40***a* which extends diametrically through the generally cylindrical bone **20***a*. The suture **38***a* has a pair of limbs or sections **72***a* and **74***a* which are connected with a suture anchor **50***a*. The suture anchor **50***a* has the same construction as the suture anchor **50** of FIG. **2**.

In accordance with a feature of this embodiment of the invention, a suture retainer **92** is used in place of the suture anchor **52** of FIG. **2**. The suture retainer **92** has a spherical configuration. A cylindrical passage **94** extends through the center of the spherical suture retainer **92**. The sections **72***a* and **74***a* of the suture **38***a* extend around the spherical outer side surface of the suture retainer **92**. Thus, a loop is formed in each of the sections **72***a* and **74***a* around portions of the suture retainer **92**.

If desired, the suture retainer **92** could have a different configuration. For example, the suture retainer **92** could have an oval or elliptical configuration. Although the passage **94** has a linear central axis, the passage could have a nonlinear central axis. If desired, a plurality of passages having the same or different configurations could be provided in the suture retainer **92**.

After the suture **38***a* has been inserted through the suture retainer **92**, in the manner illustrated schematically in FIG. **3**, the suture retainer **92** is moved along the sections **72***a* and **74***a* of the suture **38***a* toward the bone **20***a*. The suture retainer **92** is formed as one piece of a polymeric material having a relatively low coefficient friction. Therefore, the two sections **72***a* and **74***a* of the suture **30***a* can readily slide along the surfaces of the suture retainer **52***a* while the suture retainer moves toward the bone **20***a*.

A predetermined tension is maintained in the sections **72***a* and **74***a* of the suture **38***a* while the suture retainer **92** is

pressed against the bone **20***a*. This results in the suture **38***a* being pulled tightly against the suture anchor **50***a*. The tension in the suture **38***a* is effective to press the suture anchor **50***a* and retainer **92** against opposite sides of the bone **20***a* with a predetermined force.

Once the suture retainer **92** has been moved along the suture **38***a* and is being pressed against the bone **20***a* with a predetermined force, the suture retainer is plastically deformed to grip the sections **72***a* and **74***a* of the suture **38***a*. An apparatus **98** for pressing the suture retainer **92** against the bone **20***a* includes a tubular cylindrical plunger **102** (FIG. **3**) having a cylindrical central passage through which the sections **72***a* and **74***a* of the suture **38***a* extend. The plunger **102** is enclosed by a tubular cylindrical housing **106**. The plunger **102** is pressed downward, relative to the housing **106** with a predetermined force, indicated by arrows **108** and **110** in FIG. **3**. An annular transducer or load cell **114** provides an output indicative of the magnitude of the force **108** and **110** with which the suture retainer **92** is pressed against the bone **20***a* by the plunger **102**.

While the sections **72***a* and **74***a* of the suture **38***a* are being tensioned with a predetermined force and while the plunger **102** is being pressed against the suture retainer **92** with a predetermined force, the suture retainer **92** is plastically deformed. To plastically deform the suture retainer **92**, a plurality of force applying or clamp members **120** and **122** are pressed against the suture retainer **92** with a predetermined minimum force, indicated schematically by arrows **126** in FIG. **3**. The force application members **120** and **122** may have an arcuate configuration to conform to the spherical configuration of the suture retainer **92** or may have a flat configuration. The force applied against the suture retainer **92** by the force applying members **120** and **122** is sufficient to cause plastic deformation of the material of the suture retainer.

The force **126** is applied against the suture retainer **92** while the suture retainer is at a temperature which is below the transition temperature of the biodegradable polymer which forms the suture retainer **92**. Thus, the suture retainer **92** is at approximately the same temperature as the bone **20***a* when the force **126** is applied against the suture retainer. The force **126** causes the material of the suture retainer **92** to flow and grip the sections **72***a* and **74***a* of the suture **38***a*.

Upon disengagement of the force application members **120** and **122** from the suture retainer **92**, the application of downward (as viewed in FIG. **3**) force against the suture retainer **92** is interrupted. The upward tensioning of the sections **72***a* and **74***a* of the suture **38***a* is also interrupted. At this time, the plastically deformed suture retainer **92** securely grips the two sections **72***a* and **74***a* of the suture **38***a* to maintain the tension in the suture **38***a*. If desired, a knot may be formed between the sections **72***a* and **74***a* of the suture as additional protection against the suture working loose over an extended period of time.

The suture retainer **92** may be formed of many different materials. However, it is believed that it will be preferred to form the suture retainer **92** of a biodegradable polymer. One biodegradable polymer which may be utilized is polycaperlactone. Alternatively, the suture retainer **92** could be formed of polyethylene oxide terephthalate or polybutylene terephthalate. It is also contemplated that other biodegradable or bioerodible copolymers could be utilized.

Although it is preferred to form the suture retainer **92** of a biodegradable material, the suture retainer could be formed of a material which is not biodegradable. For example, the suture retainer **92** could be formed of an acetyl resin, such as "DELRIN" (trademark). Alternatively, the suture retainer **92** could be formed of para-dinethylamino-benzenediazo sodium sulfonate, such as "DEXON" (trademark). The construction of the suture retainer **92** and the manner in which is cooperates with the suture **38***a* is the same as is disclosed in U.S. patent application Ser. No. 08/905,084 filed Aug. 1, 1997 by Peter M. Bonutti et al. and entitled "Method and Apparatus for Securing a Suture".

The suture retainer **92** is plastically deformed to grip the limbs **72***a* and **74***a* of the suture **38***a*. However, the suture retainer **92** could be constructed so as to be mechanically actuated to grip the suture **38***a*. If desired, a combination of a mechanical gripping action and plastic deformation could be utilized by a retainer to grip the suture **38***a*.

Retaining Body Tissue Against Bone

In the embodiment of the invention illustrated in FIG. **2**, a bone suture assembly **32** is utilized to press surfaces **28** and **30** of a fracture **26** together. In the embodiment of the invention illustrated in FIG. **4**, the suture anchor assembly is utilized to hold body tissue against movement relative to a bone. Since the embodiment of the invention illustrated in FIG. **4** is generally similar to the embodiments of the invention illustrated in FIGS. **2** and **3**, similar numerals will be utilized in association with similar components, the suffix letter "b" being associated with the numerals of FIG. **4** to avoid confusion.

A cylindrical passage **40***b* extends diametrically through a generally cylindrical bone **20***b*. A bone suture assembly **32***b* is utilized to retain body tissue **132** against movement relative to the bone **20***b*. The body tissue **132** may be a muscle, ligament, cartilage or other tissue which is to be held against movement relative to the bone **20***b*.

The bone suture assembly **32***b* includes a first suture anchor **50***b* and a second suture anchor **52***b*. A suture **38***b* extends through the passage **40***b* and interconnects the suture anchors **50***b* and **52***b*. Tension in the suture **38***b* presses the body tissue **132** against a side surface area on the bone **20***b*. The suture **38***b* has sections or limbs **72***b* and **74***b* which extends through openings in the suture anchors **50***b* and **52***b* in the manner previously explained. A knot **78***b* interconnects the sections **72***b* and **74***b* of the suture **38***b* to press the suture anchor **52***b* firmly against the body tissue **132**. Although the illustrated suture has a pair of sections **72***b* and **74***b*, the suture could have a single section if desired.

The suture anchor assembly **32***b* is installed in association with the bone **20***b* and body tissue **132** in the same manner as previously explained in conjunction with the embodiment of the invention illustrated in FIG. **2**. Thus, the passage **40** (FIG. **4**) is formed in the bone **20***b* by drilling or other methods. The body tissue **132** may be offset to one side of the location where the passage **40***b* is formed during formation of the passage. This enables the passage **40***b* to be formed in the bone **20***b* without damaging the body tissue **132**.

The suture anchor **50***b* is moved through the passage **40***b* with a longitudinal central axis of the suture anchor aligned with the longitudinal central axis of the passage **40***b*. When the suture anchor **50***b* emerges from the passage **40***b*, the anchor is pivoted to the orientation shown in FIG. **4**. Alternatively, the anchor **50***b* may be mechanically expanded after emerging from the passage **40***b*. A cylindrical tubular member may be used to line the passage **40***a* during movement of the anchor **50***b* through the passage in the manner previously described in connection with the embodiment of FIG. **2**.

After the anchor **50***b* has been moved to the position shown in FIG. **4**, the body tissue **132** is positioned between the limbs **72***b* and **74***b* of the suture **38***b*. The limbs **72***b* and **74***b* of the suture **38***b* are then inserted through the openings in the suture anchor **52***b*. While a predetermined tension is maintained in the suture **38***b*, the knot **78***b* is tied between the limbs **72***b* and **74***b* of the suture. This results in the body tissue **132** being pressed against the bone **20***b* with a predetermined force. A button or other force distributing member may be provided between the suture anchor **52***b* and body tissue **132** if desired.

In the embodiment of the invention illustrated in FIG. **4**, two suture anchors **50***b* and **52***b* are utilized to press the body tissue **132** against the bone **20***b*. However, a suture retainer could be substituted for one or more of the suture anchors **50***b* or **52***b*. For example, a suture retainer having the same construction and installed in the same manner as the suture retainer **92** of FIG. **3** could be substituted for the anchor **52***b* of FIG. **4**. It should be understood that the suture retainer substituted for the anchor **52***b* of FIG. **4** could have any desired construction. Thus, a suture retainer having the construction of any one of the suture retainers disclosed in the aforementioned U.S. patent application Ser. No. 08/905,084, filed Aug. 1, 1997 by Peter M. Bonutti et al. and entitled "Method and Apparatus for Securing a Suture" could be utilized in place of the anchor **52***b* and/or the anchor **50***b*.

When a suture retainer is used in place of the anchor **52***b*, the suture retainer applies force against the body tissue **132** to press the body tissue against the bone **20***b*. If desired, a force distribution member could be provided between the suture retainer and the body tissue **132**.

Although the passage **40***b* has been illustrated in FIG. **4** as having a linear configuration, the passage could have a nonlinear configuration if desired.

In the embodiment of the invention illustrated in FIG. **4**, body tissue **132** is disposed adjacent to only one side of the bone **20***b*. However, if desired, body tissue could be disposed adjacent to opposite sides of the bone **20***b*. The body tissue could be connected with the anchor **50***b* in many different ways. For example, a separate length of suture could be connected with the body tissue and anchor **50***b* or with the suture **38***b* adjacent to the anchor **50***b*.

An alternative manner of connecting body tissue with the side of the bone adjacent to the anchor **50***b* would be to insert the body tissue between the limbs **72***b* and **74***b* of the suture **36***b* in the same manner as shown with the anchor **52***b*. If this is to be done, an end portion of the body tissue may be manually inserted between the limbs **72***b* and **74***b* of the suture **38***b*. If a central portion of the body tissue is to be disposed between the anchor **50***b* and the bone **20***b*, the connector section **76***b* of the suture could be cut. One of the limbs **72***b* or **74***b* of the suture would then be separated from the anchor **50***b*. The body tissue would be inserted between the limbs of the suture **38**. The separated end of the suture would then be inserted through the anchor **50***b* and connected with the other limb of the suture **38***b*.

In the embodiment of the invention illustrated in FIG. **4**, the body tissue **132** is pressed against a bone **20***b* which has not been fractured. However, it is contemplated that the bone suture assembly **32** could be utilized to perform the dual functions of pressing body tissue against a bone and of pressing opposite side surfaces of a fracture together. This would result in the body tissue being pressed against the bone **20***b* in the manner illustrated in FIG. **4** and in opposite side surfaces of a fracture being pressed together in the manner illustrated in FIG. **2** for the opposite side surfaces **28** and **30** of the fracture **26**.

Nonlinear Suture Passage

In the embodiment of the invention illustrated in FIG. **2**, the passage **40** through which the suture **38** extends has a linear configuration. In the embodiment of the invention illustrated in FIG. **5**, the passage through which the suture extends has a nonlinear configuration. Since the embodiment of the invention illustrated in FIG. **5** is generally similar to the embodiment of the invention illustrated in FIGS. **2–4**, similar numerals will be utilized to identify similar components, the suffix letter "c" being associated with the components of the embodiment of the invention illustrated in FIG. **5** to avoid confusion.

A bone **20***c* as a fracture **26***c* which divides the bone into two sections **22***c* and **24***c*. Opposite side surfaces **28***c* and **30***c* of the fracture **26***c* are pressed together by a bone suture assembly **32***c*. The bone suture assembly **32***c* includes a suture **38***c* which extends between first and second suture anchors **50***c* and **52***c*.

In accordance with a feature of this embodiment of the invention, the suture **38***c* is disposed in a passage **40***c* having a nonlinear configuration. Thus, the passage **40***c* includes a first section **140** which is skewed relative to a second section **142** of the passage **40***c*. A bend **144** is formed in the passage **40***c* at an intersection **146** of the first and second sections **140** and **142** of the passage **40***c*. The flexible suture **38***c* extends around the bend **144** along a nonlinear path between the suture anchors **50***c* and **52***c*. At the bend **144**, the suture **38***c* applies force against the section **24***c* of the bone **20***c* urging the section **24***c* toward the left (as viewed in FIG. **5**). This force presses the sections **22***c* and **24***c* of the bone **20***c* firmly together at the fracture **26***c*.

The suture anchors **50***c* and **52***c* have the same cylindrical construction as the suture anchors **50** and **52** in the embodiment of the invention illustrated in FIG. **2**. A knot **78***c* (FIG. **5**) is provided between limbs of the suture **38***c* to maintain a desired tension in the suture **38***c*. This tension pulls the suture anchors **50***c* and **52***c* toward each other. In addition, this tension presses the section **24***c* of the bone **20***c* firmly against the section **22***c* of the bone at the fracture **26***c*.

The first section **140** of the passage **40***c* is formed at an angle to and extends through a longitudinal central axis of the generally cylindrical bone **20***c*. The second section **142** of the passage **40***c* is formed in a direction perpendicular, i.e., along a radius, of the generally cylindrical bone **20***c*. The two sections **140** and **142** of the passage **40***c* terminate in the spongy cancellous bone tissue **44***c*.

When the suture assembly **32***c* is to be used to treat the fracture **26***c* in the bone **20***c*, the two sections **22***c* and **24***c* of the bone are pressed together at the fracture **26***c* to align the side surfaces **28***c* and **30***c* of the fracture. A drill or other hole forming apparatus is then used to form the first section **140** of the passage **40***c*. The drill or other hole forming apparatus is then used to form the second section **142** of the passage **40***c*. When the second section **142** of the passage **40***c* intersects the first section **140** of the passage **40***c*, formation of the section **142** of the passage **40***c* is interrupted.

Once the nonlinear passage **40***c* has been formed in the two sections **22***c* and **24***c* of the bone **20***c*, a tubular cylindrical liner (not shown) is inserted into the passage **40***c*. The tubular cylindrical liner may be formed by two separate tubular members which are inserted at opposite ends of the passage **40***c*. Alternatively, the tubular cylindrical liner may be formed by a single flexible tubular member which is inserted into the section **140** of the passage **40***c* and then moved around the bend **144** into the section **142** of the

passage **40***c*. It should be understood that the tubular cylindrical liner for the passage **40***c* could be omitted if desired.

The cylindrical anchor **50***c*, with the suture **38***c* connected thereto, is then positioned in axial alignment with the section **142** of the passage **40***c*. The leading end **58***c* of the anchor **50***c* is then moved into the lined section **142** of the passage **40***c*. A flexible pusher member applies force against the trailing end **60***c* of the anchor **50***c* and pushes the anchor around the bend **144** and through the section **140** of the passage **40***c*.

Alternatively, a flexible wire or other member could be inserted into the section **140** of the passage **40***c*. The wire would move around the bend **144** and extend outward from the section **142** of the passage. The wire would then be connected with the anchor **50***c* and suture **38***c*. The leading end **58***c* of the anchor **50***c* would then be inserted into the section **142** of the passage **40***c*. Tension on the wire would pull the anchor **50***c* around the bend **144** and out of the section **140** of the passage **40***c*.

Once the anchor **50***c* has been moved out of the passage **40***c*, the tubular liner for the passage may be withdrawn. If a one-piece tubular liner is used, it may be withdrawn from the open end of the section **142** of the passage **40***c*. If a two-piece liner is used, one of the pieces may be withdrawn from the open end of the passage section **140** and slit to clear the suture **38***c*. Alternatively, the slit could be formed in the piece of the liner before it is inserted into the passage section **140**. The other piece of the liner would be withdrawn from the open end of the passage section **142**. Alternatively, the tubular liner for the passage **40***c* may be left in place. Of course, the use of a tubular liner for the passage **40***c* may be omitted.

The suture **38***c* is then threaded through openings in the suture anchor **52***c*. The suture **38***c* is then tensioned and the second anchor **52***c* is pressed against the outer side surface of the bone **20***c*. While a predetermined tension force is maintained in the suture **38***c*, the knot **78***c* is tied.

In the illustrated embodiment of the invention, the two sections **140** and **142** of the passage **40***c* have a straight cylindrical configuration. However, it is contemplated that the sections **140** and **142** of the passage **40***c* could have a different configuration if desired. For example, the section **140** and/or **142** of the passage **40***c* could have a nonlinear central axis and could have a noncircular cross-sectional configuration of desired.

Body tissue, corresponding to the body tissue **132** of FIG. **4** could be disposed between the anchor **50***c* and/or **52***c* and the bone **20***c*. Although the suture **38***c* has been illustrated as having a pair of limbs or sections which extend between the anchors **50***c* and **52***c*, the suture **38***c* could have a single limb or section if desired. The anchor **50***c* could mechanically expand, by absorbing body liquid or under the influence of expansion springs, after the anchor has emerged from the passage **40***c* to prevent the anchor from being pulled back through the passage.

Nonlinear Passage—Second Embodiment

In the embodiment of the invention illustrated in FIG. **5**, the bone suture assembly **32***c* associated with the nonlinear passage **40***c* includes a pair of suture anchors **50***c* and **52***c*. In the embodiment of the invention illustrated in FIG. **6**, a suture retainer in substituted for one of the suture anchors in much the same manner as previously described in conjunction with the embodiment of the invention illustrated in FIG. **3**. Since the embodiment of the invention illustrated in FIG. **6** is generally similar to the embodiment of the invention illustrated in FIGS. **2–5**, similar numerals will be utilized to designate similar components, the suffix letter "d" being associated with the numerals of FIG. **6** in order to avoid confusion.

A bone **20***d* has a fracture **26***d* which divides the bone into two sections **22***d* and **24***d*. The fracture **26***d* has side surfaces **28***d* and **30***d* which are pressed together by a bone suture assembly **32***d*. The bone suture assembly **32***d* includes a suture **38***d* which extends through a nonlinear passage **40***d* having the same construction as the nonlinear passage **40***c* of FIG. **5**.

In accordance with a feature of this embodiment of the invention, the bone suture assembly **32***d* includes a suture anchor **50***d* having the same construction as the suture anchor **50** of FIG. **2**, and a suture retainer **92***d* having the same construction as the suture retainer **92** of FIG. **3**. The suture anchor **50***d* and suture retainer **92***d* maintain a predetermined tension in the suture **38***d*. This results in the suture anchor **50***d* being firmly pressed against the section **24***d* of the bone **20***d*. The suture retainer **92***d* is firmly pressed against the section **22***d* of the bone **20***d* by the tension in the suture **38***d*.

Since the passage **40***d* has a nonlinear configuration, the suture **38***d* is effective to apply a force component to the section **24***d* of the bone **20***d* urging the section **24***d* of the bone toward the left (as viewed in FIG. **6**). This results in the surface **30***d* of the fracture **26***d* being pressed firmly against the surface **28***d* of the fracture.

The suture retainer **92***d* is plastically deformed to grip the suture **38***d* in the same manner as previously described herein in conjunction with the suture retainer **92** of FIG. **3**. However, the suture retainer **92***d* could be constructed so as to form a mechanical connection with the suture **38***d*. If desired, a suture retainer could be substituted for the anchor **50***d*.

Although both the suture retainer **92***d* and anchor **50***d* have been illustrated in FIG. **6** as being disposed in engagement with the bone **20***d*, a force distributing member could be provided between the anchor and/or suture retainer and the bone. It is contemplated that body tissue, similar to the body tissue **132** of FIG. **4**, could be disposed between the anchor **50***d* and/or the suture retainer **92***d* and the bone **20***d*.

Tissue Tensioning With Bone Fragment Retaining

In the embodiment of the invention illustrated in FIG. **2**, the fracture in a portion of a bone is treated. In the embodiment of the invention illustrated in FIGS. **7** and **8**, a fracture results in a fragment of a bone being separated from a main portion of the bone. The bone fragment is connected with the main portion of the bone by muscle, tendon, ligament, cartilage or other fibrous body tissue. In the embodiment of the invention illustrated in FIGS. **7** and **8**, the fibrous body tissue is tensioned as the bone fragment is positioned relative to the main portion of the bone. Since the embodiment of the invention illustrated in FIGS. **7** and **8** is generally similar to the embodiment of the invention illustrated in FIGS. **2–6**, similar numerals will be utilized to designate similar components, the suffix "e" being associated with the numerals of FIGS. **7** and **8** in order to avoid confusion.

A bone fragment **154** is separate from a main bone **20***e* (FIG. **7**). The fragment **154** is connected with the main bone **20***e* by fibrous body tissue **158**, i.e., muscle, tendon, ligament, cartilage, etc. The fibrous body tissue **158** extends between the bone fragment **154** and a portion **160** of the main bone **20***e*. The bone fragment **154** has a side surface

28e with a configuration which matches the configuration of a side surface 30e of a fracture 26e which occurred in the main bone 20e.

In order to promote healing of the main bone 20e, a bone suture assembly 32e (FIG. 8) is utilized to pull the bone fragment 154 toward the main bone 20e. As this occurs, the fibrous body tissue 158 is tensioned and the side surface 28e on the bone fragment 154 is pressed against the side surface 30e on the main bone 20e. The bone fragment 154 is pressed firmly against the main bone 20e by the bone suture assembly 32e. Thus, the gap illustrated schematically in FIG. 8, between the side surfaces 28e and 30e of the fracture 26e, is eliminated and the side surfaces of the fracture are pressed firmly together by the bone suture assembly 32e. If desired, the bone fragment 154 may be manually pressed against the main bone 20e before the bone suture assembly is pulled tight.

The bone suture assembly 32e includes a suture 38e having limbs or sections 72e and 74e. The suture 38e extends through openings in a first suture anchor 50e. The suture then extends into a passage 40e formed in the bone fragment 154 and the main bone 20e.

The passage 40e includes a first section 140e which extends through the bone fragment 154. In addition, the passage 40e includes a second section 142e which extend through the main bone 20e. The limbs or section 72e and 74e of the suture 38e extends through a second anchor 52e.

During installation of the bone suture assembly 32e, the limbs 72e and 74e of the suture 38e are gripped by a force or tension measurement device 98e. The tension measurement device 98e includes a load cell which measures the amount of tension applied to the limbs 72e and 74e of the suture 38e.

As tension is applied to the limbs 72e and 74e of the suture 38e, the bone fragment 154 is pulled toward the right (as viewed in FIG. 8) to move the side surface 28e on the bone fragment into alignment with the side surface 30e on the main bone 20e. As this occurs, the fibrous body tissue 158 is stretched or tensioned. While a predetermined force is transmitted through the limbs 72e and 74e to the suture anchor 50e and the bone fragment 154 to firmly press the bone fragment against the main bone 20e, a knot 78e is tied to interconnect the limbs 72e and 74e. While the predetermined tension is maintained and the knot 78e tied, the second anchor 52e is firmly pressed against the side surface of the main bone 20e.

Although the passage 40e could have a linear configuration if desired, in the embodiment of the invention illustrated in FIG. 8, the passage 40e has a nonlinear configuration. Thus, the first section 140e of the passage 40e has a central axis which is skewed relative to a central axis of the second section 142e of the passage 40e. This enables the flexible suture 38e to apply force to the bone fragment 154 having components urging the bone fragment rightward (as viewed in FIG. 8) against the surface 30e on the main bone 20e and downward (as viewed in FIG. 8) to maintain the tension in the fibrous body tissue 158.

When the passage 40e is to be formed in the bone fragment 154 and main bone section 20e, a hole is drilled through the bone fragment 154 to form the first section 140e of the passage. The second portion 142e of the passage 40e is drilled in the main bone 20e. It should be understood that the passage 40e could be formed in many different ways other than drilling. For example, a cutting tool or laser could be used to form the passage 40e.

The second section 142e of the passage 40e has a longitudinal central axis which is skewed at an acute angle relative to the longitudinal central axis of the first section 140e of the passage in the bone fragment 154. Thus, the first portion 140e of the passage 40e in the bone fragment 154 has a central axis which is close to being perpendicular to a longitudinal central axis of the main bone 20e. The second portion 142e of the passage 40e has a longitudinal central axis which is angularly offset to a substantial arc relative to the longitudinal central axis of the main bone 20e.

The anchor 50e is moved through the first section 140e of the passage 40e and positioned in engagement with an outer side surface of the bone fragment. The free ends of the limbs 72e and 74e of the suture 38e are then moved rightward (as viewed in FIG. 8) through the second portion 142e of the passage 40e. The free ends of the suture 38e are then threaded through openings in the second anchor 52e.

After the suture 38e has been inserted through openings in the second anchor 52e, the force or tension measuring device 98e is utilized to pull the free ends of the suture 38e toward the right (as viewed in FIG. 8). This tension pulls the bone fragment 154 into engagement with the main bone 20e. The knot 78e is tied in the free ends of the suture 38e while the tension is maintained in the suture.

If desired, the bone suture assembly 32e could be positioned relative to the bone 20e and the bone fragment 154 by moving the anchor 50e first through the second section 142e of the passage disposed in the main bone 20e and then through the first section 140e of the passage disposed in the fragment 154. The free ends of the suture would then be inserted through the second anchor 52e. The suture 38e would be tensioned to pull the bone fragment 154 into place with the side surface 28e in aligned engagement with the surface 30e on the main bone 20e. The knot 78e would then be tied while maintaining the desired tension in the suture 38e.

It should be understood that the anchor 52e and knot 78e could be positioned adjacent to the bone fragment 154 and the anchor 50e positioned adjacent to the bone 20e. Although only a single bone suture assembly 32e has been illustrated in FIG. 8, multiple bone suture assemblies could be used to position the bone fragment 154 relative to the bone 20e.

In the embodiment of the invention illustrated in FIGS. 7 and 8, the bone suture assembly 32e includes a pair of anchors 50e and 52e. If desired, a suture retainer could be substituted for either or both of the anchors 50e and 52e. Thus, a suture retainer having a construction similar to the construction of the suture retainer 92 of FIG. 3 could be used in place of the second anchor 52e. It should be understood that the suture retainer 92 could have the same construction as any one of the suture retainers disclosed in the aforementioned U.S. patent application Ser. No. 08/905,084 filed Aug. 1, 1997 by Peter M. Bonutti et al. and entitled "Method and Apparatus for Securing a Suture".

In the embodiment of the invention illustrated in FIG. 8, the anchors 50e and 52e are placed in engagement with the bone of fragment 154 and main bone 20e. However, it is contemplated that the anchor 50e and/or 52e could be positioned in engagement with body tissue other than bone. For example, the anchor 50e could be positioned in engagement with a portion of the fibrous body tissue 158 to position the fibrous body tissue 158 relative to the bone fragment 154 and to more securely interconnect the fibrous body tissue and the bone fragment. If desired, body tissue could be positioned between the anchor 52e and the main bone 20e.

In FIG. 8, there is a single bone fragment 154. However, fractures may occur in such a manner as to have a plurality

of bone fragments. A plurality of bone suture assemblies **32***e* could be utilized to interconnect the plurality of bone fragments and the main bone.

When a fracture occurs in such a manner as to form a plurality of bone fragments, it may be desired to use bone suture assemblies **32***e* in association with only the larger bone fragments. If desired, a bridge or cover member could extend across the bone fragments to position the bone fragments relative to each other. One or more bone suture assemblies **32***e* would extend through one or more of the larger bone fragments and through the bridge or cover member. Force applied against the bridge or cover member by an anchor or anchors in a bone suture assembly or assemblies **32***e* would urge the bridge or cover member toward the main bone **20***e* to position the smaller bone fragments relative to the larger bone fragments and main bone **20***e* and to press the bone fragments against each other and against the main bone.

One or more of the anchors **50***e* and **52***e* could be formed of body tissue or of material which absorbs body fluid and expands. Alternatively, one or more of the anchors **50***e* or **52***e* could be mechanically expanded to block movement into the passage **50***e*.

Bone Fragment Retention

In the embodiment of the invention illustrated in FIG. **2**, the bone suture assembly **32** extends between diametrically opposite outer side surface areas on the bone **20**. This results in the first suture anchor **50** being disposed against an outer side surface of the hard outer layer **42** of the bone **20** (FIG. **1**) and the suture anchor **52** being disposed against the outer side surface of the hard outer layer **42** on the opposite side of the bone. In the embodiment of the invention illustrated in FIG. **9**, one of the anchors is disposed within the bone and the other anchor is disposed outside of the bone. Since the embodiment of the invention illustrated in FIG. **9** is generally similar to the embodiment of the invention illustrated in FIGS. **2–8**, similar numerals will be utilized to identify similar components, the suffix letter "f" being associated with the numerals of FIG. **9** in order to avoid confusion.

A bone **20***f* has a hard outer layer **42***f* which encloses spongy cancellous bone tissue **44***f*. A fragment **164** has broken away from the hard outer layer **42***f*. A bone suture assembly **32***f* is used to position and hold the fragment **164** in engagement with the bone **20***f*. The bone suture assembly **32***f* includes a first suture anchor **50***f* which is disposed in engagement with an inner side surface **166** of the outer layer **42***f* of bone. A second anchor **50***f* is disposed in engagement with an outer side surface **168** of the fragment **164**. A suture **38***f* extends between the first and second anchors **50** and **52***f*. The suture **38***f* extends through a passage **40***f* which extends across a fracture **26***f*.

When the bone suture assembly **32***f* is used to position the fragment **164** against the outer layer **42***f* of the bone **20***f*, the fragment **164** is aligned with the outer layer **42***f* of the bone **20***f*. At this time, a side surface **172** on the fragment **164** is disposed in aligned engagement with a side surface **174** on the bone **20***f*. The two side surfaces **172** and **174** were formed by breaking away of the fragment **164** from the outer layer **42***f* of the bone.

Once the fragment **164** has been aligned with the bone **20***f*, the linear passage **40***f* is formed by drilling or other methods through the fragment **164** and the outer layer **42***f* of bone. A cylindrical tubular member (not shown) having a thin cylindrical side wall is then inserted through the passage **40***f*. The first anchor **50***f* is moved to an orientation in which a longitudinal central axis of the first anchor is aligned with a longitudinal central axis of the cylindrical tubular member.

The first anchor **50***f* is then moved through the cylindrical tubular member, across the fracture **26***f* and into the spongy cancellous bone tissue **44**. A pusher member applies force against a trailing end of a first anchor **50***f* to push the anchor through the tubular member. When the leading end of the first anchor **50***f* emerges from the passage **40***f*, the longitudinal central axis of the first anchor is aligned with the longitudinal central axis of the passage **40***f*.

The first anchor **50***f* is then pivoted through 90° to change its orientation to the orientation shown in FIG. **9**. The tubular member is then withdrawn from the passage **40***f*. The free ends of the suture **38***f* are then inserted through openings in the anchor **52***f*. The suture is tensioned to press the anchor **50***f* against the inner side surface **166** on the outer layer **42***f* of the bone **20***f*. The second anchor **52***f* is pressed against the outer side surface **168** or the fragment **164** with a predetermined force by the tension in the suture **38***f*. A knot **78***f* is then tied in the free ends of the suture **38***f* to maintain the desired tension in the suture.

Although it is believed that it may be desired to remove the tubular member from the passage **40***f*, the tubular member could be left in the passage if desired. If the tubular member is to be left in the passage **40***f*, the tubular member may be formed of a biodegradable or bioerodible copolymer. Of course, the use of the tubular member could be eliminated if desired.

It should be understood that a suture retainer, having a construction similar to the construction of the suture retainer **92** of FIG. **3**, could be used in place of the second anchor **52***f* if desired. Although the suture anchor **52***f* has been shown in FIG. **9** as being disposed in direct abutting engagement with the outer side surface **168** of the bone fragment **164**, a layer of body tissue could be provided between the suture anchor **52***f* and the outer side surface **168** of the bone fragment **164** to hold the body tissue against movement relative to the bone **20***f*. If desired, a plurality of bone suture assemblies **32***f* could be utilized to hold the bone fragment **164**.

Use of Plates with Bone Suture Assembly

In the embodiment of the invention illustrated in FIG. **2**, the suture anchors **50** and **52** are disposed in abutting engagement with an outer side surface of a bone. In the embodiment of the invention illustrated in FIG. **10**, a pair of bone plates and rigid fasteners are used in association with a bone suture assembly. Since the embodiment of the invention illustrated in FIG. **10** is generally similar to the embodiment of the invention illustrated in FIGS. **2–9**, similar numerals will be utilized to designated similar components, the suffix "g" being associated with the numerals of FIG. **10** to avoid confusion.

A bone **20***g* has sections **22***g* and **24***g* which are separated by a fracture **26***g*. In accordance with a feature of this embodiment of the invention, a pair of plate members **184** and **186** are used in association with a bone suture assembly **32***g*. The plate members **184** and **186** may be formed of any desired biocompatible material. Thus, the plate members may be formed of metal or a polymeric material. If the plate members **184** and **186** are formed of polymeric material, biodegradable or bioerodible copolymers could be utilized.

In the illustrated embodiment of the invention, the plate members **184** and **186** are rigid and are shaped to engage the bone **20***g*. If desired, the plate members **184** and **186** could have sufficient flexibility to enable the plate members to be plastically deformed to the configuration of the bone **20***g* after having been positioned in engagement with the bone.

A first suture anchor **50***g* is pressed against the plate member **184** by tension in a suture **38***g*. The suture **38***g* extends through a passage **40***g* in the bone **20***g*. A second anchor **52***g* is pressed against the plate member **186** by the tension in the suture **38***g*. A knot **78***g* is provided in the suture **38***g*.

A pair of screws **190** and **192** extend diametrically through the bone **20***g* between the plate members **184** and **186**. The screws **190** and **192** are engaged by nuts **196** and **198** which engage the plate member **184**. The screws **190** and **192** and nuts **196** and **198** cooperate to press the plate members **184** and **186** against the bone **20***g*. If desired, bone suture assemblies having the same construction as the bone suture assembly **32***g* could be substituted for the screws **190** and **192** and nuts **196** and **198** so that the plates **184** and **186** would be held in position against the bone **20***g* by only the plurality of bone suture assemblies **32***g*.

The screws **190** and **192** and nuts **196** and **198** may be formed of any desired biocompatible material. Thus, the screws **190** and **192** and nuts **196** and **198** may be formed of metal or a polymeric material. If the screws **190** and **192** and nuts **196** and **198** are formed of polymeric material, biodegradable or bioerodible copolymers could be utilized.

In the illustrated embodiment of the invention, the screws **190** and **192** extend through the bone **20***g*. It is contemplated that shorter screws could be utilized if desired. These shorter screws would have relatively coarse bone engaging thread convolutions to hold the short screws and plate members **184** and **186** in place. The shorter screws would have a length which is less than diameter of the bone **20***g*.

In the illustrated embodiment of the invention, the bone suture assembly **32***g* extends through a linear passage **40***g*. If desired, the passage **40***g* could have a nonlinear configuration. If bone suture assemblies **32***g* are substituted for the screws **190** and **192** and nuts **196** and **198**, some of the bone suture assemblies could extend through linear passages while other bone suture assemblies extend through nonlinear passages.

Installation Method

In the embodiment of the invention illustrated in FIG. **2**, the passage **40** is formed in the bone **20** by any desired method. A thin walled cylindrical tubular member is then inserted into the passage and the first suture anchor **50** moved through the thin walled member. In the embodiment of the invention illustrated in FIGS. **11** and **12**, a cannulated drill is used to drill a passage through a bone and to guide movement of the first anchor through the bone. Since the embodiment of the invention illustrated in FIGS. **11** and **12** is generally similar to the embodiments of the invention illustrated in FIGS. **2–10**, similar numerals will be utilized to identify similar components, the suffix "h" being associated with the numerals in FIGS. **11** and **12** to avoid confusion.

A bone **20***h* has a fracture (not shown). When the fracture is to be treated with a bone suture assembly **32***h* (FIG. **12**), a thin elongated cylindrical member or K-wire **204** is first inserted through the bone **20***h*. This may be done by rotating the thin elongated member **204** with a drill drive mechanism in the manner indicated by an arrow **206** in FIG. **11**. The drill drive mechanism is provided with a passage which extends through a drive shaft for the mechanism. While the thin elongated member **204** is being rotated by the drill drive mechanism, the K-wire extends through the passage in the drill drive mechanism.

As the thin elongated member **204** is rotated by the drill drive mechanism, it is pressed against the bone **20***h*. As the thin elongated member **204** is rotated, in the manner indicated by the arrow **206** in FIG. **11**, the thin elongated member is moved diametrically through the generally cylindrical bone **20***h* until the leading end of the thin elongated member **204** extends from the opposite side of the bone. Thus, the thin elongated member **204** is moved through the hard outer layer **42***h* (FIG. **12**) at one side of the bone **20***h*, through the spongy or cancellous bone tissue **44***h*, and through the hard outer layer at the diametrically opposite side of the bone. When this has been done, the thin elongated member **204** will extend across the fracture in the bone.

The drill drive mechanism is then disengaged from the thin elongated member **204**. A cannulated drill **210** is moved axially along the thin elongated member until the leading end portion **212** of the drill **210** engages the bone **20***h* (FIG. **11**). The drill **210** is then gripped by the drill drive mechanism.

While the thin elongated member **204** remains stationary, the drill **210** is rotated about the thin elongated member in the manner indicated by an arrow **214** in FIG. **11**. As the drill **210** is rotated about the stationary thin elongated member **204**, the drill is moved axially into the bone **20***h*. As this occurs, the leading end **212** of the drill enlarges the hole or passage formed in the bone **20***h* by the thin elongated member **204**. The drill **210** is moved along the thin elongated member **204** until the drill extends diametrically across the bone **20***h*. This movement of the drill **210** is guided by engagement of the thin elongated member **204** with a side wall of a cylindrical passage **218** which extends axially through the drill **210**. Movement of the drill **210** through the bone **20***h* forms a passage **40***h* which extends through a fracture in the bone.

Once the drill **210** has been moved diametrically through the generally cylindrical bone **20***h* (FIG. **12**), the thin elongated member **204** is withdrawn from the drill. This leaves an open cylindrical passage **218** extending through the drill **210** and across the bone **20***h*. The passage **218** has a diameter which is just slightly greater than the diameter of a cylindrical first anchor **50***h* of the bone suture assembly **32***h*. The cylindrical first anchor **50***h* is axially aligned with the passage **218** in the drill **210**, in the manner shown in FIG. **12**. At this time, the suture **38***h* has been inserted through openings in the first anchor **50***h* and suture limbs or sections **72***h* and **74***h* extend away from the first anchor **50***h*, in the manner indicated schematically in FIG. **12**.

A cylindrical pusher member **222** is axially aligned with the first anchor **50***h* and the passage **218** through the drill **210**. The pusher member **222** is utilized to push the first anchor **50***h* through the drill **210** to the far side of the bone **20***h*.

As the first suture anchor **50***h* emerges from the passage **28** in the drill **210**, the anchor is pivoted through ninety degrees. This pivotal movement changes the orientation of the anchor **50***h* from an orientation in which the longitudinal central axis of the anchor **50***h* is aligned with the longitudinal central axis of the passage **218** and drill **210** to an orientation in which a longitudinal central axis of the cylindrical anchor **50***h* extends perpendicular to the longitudinal central axis of the passage and drill. The manner in which the anchor **50***h* is pivoted is the same as is described in the aforementioned U.S. Pat. Nos. 5,527,343 and 5,534,012.

The pusher member **222** is then withdrawn from the drill **10** and the drill is withdrawn from the passage formed through the bone **20***h*. As this occurs, the suture **38***h* is tensioned to hold the anchor **50***h* in place against the bone

20*h*. The drill **210** is then disengaged from the suture **38***h*. The free limbs **72** and **74** of the suture **38***h* are then inserted through a second anchor corresponding to the anchor **52** in FIG. **2**. While a predetermined tension is maintained in the suture **38***h*, the suture is tied to hold the second suture anchor, corresponding to the suture anchor **52** in FIG. **2**, against the bone **20***h* on a side of the bone opposite from the anchor **50***h*.

In the foregoing description, the drill **210** has been a rigid drill which has been used to form a linear passage to the bone **20***h*. However, it is contemplated that a flexible drill could be utilized to drill a passage through the bone. If this was done, the drill could be guided in such a manner as to form a nonlinear passage in the bone.

The foregoing description of how the passage **40***h* is formed has been in conjunction with a bone **20***h* having a fracture similar to the fracture **26** of FIG. **2**. However, it is contemplated that the thin elongated member **204** and drill **210** could be used to form a passage in a bone which has not been fractured (FIG. **4**). The thin elongated member **204** and **210** could be used to form a passage which extends only part way through a bone (FIG. **9**).

In the description of the embodiments of the invention illustrated in FIGS. **1–12**, the suture **38** (FIG. **2**) has a pair of limbs or sections **72** and **74**. It is contemplated that the suture **38** could have only a single limb which would be connected at one end with the first anchor **50** and at the opposite end with the second anchor **52**. This single limb could either be tied off at the second anchor **52** or gripped by a suture retainer, similar to the suture retainer **92** of FIG. **3**.

In the embodiments of the invention illustrated in FIGS. **1–12**, the suture **38** has been formed separately from the first suture anchor **50**. It is contemplated that the first suture anchor **50** could be formed as one piece with the suture **38**. For example, the suture and anchor could be formed as one piece in a manner similar to that disclosed in U.S. Pat. No. 4,669,473 or in U.S. Pat. No. 4,741,330.

The anchors **50** and **52** in the embodiment of FIGS. **2–12** could have any one of many different constructions. For example, the anchors could expand by absorbing body fluid. The anchor **50**, which is moved through a passage **40** in the embodiments of FIGS. **2–12**, could mechanically expand upon exiting from the passage.

CONCLUSION

In view of the foregoing description, it is apparent that the present invention relates to a method of securing sections **22** and **24** of a fractured bone **20** and/or of securing body tissue **132** or **158** to bone which may or may not have been fractured. Sections **22** and **24** of a fractured bone **20** are held against movement relative to each other by a suture **38** which extends through a passage **40** in the bone. Body tissue **132** or **158** may be held against movement relative to bone **20** by a suture **38** which extends through a passage in the bone. Since the suture **38** is flexible, the passage **40** in the bone may have a linear or nonlinear configuration. Tension is maintained in the suture **38** to press surfaces **28** and **30** on the fracture together and/or to hold body tissue **132** or **158** by securing anchors **50** and **52** or suture retainers **92** to opposite ends of the suture.

The linear or nonlinear passage **40** through bone may be formed in any one of many different ways. One specific way of forming the passage is moving a thin elongated member **204** through the bone. A drill **210** is then moved along the thin elongated member **204** to enlarge a passage formed through the bone by the thin elongated member. The thin elongated member **204** is then withdrawn from the drill **210** and a suture anchor **50** connected with a suture **38** is moved through the drill.

Having described the invention, the following is claimed:

1. A Method of treating a fractured bone, said method comprising the steps of moving a first anchor connected with a suture through bone disposed on opposite sides of the fracture, tensioning the suture to transmit force from the first anchor to bone on a first side of the fracture with the suture extending across the fracture, and transmitting force from a second anchor to bone on a second side of the fracture under the influence of force transmitted from the first anchor and across the fracture through the suture to the second anchor.

2. A method as set forth in claim **1** wherein said step of moving a first anchor connected with a suture through bone disposed on opposite sides of the fracture is performed with the first anchor in a first orientation, said method further including the step of changing the orientation of the first anchor from the first orientation to a second orientation after having performed said step of moving the first anchor through bone disposed on opposite sides of the fracture and prior to performance of said step of transmitting force from the second anchor to bone on the second side of the fracture.

3. A method as set forth in claim **1** further including the step of moving a tubular member through bone disposed opposite sides of the fracture, said step of moving a first anchor connected with the suture through bone disposed on opposite sides of the fracture includes moving the first anchor through the tubular member.

4. A method as set forth in claim **3** further including the step of removing the tubular member from the bone after having performed said step of moving the first anchor through the tubular member.

5. A method as set forth in claim **3** wherein said steps of tensioning the suture and transmitting force from a second anchor to bone on a second side of the fracture are performed with the tubular member extending through bone on opposite sides of the fracture.

6. A method as set forth in claim **1** further including the step of determining when a predetermined force has been transmitted from the first anchor through the suture and securing the suture against movement relative to the second anchor while the predetermined force is transmitted from the first anchor through the suture.

7. A method as set forth in claim **1** further including the step of moving a suture retainer along the suture toward the second suture anchor and deforming material of the suture retainer to grip the suture with the suture retainer adjacent to the second anchor.

8. A method as set forth in claim **1** further including the step of securing the suture relative the second anchor while transmitting force from the first and second anchors to the bone to press together surfaces of the bone which at least partially define the fracture.

9. A method as set forth in claim **8** wherein said step of securing the suture relative to the second anchor includes tying a knot in the suture.

10. A method as set forth in claim **8** wherein said step of securing the suture relative to the second anchor includes deforming a suture retainer to grip the suture with the suture retainer.

11. A method as set forth in claim **1** further including the step of forming a passage which extends through bone on opposite sides of the fracture, said step of moving a first anchor connected with a suture through bone disposed on opposite sides of the fracture includes moving the anchor through the passage with the suture connected with the anchor.

12. A method as set forth in claim 1 wherein said step of transmitting force from the first anchor to bone on a first side of the fracture includes pressing the first anchor against an outer side surface of the bone on the first side of the fracture.

13. A method as set forth in claim 12 wherein said step of transmitting force from the second anchor to bone on a second side of the fracture includes pressing the second anchor against an outer side surface of the bone on the second side of the fracture.

14. A method as set forth in claim 1 further including the steps of moving a long thin member through the bone disposed on opposite sides of the fracture, moving a drill along the long thin member with the long thin member extending through a passage in the drill, and rotating the drill about its central axis while moving the drill along the long thin member to enlarge an opening through which the long thin member extends.

15. A method as set forth in claim 14 further including the steps of removing the long thin member from the passage in the drill, said step of moving a first anchor connected with a suture through bone disposed on opposite sides of the fracture includes moving the first anchor through the passage in the drill.

16. A method as set forth in claim 15 wherein said step of moving the first anchor through the passage in the drill is performed with the first anchor in a first orientation in which an axis of the first anchor extends along the central axis of the drill, said method further including moving the first anchor to a second orientation in which the axis of the first anchor extends transverse to the central axis of drill when the drill is disposed in the enlarged opening in the bone.

17. A method as set forth in claim 14 wherein said step of moving a first anchor connected with a suture through bone includes moving the first anchor through the opening enlarged by moving the drill along the long thin member.

18. A method as set forth in claim 1 wherein the suture has first and second sections which extend from the first anchor and across the fracture to the second anchor, said step of tensioning the suture includes tensioning the first and second sections of the suture.

19. A method as set forth in claim 1 wherein the suture has a single section which extends from the first anchor and across the fracture to the second anchor, said step of tensioning the suture includes tensioning the single section of the suture.

20. A method as set forth in claim 1 wherein said step of transmitting force from a second anchor to bone on a second side of the fracture includes transmitting force from the second anchor to body tissue other than the bone and transmitting force from the body tissue to the bone.

21. A method as set forth in claim 1 further including the step of forming a nonlinear passage which extends through bone on opposite sides of the fracture, said step of moving a first anchor connected with a suture through bone disposed on opposite sides of the fracture includes moving the anchor through at least a portion of the nonlinear passage with the suture connected with the anchor.

22. A method as set forth in claim 1 wherein said step of transmitting force from the first anchor to bone on a first side of the fracture includes pressing the first anchor against body tissue disposed between an outer side surface of the bone on the first side of the fracture and the first anchor.

23. A method as set forth in claim 22 wherein said step of transmitting force from the second anchor to bone on a second side of the fracture includes pressing the second anchor against body tissue disposed between an outer side surface of the bone on the second side of the fracture and the second anchor.

24. A method of treating a fractured bone, said method comprising the steps of moving an anchor connected with a suture through bone on opposite sides of the fracture, tensioning the suture to transmit force from the suture to the anchor with the anchor on a first side of fracture and with the suture extending across the fracture, transmitting force from a suture retainer to bone on a second side of the fracture, and gripping the suture with the suture retainer while transmitting force from the suture retainer to bone on the second side of the fracture and while tensioning the suture.

25. A method as set forth in claim 24 wherein said step of gripping the suture with the retainer includes deforming material of the suture retainer.

26. A method as set forth in claim 24 wherein said step of gripping the suture with the suture retainer includes deforming the suture retainer by applying force against the suture retainer and pressing the suture retainer against the suture under the influence of force applied against the suture retainer.

27. A method as set forth in claim 24 further including the step of moving the suture retainer along the suture into engagement with the bone, said step of transmitting force from the suture retainer to bone on a second side of the fracture includes pressing the suture retainer against the bone on the second side of the fracture.

28. A method as set forth in claim 24 wherein said step of moving an anchor connected with a suture through bone disposed on opposite sides of the fracture is performed with the anchor in a first orientation, said method further including the step of changing the orientation of the anchor from the first orientation to a second orientation after having performed said step of moving the anchor through bone disposed on opposite sides of the fracture and prior to performance of said step of transmitting force from the suture retainer to bone on the second side of the fracture.

29. A method as set forth in claim 24 further including the step of moving a tubular member through bone disposed opposite sides of the fracture, said step of moving an anchor connected with the suture through bone disposed on opposite sides of the fracture includes moving the anchor through the tubular member.

30. A method as set forth in claim 24 further including the step of determining when a predetermined force has been transmitted from the anchor through the suture and gripping the suture with the suture retainer while the predetermined force is transmitted from the anchor through the suture.

31. A method as set forth in claim 24 further including the step of forming a passage which extends through bone on opposite sides of the fracture, said step of moving an anchor connected with a suture through bone disposed on opposite sides of the fracture includes moving the anchor through the passage with the suture connected with the anchor.

32. A method as set forth in claim 24 wherein said step of transmitting force to the anchor with the anchor on a first side of the fracture includes pressing the anchor against an outer side surface of the bone on the first side of the fracture.

33. A method as set forth in claim 32 wherein said step of transmitting force from the suture retainer to bone on a second side of the fracture includes pressing the suture retainer against an outer side surface of the bone on the second side of the fracture.

34. A method as set forth in claim 24 further including the steps of moving a long thin member through the bone disposed on opposite sides of the fracture, moving a drill along the long thin member with the long thin member extending through a passage in the drill, and rotating the drill about its central axis while moving the drill along the long

thin member to enlarge an opening through which the long thin member extends.

35. A method as set forth in claim **34** further including the step of removing the long thin member from the passage in the drill, said step of moving an anchor connected with a suture through bone disposed on opposite sides of the fracture includes moving the anchor through the passage in the drill.

36. A method as set forth in claim **34** wherein said step of moving anchor through the passage in the drill is performed with the anchor in a first orientation in which an axis of the anchor extends along the central axis of the drill, said method further including moving the anchor to a second orientation in which the axis of the anchor extends transverse to the central axis of drill when the drill is disposed in the enlarged opening in the bone.

37. A method as set forth in claim **34** wherein said step of moving an anchor connected with a suture through bone includes moving the anchor through the opening enlarged by moving the drill along the long thin member.

38. A method as set forth in claim **24** wherein the suture has first and second sections which extend from the anchor and across the fracture to the suture retainer, said step of tensioning the suture includes tensioning the first and second sections of the suture.

39. A method as set forth in claim **24** wherein the suture has a single section which extends from the anchor and across the fracture to the suture retainer, said step of tensioning the suture includes tensioning the single section of the suture.

40. A method of attaching a bone fragment to a bone, said method comprising the steps of forming a first hole in the bone fragment, forming a second hole in the bone, positioning a first suture anchor adjacent to a surface of the bone fragment, positioning a second suture anchor adjacent to a surface of the bone, and tensioning a suture extending between the first and second suture anchors through the first and second holes to press the bone fragment against the bone.

41. A method as set forth in claim **40** wherein said steps of forming a first hole in a bone fragment and a second hole in the bone includes forming a first hole having a central axis which is skewed relative to a central axis of the second hole when the bone fragment is pressed against the bone by tension in the suture.

42. A method as set forth in claim **40** further including the step of tensioning fibrous body tissue connected with the bone fragment during tensioning of the suture.

43. A method as set forth in claim **40** wherein said steps of positioning a first suture anchor adjacent to a surface of the bone fragment and positioning a second suture anchor adjacent to a surface of the bone includes moving one of the suture anchors through the first and second holes with the suture connected with the one suture anchor.

44. A method as set forth in claim **43** further including the step of changing the orientation of the one anchor relative to one of the first and second holes after having performed said step of moving the one anchor through the first and second holes.

45. A method as set forth in claim **40** further including the step of determining when a predetermined tension force is being transmitted through the suture and securing the suture against movement relative to the first and second anchors while the predetermined tension force is transmitted through the suture.

46. A method of attaching a bone fragment to a bone, said method comprising the steps of forming a first hole in the bone fragment, forming a second hole in the bone, moving an anchor connected with a suture through the first and second holes to a position adjacent to a surface on one of the bone fragment and bone, tensioning the suture to transmit force from the suture to the anchor, gripping the suture with a suture retainer, and pressing bone fragment against the bone under the influence of force transmitted between the suture retainer and anchor through the suture.

47. A method as set forth in claim **46** wherein said steps of forming a first hole in a bone fragment and a second hole in the bone includes forming a first hole having a central axis which is skewed relative to a central axis of the second hole when the bone fragment is pressed against the bone by tension in the suture.

48. A method as set forth in claim **46** further including the step of tensioning fibrous body tissue connected with the bone fragment during tensioning of the suture.

49. A method as set forth in claim **46** further including the step of changing the orientation of the anchor relative to one of the first and second holes after having performed said step of moving the anchor through the first and second holes.

50. A method as set forth in claim **46** further including the step of determining when a predetermined tension force is being transmitted through the suture and securing the suture against movement relative to the first and second anchors while the predetermined tension force is transmitted through the suture.

51. A method as set forth in claim **46** wherein said step of gripping the suture with the suture retainer includes deforming the suture retainer by applying force against the suture retainer and pressing the suture retainer against the suture under the influence of force applied against the suture retainer.

52. A method as set forth in claim **46** wherein said step of gripping the suture with the retainer includes deforming the material of the suture retainer.

53. A method of positioning a suture anchor relative to a bone, said method comprising the steps of moving a long thin member into the bone, moving a drill along the long thin member with the long thin member extending into a passage in the drill, rotating the drill while moving the drill along the long thin member to enlarge an opening through which the long thin member extends, removing the long thin member from the passage in the drill while the drill remains in the bone, and moving an anchor connected with a suture along the passage in the drill while the drill remains in the opening in the bone.

54. A method as set forth in claim **53** wherein said step of moving the anchor along the passage in the drill is performed with an axis of the anchor in a first orientation relative to a path of movement of the anchor along the passage in the drill, said method further including moving the anchor to an orientation in which the axis of the anchor is in a second orientation relative to the path of movement of the anchor along the passage in the drill.

55. A method as set forth in claim **53** wherein there is a fracture in the bone, said step of moving a long thin member into the bone includes moving the long thin member through bone on opposite sides of the fracture and across the fracture, said step of moving the drill along thin member with the long thin member extending through a passage in the drill includes moving the drill through bone on opposite sides of the fracture and across the fracture.

56. A method of treating a fractured bone, said method comprising the steps of moving a long thin member through bone disposed on opposite sides of the fracture, moving a drill along the long thin member and through the bone

disposed on opposite sides of the fracture with the long thin member extending through a passage in the drill, rotating the drill while moving the drill along the long thin member and through the bone on opposite sides of the fracture with the long thin member extending through the passage in the drill, removing the long thin member from the passage while the drill remains in the bone disposed on opposite sides of the fracture, moving at least one anchor connected with a suture through the passage in the drill along a path which extends through the bone on opposite sides of the fracture, removing the drill from the bone on both sides of the fracture, and tensioning suture to transmit force through the suture and the one anchor to the bone with the suture extending across the fracture.

57. A method as set forth in claim **56** further including transmitting force from a second anchor to bone disposed on a side of the fracture opposite from the one anchor.

58. A method as set forth in claim **56** further including transmitting force from a suture retainer to bone disposed on a side of the fracture opposite from the one side.

59. A method of treating a fractured bone, said method comprising the steps of forming a nonlinear passage which extends across the fracture from bone on a first side of the fracture to bone on a second side of the fracture, moving an anchor connected with a suture through the nonlinear passage, transmitting force from the suture to the anchor with the anchor on the first side of the fracture and with the suture extending through the nonlinear passage and across the fracture, and transmitting force from the suture to the bone at a location disposed between opposite ends of the nonlinear passage.

60. A method as set forth in claim **59** further including the step of securing a second anchor disposed on the second side of the fracture with the suture to transmit force from the second anchor to bone on the second side of the fracture.

61. A method as set forth in claim **59** further including the step of gripping the suture with a suture retainer disposed on the second side of the fracture to transmit force from the suture retainer to bone on the second side of the fracture.

62. A method as set forth in claim **59** wherein said step of forming a nonlinear passage includes moving a drill along a first path and moving a drill along a second path which is skewed relative to and intersects said first path.

63. A method as set forth in claim **59** wherein said step of forming a nonlinear passage includes forming a passage having a first section and a second section which is skewed relative to said first section, said step of moving an anchor through the nonlinear passage includes moving the anchor through the first and second sections of the nonlinear passage.

64. A method of positioning body tissue relative to a bone, said method comprising the steps of moving a first anchor connected with a suture through a passage extending between opposite sides of a bone, tensioning the suture to transmit force from the suture to the first anchor with the first anchor on a first side of the bone, connecting a second anchor with the suture, and transmitting force from the second anchor to the body tissue to press the body tissue against a second side of the bone under the influence of force transmitted from the first anchor through the suture to the second anchor.

65. A method as set forth in claim **64** wherein said step of moving a first anchor connected with a suture through a passage extending between opposite sides of a bone is performed with the first anchor in a first orientation, said method further including the step of changing the orientation of the first anchor from the first orientation to a second orientation after having performed said step of moving the first anchor through the passage and prior to performance of said step of transmitting force from the second anchor to body tissue.

66. A method as set forth in claim **64** further including the step of moving a tubular member through the bone, said step of moving a first anchor connected with the suture through a passage extending between opposite sides of the bone includes moving the first anchor through the tubular member.

67. A method as set forth in claim **64** further including the step of determining when a predetermined force has been transmitted from the first anchor through the suture and securing the suture against movement relative to the second anchor while the predetermined force is transmitted from the first anchor through the suture.

68. A method as set forth in claim **64** further including the step of moving a suture retainer along the suture toward the second suture anchor and deforming material of the suture retainer to grip the suture with the suture retainer adjacent to the second anchor.

69. A method as set forth in claim **64** further including the step of securing the suture relative the second anchor while transmitting force between the first and second anchors through the suture to press the body tissue against the second side of the bone.

70. A method as set forth in claim **69** wherein said step of securing the suture relative to the second anchor includes tying a knot in the suture.

71. A method as set forth in claim **69** wherein said step of securing the suture relative to the second anchor includes deforming a suture retainer to grip the suture with the suture retainer.

72. A method as set forth in claim **64** wherein said step of tensioning the suture to transmit force from the suture to the first anchor includes pressing the first anchor against an outer side surface of the bone on the first side of the bone.

73. A method as set forth in claim **64** wherein the suture has first and second sections which extend from the first anchor to the second anchor, said step of tensioning the suture includes tensioning the first and second sections of the suture.

74. A method as set forth in claim **64** wherein the suture has a single section which extends from the first anchor to the second anchor, said step of tensioning the suture includes tensioning the single section of the suture.

75. A method as set forth in claim **64** wherein said step of transmitting force from a second anchor includes transmitting force from the second anchor to body tissue other than the bone and transmitting force from the body tissue to the bone.

76. A method of positioning body tissue relative to bone, said method comprising the steps of moving an anchor connected with a suture through a passage extending between opposite sides of a bone, tensioning the suture to transmit force from the suture to the anchor with the anchor on a first side of the bone, gripping the suture with a suture retainer, and transmitting force from the suture retainer to the body tissue to press the body tissue against a second side of the bone under the influence of force transmitted from the anchor through the suture to the suture retainer.

77. A method as set forth in claim **76** wherein said step of gripping the suture with the suture retainer includes deforming material of the suture retainer.

78. A method as set forth in claim **76** wherein said step of gripping the suture with the suture retainer includes deforming the suture retainer by applying force against the suture

retainer and pressing the suture retainer against the suture under the influence of force applied against the suture retainer.

79. A method as set forth in claim **76** further including the step of moving the suture retainer along the suture into engagement with the body tissue, said step of transmitting force from the suture retainer to body tissue includes pressing the suture retainer against the body tissue.

80. A method as set forth in claim **76** wherein said step of moving an anchor connected with a suture through a passage extending between opposite sides of the bone is performed with the anchor in a first orientation, said method further including the step of changing the orientation of the anchor from the first orientation to a second orientation after having performed said step of moving the anchor through the passage and prior to performance of said step of transmitting force from the suture retainer to body tissue.

81. A method as set forth in claim **76** further including the step of moving a tubular member through bone, said step of moving an anchor connected with the suture through a passage includes moving the anchor through the tubular member.

82. A method as set forth in claim **76** further including the step of determining when a predetermined force has been transmitted from the anchor through the suture and gripping the suture with the suture retainer while the predetermined force is transmitted from the anchor through the suture.

83. A method as set forth in claim **76** wherein said step of tensioning the suture to transmit force to the anchor includes pressing the anchor against an outer side surface of the bone on the first side of the bone.

84. A method as set forth in claim **83** wherein said step of transmitting force from the suture retainer to the body tissue includes pressing the suture retainer against an outer side surface of the body tissue.

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