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**Knotless suture anchor assembly**

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(56) Related Art  
**US 5074874**  
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ABSTRACT

A knotless suture anchor assembly is used to attach tissue to a bone mass. The assembly includes an anchor (86) adapted to be inserted through the tissue, a suture (88) having one end connected to the anchor (86), and an anchor base member, typically a sleeve (84), connected to the other end of the suture. In use, the sleeve is inserted in the bone mass, and the anchor member is inserted into the sleeve such that the suture element forms a loop encompassing at least part of the tissue. In another embodiment, the knotless suture assembly comprises an anchor (212, 232, 240, 250, 260) for attachment, either directly to the bone mass or to a sleeve inserted in the bone mass, a suture (218, 234, 242, 252, 262) having one end connected to the anchor, and a stop member (222, 236, 244, 254, 264) connected to the other end of the suture element. The anchor member is threaded through the tissue, but the stop member is thicker or wider than the anchor and does not pull through the tissue when the anchor is secured to the bone.



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COMPLETE SPECIFICATION  
FOR A STANDARD PATENT



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Invention Title: KNOTLESS SUTURE ANCHOR ASSEMBLY

The following statement is a full description of this invention, including the best method of performing it known to me:

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**KNOTLESS SUTURE ANCHOR ASSEMBLY  
BACKGROUND OF THE INVENTION**

1. Field of the Invention

5           The present invention relates to devices or assemblies used in tissue repair. More particularly, the assembly enables the attachment together or repair of portions of biological tissue (i.e., tendons or ligaments) onto a bone surface.

10          2. Description of the Background Art

Soft tissues, such as tendons and ligaments, generally are attached to bone by small collagenous fibers. These connections are strong but permit the tendons and ligaments to be flexible. When a tissue is torn away from the bone and requires repair, a surgeon is often required to repair the detached soft tissue with sutures which are passed through bone tunnels and tied. A number of devices have been developed for securing a ligament or tendon to a bone mass. These devices can be used in place of bone tunnelling techniques. These attachment devices are usually inserted through extensive surgical incisions and, in some circumstances, by arthroscopic surgical techniques. The use of bone tunnels for repair can be difficult and generally require large open incisions. Recently, through the advent of endoscopic surgery, where the surgeon looks into a joint cavity with a telescope, there has been a trend to repair soft tissues back to bone through small incisions called portals. The unique knotless suture anchor assemblies described herein facilitate this difficult and precise procedure.

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30          A variety of devices are available for attaching objects to bone, such as screws, staples, cement, suture anchors, and sutures alone. These devices have been used to attach soft tissue, such as ligaments, tendons, muscles, as well as objects such as prostheses, to bone. A suture anchor is a device which utilizes small anchors with suture materials attached thereto.  
35          A device, such as a screw, is inserted into the bone mass and anchored in place. After insertion of the anchor, the attached suture is passed through the tissue to be repaired. The tying of a knot in the suture is then required to secure the tissue to the bone. The process of passing the anchored suture through the

soft tissue and tying a knot is time consuming and difficult to undertake in the tight space encountered during endoscopic surgery and sometimes even in conventional open surgery.

5 One example of a suture anchor assembly is disclosed in U.S. Patent No. 5,370,662, wherein an anchor assembly includes a pre-threaded suture positioned at its posterior. First the anchor is inserted into the bone mass. The attached suture is then passed through the tissue for reattachment. The surgeon is required to tie a knot with the suture to complete the surgical process. 10 Some suture anchors can be passed through the soft tissue first and then into the bone. Most suture anchors need to be inserted into the bone first. Only after this has been accomplished can the sutures be passed through the soft tissue. Alternatives to this procedure include non-suture soft tissue anchor systems. A few of these systems, such as those disclosed in U.S. Patent Nos. 5,013,316 and 4,532,926, can be used arthroscopically but fixation with these devices may not be as secure as that achieved with sutures. Only a few points of fixation are possible with the non-suture type anchor since the device is relatively large. Therefore suture devices are more favorable. This type of non-suture staple device is disadvantageous in that it has been known to crack the bone during deployment, or accidentally transect the object being attached to the bone. In addition, the device itself has been known to crack or break during or after deployment. 15 20 25

U.S. Patent Nos. 5,037,422; 5,224,946; and 5,236,445 all disclose bone anchor configurations for attaching sutures within openings formed in bones during joint reconstructive surgery and endoscopic surgical procedures. With all these intricate procedures, the suture itself must be inserted through a tissue mass and tied with a surgical knot to repair the soft tissue to bone. 30

A primary object of the present invention is to provide a suture anchor assembly which is easy to use and install.

35 Another object of the present invention is to provide a suture anchor assembly which allows for secure attachment of

soft tissue to bone without the use or requirement of tying a knot.

#### SUMMARY OF THE INVENTION

In one broad form, the invention provides a  
5 knotless suture anchor assembly for the attachment of tissue to a bone mass, comprising:

- a) an anchor member adapted to be inserted through the tissue and attached to the bone mass;
- b) a suture element having one end connected to  
10 the anchor member; and
- c) an anchor base member connected to the other end of the suture element and being adapted to be inserted into the bone mass, the anchor member being engageable with the anchor base member.

15 The anchor base member may suitably be a hollow anchoring sleeve which is itself installed directly into the bone mass.

The anchoring sleeve can have a closed pointed drill end or be totally cylindrical in shape. The hollow  
20 anchoring sleeve can be ribbed or threaded on its exterior for secure attachment to the bone, or embody varying types of anchor configurations, such as expandable, wedge-shaped, umbrella-like or prong-like, to facilitate a strong bond with the bone mass. A number of  
25 prior patents disclose configurations for the exterior of a bone anchor which may be used as the anchoring means for the exterior of the hollow anchoring sleeve.

Incorporated by reference are U.S. Patent Nos. 4,007,743; 4,632,101; 4,721,103; 4,870,957; 4,898,156;  
30 4,946,468; 5,084,050; 5,102,421; 5,141,520; 5,192,303 and 5,207,679, which all illustrate varying exterior structures which may be used on the anchoring sleeve portion of the invention. These patents disclose various means and mechanisms for anchoring a device to a bone  
35 mass thus preventing pull-out of the sleeve after insertion into bone.

Further, the hollow anchoring sleeve can have a collar on the rear or outer end thereof to control the

depth of sleeve insertion into the bone and prevent excessive insertion depth.

The suture element is typically connected to one end of the anchor member. The other end can be pointed or frustoconical in shape. The anchor member can be ribbed, beaded, threaded or expandable on its exterior surface for secure mating with the interior wall section of the hollow anchoring sleeve. Further, or in the alternative, the hollow anchoring sleeve may have an interior surface which is threaded or beaded for secure engagement of the anchor member.

In another form, the invention provides a method for the attachment of tissue to a bone mass using the above-described knotless suture anchor assembly, the method comprising the steps of:

- a) inserting the anchor member through the tissue;
- b) inserting the anchor member into the hollow anchoring sleeve such that the suture element forms a loop encompassing at least part of the tissue; and
- c) installing the hollow anchoring sleeve in the bone mass with the anchor member inserted in the sleeve for secure attachment of the tissue to the bone mass.

In another embodiment, the invention provides:

- a) an anchor member for attachment to the bone mass;
- b) a suture element having one end connected to the anchor member;
- c) a stop member connected to the other end of the suture element, the stop member having at least one dimension which is much greater than the thickness of the suture element and/or the anchor member.

The assembly may include a hollow anchoring sleeve which, in use, is inserted into the bone mass. The anchor member is then inserted in the sleeve.

Alternatively, the anchor member may be inserted directly into the bone. For this purpose, the

anchor member may be of any suitable anchor configuration, such as expandable, wedge-shape, umbrella-like or prong-like.

The stop member may be disc-shaped, rod-shaped, 5 ring-shaped, X-shaped, horseshoe-shaped, or of any other suitable shape.

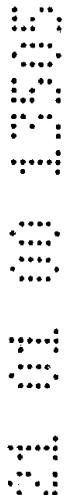
In use, the anchor member is inserted through the tissue, and then into the bone directly or into a hollow anchoring sleeve previously installed in the bone. 10 The stop member is substantially wider than the anchor member so that it does not pull through the aperture in the tissue formed by the passage of the anchor therethrough.

Alternatively, where the stop member is narrow 15 in one dimension, it may be inserted through the tissue and re-orientated so that it is unable to pass back through the insertion path. The anchor member, to which the stop member is attached by the suture element, is then inserted into the bone, or a hollow anchoring sleeve 20 fixed to the bone.

In an alternative method for attachment of the tissue to a bone mass, the anchor member is first inserted through the tissue and into the hollow anchoring sleeve. The sleeve, together with the anchor member 25 therein, is then inserted into the bone mass.

Due to the configuration of the knotless suture anchor assembly, it "captures" the tissue, and secures it to the bone mass when the anchor is inserted into the bone mass (or the hollow sleeve which, in turn, is 30 secured to the bone mass). Endoscopic procedures and some open surgical procedures are extremely difficult and must be completed in a very tight space. Obviation of the need of tying a knot is extremely beneficial and innovative.

35 Various embodiments of knotless suture anchor assemblies will now be described with reference to the accompanying drawings. Not all of the illustrated embodiments are claimed in the following claims. Some of





the illustrated embodiments are claimed in the parent patent application, or in further application(s) divided from the parent application. However, the various knotless suture anchor assemblies are described in this application for completeness and comparative purposes.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Figs. 1a, 1b, 1c and 1d are perspective views of a hollow anchoring sleeve;

Fig. 2 is a perspective view of a spike member with suture element;

Fig. 3 is a perspective view of an alternative spike member with suture element;

Fig. 4 illustrates usage of a hollow anchoring sleeve and a spike member in conjunction with a bone mass and tissue during surgical reattachment;

Fig. 5 illustrates the spike member in place in the hollow anchoring sleeve after attachment of tissue to bone mass has been completed;

Fig. 6 illustrates a knotless suture anchor assembly according to one embodiment of the invention;

Fig. 7 illustrates the procedure for attachment of tissue to bone mass using the knotless suture anchor assembly of Fig. 6;

Fig. 8 illustrates the knotless suture anchor assembly of Fig. 6 showing tissue attached to bone;

Fig. 9 illustrates the spike components for an alternative knotless suture anchor assembly;

Fig. 10 is a partial exploded view of the spike components of Fig. 9 and hollow anchoring sleeves inserted through soft tissue and mated together for attachment of tissue to bone mass;

Fig. 11 is an illustration of the knotless suture assembly of Figs. 9 and 10 wherein tissue is attached to a bone mass in a secure manner;

Fig. 12 illustrates an alternative spike member with suture element;

Fig. 13 illustrates the spike member of Fig. 12 in conjunction with a bone mass and tissue during

surgical reattachment;

Fig. 14 illustrates an alternative knotless suture assembly;

Fig. 15 illustrates the knotless suture assembly of Fig. 14 in conjunction with a bone mass and tissue during surgical reattachment;

Fig. 16 is an enlarged perspective view of a harpoon anchor;

Fig. 17 is an enlarged perspective view of an umbrella-like anchor;

Fig. 18 is an enlarged perspective view of a ribbed anchor;

Fig. 19 is an enlarged perspective view of wedge-like anchor;

Fig. 20 is an enlarged perspective view of a threaded anchor;

Fig. 21 is an enlarged perspective view of a pronged anchor;

Figs. 22a and 22b are perspective views of spike members with suture element and stop means;

Figs. 23a and 23b are perspective views of spike members with suture element and alternative stop means;

Figs. 24a and 24b are perspective views of spike members with alternative suture element and stop means;

Figs. 25a and 25b are perspective views of spike members with suture element and alternative stop means;

Figs. 26a and 26b are perspective views of spike members with suture element and alternative stop means;

Fig. 27 illustrates the procedure for attachment of tissue to bone mass for the knotless suture assembly of Fig. 22b;

Fig. 28 illustrates the procedure for attachment of tissue to bone mass for the knotless suture assembly of Fig. 22a; and

Fig. 29 illustrates one procedure for attachment of tissue to bone mass for the knotless suture assembly of Fig. 23b.

#### DETAILED DESCRIPTION OF EMBODIMENTS

5 Referring now to Fig. 1, a knotless suture anchor assembly has a hollow anchoring sleeve for installation and attachment to a bone mass. The hollow anchoring sleeve 1, as shown in Fig. 1a, is cylindrical in shape and possesses ribs or threads on its exterior.

10 The device can also contain or be configured with prongs, umbrella spokes, have threads, be expandable, or have wedges, on its exterior, for secure attachment with the bone mass. These exterior attachment features are known to the industry and incorporated herein by reference.

15 Fig. 1b illustrates an alternate embodiment of the hollow anchoring sleeve 2 having a collar 3 to control depth of bone penetration. The collar prevents the sleeve from being forced too deep into the bone mass when the spike or plug member is inserted.

20 Fig. 1c illustrates an alternate embodiment of the hollow anchoring sleeve 4 wherein the sleeve has a pointed closed end 5 for ease of penetration into a bone mass.

25 Fig. 1d illustrates a hollow anchoring sleeve 7 with a collar 6 and a closed pointed end 8 as an alternate construction.

The hollow anchoring sleeve may also be shaped or configured with any suitable means to secure said structure to a bone mass. The hollow anchoring sleeve 30 may include a threaded exterior as disclosed in U.S. Patent No. 5,370,662, incorporated herein by reference. Further, the device may be expandable as disclosed in U.S. Patent No. 5,084,050 incorporated herein by reference. A configuration such as disclosed in U.S. 35 Patent Nos. 5,037,422; 5,224,946; and 5,236,445 are also contemplated by the invention and these disclosures are incorporated by reference. Harpoon configurations such as disclosed in U.S. Patent Nos. 5,141,520 and 5,102,421

are also contemplated for the hollow anchoring sleeve and incorporated herein by reference.

The anchoring sleeve may also be configured in a harpoon-type fashion such as disclosed by U.S. Patent  
 5 Nos. 4,632,101 and 4,721,103 for secure anchoring within the bone mass. U.S. Patent Nos. 4,898,156; 5,207,679; 4,946,468; and 5,192,303 disclose anchoring mechanisms which can be utilized for the hollow sleeve member for installation within a bone mass. These patents are  
 10 incorporated by reference and fall within the contemplation of the present invention for methods or means for anchoring to the bone mass. It is also within the contemplation of the present invention to configure this dowel-like hollow sleeve in any suitable fashion to  
 15 securely attach same to a bone mass.

The interior surface of the hollow anchoring sleeve is ribbed, beaded, threaded, expandable or smooth for secure engagement with said exterior surface of said spike member.

In addition to a sleeve as illustrated in Fig. 1, the knotless suture anchor assembly includes an anchor member and suture element. Fig. 2 shows a perspective  
 20 view of an anchor member in the form of a spike plug member, with attached suture element. Spike or plug member 12 is preferably cylindrical in shape with a sharp first end 14 and a second end 16 wherein the suture  
 25 element 18 is attached.

The suture element 18 has at its distal end a loop or ring 22. The loop or ring portion 22 can be  
 30 constructed of the same suture material as suture element 18 or it can be a separate molded material attached to the suture element 18 and loop portion 22 may be one molded component and attached to spike member 12 at end 16 or they may be all (spike, suture element and loop  
 35 portion) one entire molded component. Further, the suture element 18, alone, can be made from any type suture material which has been approved for surgical procedures for attachment of tissue to bone.

The spike or plug member can form any shape so long as it mates with the hollow cylindrical sleeve as described above. The exterior of the spike or plug member 12 may be ribbed or threaded 24 as depicted in 5 Fig. 2 or may be beaded or expandable to allow for a secure tight fit with the inner hollow cylinder of the anchoring sleeve. Once inserted into a hollow anchoring sleeve, the exterior surface of the spike or plug member 12 engages the inner surface of the sleeve and can be 10 ratcheted down to produce the desired tight fit. This ratcheting effect allows for fine tuning and tightening of the soft tissue to the bone during repair.

The length of the suture connection 18 is variable and may be adjusted prior to selection of a tool or during surgical procedure through any appropriate means. Likewise, the diameter of the loop 22 is adjustable and may be replaced by one long strip of suture-like material, or molded strip, 26 having a slot or hole 28 for insertion of the spike or plug member once 20 it has been passed through a tissue for attachment.

Fig. 3 illustrates an alternative version of the spike member, with suturing material. The spike member 32 has attached at its rear end one complete loop of suture 34 which also has an adjustable diameter for various thicknesses of tissue reattachment. 25

Referring now to Fig. 4, there is illustrated a process for reattachment of tissue to bone mass. Bone mass 42 has a slot or hole 44 wherein a hollow anchoring sleeve 46 has been inserted. A tissue 48 has inserted therein a spike member 52 threaded through loop 54 for reattachment to the bone mass 42. 30

Fig. 5 depicts the knotless suture anchor assembly in place after the surgical procedure has been completed. Bone mass 62 has tissue 64 attached or reattached thereto. 35

The surgical procedure for reattaching or attaching tissue to bone mass includes first installation of the hollow anchoring sleeve 66. Secondly, the spike

member 68 is inserted through the tissue 64 and then through at least one loop portion 72 to form a securing loop encompassing at least some of the tissue. The spike 68 with tissue 64 securely attached thereto is then secured directly into the anchoring sleeve 66 for attachment of tissue 64 to bone mass 62.

Referring now to Fig. 6, there is illustrated an alternate knotless suture anchor system 82 according to a first embodiment of the invention. There is disclosed a hollow anchoring sleeve 84 having attached thereto a spike or plug member 86 by a suture element 88. The hollow anchoring sleeve 84 may take the shape or form of almost any type of anchor device. All the patents listed above are incorporated by reference. Configurations of the hollow anchoring sleeve having a collar, as well as a configuration incorporating any type of umbrella expansion means or threading on the exterior or interior of the sleeve are contemplated. Further, the spike or plug member 86 is preferably threaded on its exterior with a pointed end for insertion through a tissue element. This may take the form of any structure and preferably has an exterior which is ribbed, beaded, threaded, smooth or expandable. Likewise, the suture element 88 may be made of any acceptable surgical suture material and in addition is lengthened based upon thickness and need requirements.



Referring now to Fig. 7, there is depicted the initial step in a process for attachment of tissue to bone utilizing the alternate knotless suture assembly of Fig. 6. A spike member 96 is inserted through a tissue 94 and into a hollow anchoring sleeve 98. The assembly is then attached to a bone mass 92.

Referring now to Fig. 8, there is disclosed the completed attachment or reattachment of tissue 102 to bone mass 104. The spike or plug member 106 is inserted through said tissue 102 and then inserted into hollow anchoring sleeve 108 for complete attachment to bone mass 104 at a previously drilled section 110. This enables

one to surgically reattach the tissue 102 to bone mass 104 in a virtual one step process.

Additionally, the process embodiment by Fig. 8 may be undertaken in two steps. First, the spike member 5 106 is inserted through the soft tissue 102 and into the hollow anchoring sleeve 108.

Secondly, the entire assembly 112, spike member 106 which has been inserted into the sleeve 108, is inserted into the bone mass 104. Regardless of the 10 process used, the repair tightness is adjusted by the depth of anchor insertion into bone and/or the ratcheting effect of the spike in the anchor sleeve.

Fig. 9 depicts an alternate knotless suture anchor assembly. First and second spike or plug assembly 15 members, 120 and 130, respectively, are depicted for the knotless suture anchor assembly. There is disclosed first spike or plug assembly member 120 having spike means 121 for insertion into a hollow anchoring sleeve as depicted in Figs. 1a - 1d. Spike or plug member 121 is 20 preferably threaded with a pointed end for insertion through a tissue element and secure fixation with said hollow anchoring sleeve. The spike or plug member may take the form of any suitable structure and preferably has an exterior which is ribbed, threaded, beaded, expandable or smooth. The diameter or thickness of the 25 member is preferably equal to or incrementally less than the entire diameter of the hollow anchoring sleeve for a secure fit. In situations where ribs, threads, beads, or the like, are utilized on the spike member, the diameter of the member with protrusions may initially exceed the 30 inner diameters of the hollow anchoring sleeve and would deform upon insertion.

The rear end 122 of the spike member 121 has attached or tied thereto a suture element 123. The 35 suture element 123 has attached or molded therewith a catch device, such as a ring element, 124 which is preferably rigid. The spike member 121, suture element 123 and catch device (ring element) 124 may be made of

separate materials or molded together as one piece. In addition, the spike member 121 and suture element 123 may be molded as one element or the suture element 123 and catch device (ring element) 124 may be molded as one  
 5 element.

Second spike assembly member 130 includes a spike or plug member 131 for insertion into a hollow anchoring sleeve as depicted in figs. 1a - 1d. The element 131 is described above and can be the same or  
 10 different as spike element 121. To the rear end 132 of the spike member 131 there is tied or attached a suture element 133. The suture element 133 has attached or molded therewith a spherical, or the like, stop means  
 134.

As stated above, the three components, spike member 131, suture element 133 and stop means 134 can be combined as separate components or molded together as one entire component or a combination of two components.  
 15

Referring now to Fig. 10, first spike assembly member 120 is inserted into tissue 140. The spike member 121 can be inserted into a hollow anchoring sleeve 142 either before or after the hollow anchoring sleeve 142 is inserted into bone mass 150. Spike member 131, of spike member assembly 130, is inserted through catch device  
 20 (ring element) 124, of spike member assembly 120. The spike member 131 is then inserted through tissue 140 and then into hollow anchoring sleeve 144, or directly into hollow anchoring sleeve 144. The hollow anchoring sleeve 144 can be anchored to bone mass 150 before or after  
 25 spike member 131 has been inserted therein. The stop means 134 mates with catch device (ring element) 124 dragging the tissue into a secure fit with bone mass 150 (see Fig. 11).

Once the spike members have been inserted into the hollow anchoring sleeves they can be ratcheted down to a desired depth to adjust the tightness of the soft tissue repair to bone mass. Tightness can also be adjusted by the depth of anchor sleeve insertion into the  
 35



bone mass.

Stop means 134 may be spherical with a diameter greater than catch device (ring element) 124, or may be any shape which would facilitate a mating with the catch device. Likewise, the catch device need not be circular, but requires only an opening to allow passage of a spike member and prevent passage of the stop means. The catch device 124, depicted in Figs. 10 and 11, can take the form of a ring, square, slot, or any shape that will cooperate and hold stop means 134 from being pulled therethrough.

Knotless suture anchor assembly 150 shown in Fig. 12 includes a spike/anchor means 152, a suture element 154, and a loop portion 156. As discussed above, the suture element 154 and loop portion 156 may be made of the same or different materials. In addition, the spike/anchor means 152 can be molded with the suture element 154 and loop portion 156 as one piece or as separate components, as desired. The spike/anchor means can be configured, as desired, to securely attach the assembly 150 to a bone mass. The spike/anchor means may include all the attachment means as described above for the hollow anchoring sleeve such as harpoon type means 158, prongs, umbrella spokes, threads, wedges or the like.

Additionally, the entire suture element 154 may be configured in a complete loop as depicted in Fig. 3, or may merely have a slit along its length as depicted in Fig. 2.

When performing a procedure, loop portion 156 is pulled through soft tissue 160. Once the loop portion 156 has been pulled through the soft tissue 160, the spike/anchor means 152 is inserted through the loop portion 156 and directly into bone mass 170 for attachment of tissue 160 to bone mass 170. The length of suture 154 and depth of insertion of the spike/anchor means 152 controls the secure tightness of repair of tissue 160 to bone mass 170, and is adjusted as desired.

Fig. 14 depicts an alternative knotless suture system. A first knotless suture anchor assembly 180 is provided as described in accordance with knotless suture anchor assembly 150, as depicted in Fig. 12. The loop 5 181 functions as a catch device. A second knotless suture anchor assembly 185 is also provided to be used in conjunction with assembly 180 to perform a surgical attachment of tissue to bone. The anchor assembly 185 has a stop means 187.

10 First the catch device 181 is inserted through soft tissue 190 from the underside of the tissue first (see Fig. 15). Then a spike/anchor means 182 of assembly 180 is inserted into the bone mass 192. Next, a spike/anchor means 186 (with bone anchoring features) is 15 threaded through catch device 181 and inserted into bone mass 192. Stop means 187 mates or engages with catch device 181 and the sutures 183 and 188 are pulled taut to securely attach soft tissue 190 to bone mass 192.

20 Figs. 22 to 29 illustrate further embodiments of this invention.

Fig. 22, including 22a and 22b, shows perspective views of spike plug members with suture element and stop means, of the two-piece and one-piece versions, respectively. Spike or plug member 212 is 25 preferably cylindrical in shape with a sharp first end 214 and a second end 216 wherein the suture element 218 is attached. The suture element 218 has at its distal end a disc-like stop means 222. The stop means 222 can be constructed of any suitable material. The stop means 30 222 and suture 218 may be one molded component attached to spike member 212 at end 216. Further, the suture element 218, alone, can be made from any type suture material which has been approved for surgical procedures or a molded material for attachment of tissue to bone.

35 The spike or plug member can form any shape so long as it mates with the hollow cylindrical sleeve as described above. The exterior of the spike or plug member 212 may be ribbed or threaded 224 as depicted in Fig. 22

or may be beaded or expandable to allow for a secure tight fit with the inner hollow cylinder of the anchoring sleeve. Once inserted into a hollow anchoring sleeve, the exterior surface of the spike or plug member 212 engages the inner surface of the sleeve and can be ratcheted down to produce the desired tight fit. The interface of the spike and sleeve allows for movement of the spike in only one direction and resists pullout or movement out of the sleeve. This ratcheting effect allows for fine tuning and tightening of the soft tissue to the bone during repair. The length of the suture connection 218 is variable and may be adjusted prior to selection of a tool or during surgical procedure through any appropriate means. Likewise, the diameter of the disc-like stop means 222 is adjustable.

Fig. 22b is identical to 22a but for anchoring means 226 attached to the spike or plug member 228. This one-piece version allows for tissue reattachment without an anchoring sleeve. The spike or plug member anchors directly into the bone mass.

Fig 23 illustrates alternative versions of the spike member with suturing material and stop means. In Fig. 23a, the spike member 232 has attached at its rear a suture 234 and a rod-like stop means 236. This functions as a one-piece anchor. Fig. 23b illustrates the spike or plug member of the two-piece version when used in combination with an anchoring sleeve.

Fig. 24 illustrates alternative versions of the spike member with suturing material and stop means. In Fig. 24a, the two-piece embodiment, spike member 240 has attached thereto at least one suture means 242 connected to a stop means 244 configured in the shape of a ring or hoop. Fig. 24b illustrates the one-piece embodiment wherein anchoring means 246 is attached to the spike or plug member 248 for attachment to bone without an anchoring sleeve.

Fig. 25 contains alternate embodiments 25a and 25b. Fig. 25a, the two-piece embodiment, includes a spike

means 250, a suture means 252 attached thereto, and an X-like stop means 254. Fig. 25b, the one-piece embodiment, illustrates an embodiment of the configuration wherein anchoring means 256 is attached to the spike or plug means 258 for attachment to bone when an anchoring sleeve is not utilized.

Fig. 26 contains Figs. 26a and 26b which are alternative embodiments. Fig. 26a illustrates a spike member 260, suturing means 262 attached thereto, and a stop means 264 configured in a horseshoe configuration. Fig. 26b illustrates an alternative version of the horseshoe configuration wherein the spike or plug member 266 has anchoring means 268 attached thereon for direct attachment to bone without the utilization of an anchoring sleeve.

Referring now to Fig. 27 and Fig. 28, there is illustrated a surgical procedure for reattaching or attaching tissue to bone depicting the spike or plug embodiments illustrated in Fig. 22. The procedure can be used with any of the embodiments outlined in figs. 22, 23, 24, 25 and 26. Fig. 27 illustrates the procedure wherein an anchoring sleeve is not utilized. Spike or plug means 270 having anchoring means 272 is inserted through tissue 274 and directly into bone 276. The stop means 278 grabs the tissue 274 and pulls same back into reattachment or attachment with bone 276 when the spike or plug member is forced into the opening in the bone. The tightness of the repair is adjusted by the length of suture 270 and/or the depth of the insertion of spike member 272 into the bone mass.

Fig. 28 depicts a procedure wherein an anchoring sleeve 280 is first inserted into bone mass 282. Subsequent to the insertion of the anchoring sleeve 280, a spike or plug member 286 is inserted through tissue 284 and into the anchoring sleeve 280. The spike or plug member 286 is then ratcheted down into the anchoring sleeve 280 to pull tissue mass 284 into direct and secure mating with bone mass 282.

Referring now to Fig. 29, there is an alternative surgical procedure disclosed for utilization of the rod-like stop means depicted in Fig. 23. Initially the rod-like stop means 290 is inserted through tissue mass 292. Once the rod-like stop means rests on top of the tissue mass, the spike or plug member 294 is then inserted into a previously inserted anchoring sleeve 296. The spike or plug member 294 is then ratcheted down into the anchoring sleeve for secure mating or attachment of the tissue 292 to the bone mass 300. This procedure may also be undertaken with the one-piece anchor having a spike or plug means as depicted in Fig. 23a which omits the initial insertion of an anchoring sleeve.

In addition to the shapes illustrated for the stop or catch means portion, the stop means can be any planar or non-planar shape such as, but not limited to, C-shaped, planar with one or more openings, bar-shaped, curved or non-planar bar-shaped. Further the stop means is attached to the spike or plug member by one or more suture elements. The suture element or connection can be made up of a known suture material such as Ethibond® or Prolene®, or it can be made of polymer materials such as ultrahigh molecular weight polyethylene. The connection or suture element can be formed of bio-absorbable materials such as a polylactide polymer. Additionally, the suture element can be part of the stop means and formed by a molding process or the like.

The suture element can be connected to the stop means and an anchor in a variety of ways such as fusion or molding or by mechanical means such as glue, a weld or by mere tying.

In many situations throughout the discussion above, the terminology "secure attachment of soft tissue to bone" has been used. Such terminology refers to the attachment or reattachment of tissue to bone through the insertion of a spike member into a hollow anchoring sleeve or a spike/anchor means into a bone mass. In the former situation, the spike member can seat into the

sleeve in a one step mating procedure or be inserted and ratcheted down in a step wise fashion into the sleeve. Either situation will function effectively and selection is based upon the instant facts of the surgical procedure. Further, the sleeve itself may be seated in the bone mass at varying depths. Again, such depth is a selection based upon the facts of the instant procedure.

In the latter situation, where a spike/anchor means is used, depth of insertion of the device into the bone is a selection or choice of the surgeon during the procedure.

In all situations, the spike member or spike/anchor means is designed not to back up or exit once mated with the sleeve, ratcheted down into the sleeve, or inserted into the bone mass to avoid and prevent withdrawal therefrom.

It is also within the contemplation of the invention to make the spike or plug member for a direct insertion into the bone with screws, prongs, spikes, a wedge means or any means wherein the spike or plug member anchors securely into the bone mass facilitating attachment or reattachment of tissue to skin.

Further, the spike or plug member or a portion of the spike or plug member may be made with bioabsorbable material.

While various embodiments of the invention in a knotless suture anchor system have been shown and described herein, it should be understood that the present disclosure is made by way of example only and that variations to the structures shown and their use are possible within the scope of this disclosure without departing from the scope of the following claims.

Throughout this specification and claims, unless the contrary intention appears, the term "comprising" is used in the inclusive sense, i.e. to include the stated integers or steps without necessarily excluding other integers or steps.

## THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A knotless suture anchor assembly for the attachment of tissue to a bone mass, comprising:
- 5 a) an anchor member adapted to be inserted through the tissue and attached to the bone mass;
- b) a suture element having one end connected to the anchor member; and
- c) an anchor base member connected to the other  
10 end of the suture element and being adapted to be inserted into the bone mass, the anchor member being engageable with the anchor base member.
2. A knotless suture anchor assembly as claimed in claim 1 wherein the anchor base member is a hollow  
15 anchoring sleeve.
3. A knotless suture anchor assembly as claimed in claim 2, wherein the anchor member has an exterior surface which is ribbed, threaded, or expandable, for secure engagement of the anchor member with the hollow  
20 anchoring sleeve.
4. A knotless suture anchor assembly as claimed in claim 2 or 3, wherein the hollow anchoring sleeve has an exterior surface which is ribbed, threaded expandable, wedge-shaped, umbrella-like or prong like, for secure  
25 engagement of the sleeve with the bone mass.
5. A knotless suture anchor assembly as claimed in any one of claims 2 to 4, wherein the hollow anchoring sleeve has an interior surface which is threaded, beaded, or smooth for secure engagement of the anchor member.
- 30 6. A knotless suture anchor assembly as claimed in any one of claims 2 to 5, wherein the hollow anchoring sleeve has a collar at one end thereof to facilitate flush engagement with the bone mass.
7. A method for the attachment of tissue to a bone  
35 mass utilising said assembly as claimed in any one of claims 2 to 6, comprising the steps of:
- a) inserting the anchor member through the tissue;

b) inserting the anchor member into the hollow anchoring sleeve such that the suture element forms a loop encompassing at least part of the tissue; and

c) installing the hollow anchoring sleeve in the bone mass with the anchor member inserted in the sleeve for secure attachment of the tissue to the bone mass.

8. A method for the attachment of tissue to a bone mass as claimed in claim 7, wherein the anchor member is inserted in the sleeve by ratcheting down the anchor member into the hollow anchoring sleeve to a desired depth.

9. A knotless suture anchor assembly for attachment of tissue to a bone mass, the assembly comprising:

a) an anchor member for attachment to the bone mass;

b) a suture element having one end connected to the anchor member;

c) a stop member connected to the other end of the suture element, the stop member having at least one dimension which is much greater than the thickness of the suture element and/or the anchor member.

10. A knotless suture anchor assembly as claimed in claim 9 further comprising a hollow anchoring sleeve adapted to be inserted into the bone mass, the anchor member being engageable with the sleeve.

11. A knotless suture anchor assembly as claimed in claim 10, wherein the anchor member has an exterior surface which is smooth, ribbed, threaded, or expandable for secure engagement of the anchor member with the hollow anchoring sleeve.

12. A knotless suture anchor assembly as claimed in claim 10 or 11, wherein the hollow anchoring sleeve has an exterior surface which is ribbed, threaded, or smooth for secure engagement of the sleeve with the bone mass.

13. A knotless suture anchor assembly as claimed in any one of claims 10 to 12, wherein the hollow anchoring



sleeve has an interior surface which is ribbed, threaded, or beaded for secure engagement of the anchor member.

14. A knotless suture anchor assembly as claimed in any one of claims 10 to 13, wherein the hollow anchoring sleeve has a collar at one end thereof for facilitating flush engagement of the hollow anchoring sleeve with the bone mass.

15. A knotless suture anchor assembly as claimed in any one of claims 9 to 14, wherein the stop member is disc-shaped, rod-shaped, ring-shaped, x-shaped, or horseshoe-shaped.

16. A method for the attachment of tissue to a bone mass utilising the assembly as claimed in any one of claims 10 to 15, comprising the steps of:

a) installing the hollow anchoring sleeve in the bone mass; and

b) inserting the anchor member through the tissue and then into the hollow anchoring sleeve.

17. A method as claimed in claim 16, further comprising the step of:

c) ratcheting down the anchor member into the hollow anchoring sleeve to a desired depth for secure attachment of the tissue to the bone mass.

18. A method for the attachment of tissue to a bone mass utilising the assembly as claimed in any one of claims 10 to 14 comprising the steps of

a) installing the hollow anchoring sleeve in the bone mass;

b) inserting the stop member completely through the tissue and reorientating it so that it is unable to pass back through the insertion path; and

c) inserting the anchor member into the hollow anchoring sleeve.

19. A method as claimed in claim 18, further comprising the step of:

d) ratcheting down the anchor member into the hollow anchoring sleeve to a desired depth for secure attachment of the tissue to the bone mass.

20. A method for the attachment of tissue to a bone mass utilising the assembly as claimed in claim 9, comprising the step of:

5 a) inserting the anchor member through the tissue and then into the bone mass.

21. A method for the attachment of tissue to a bone mass utilising the assembly as claimed in claim 10, comprising the step of inserting the anchor member through the issue and then into the hollow anchoring sleeve and then inserting the hollow anchoring sleeve with the anchor member therein into the bone mass.

10 22. A knotless suture anchor assembly substantially as hereinbefore described with reference to Figs.6-8 or Figs. 23-27 of the accompanying drawings.

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DATED this 21<sup>st</sup> day of January 2000

RAYMOND THAL

By his Patent Attorneys

Cullen & Co.

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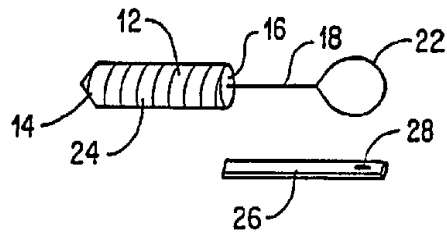
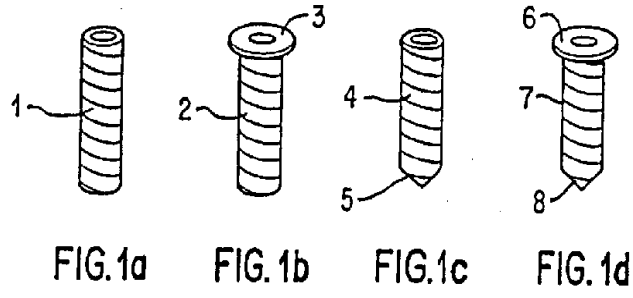


FIG. 2

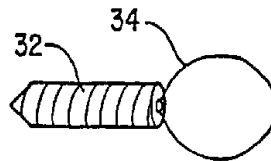


FIG. 3

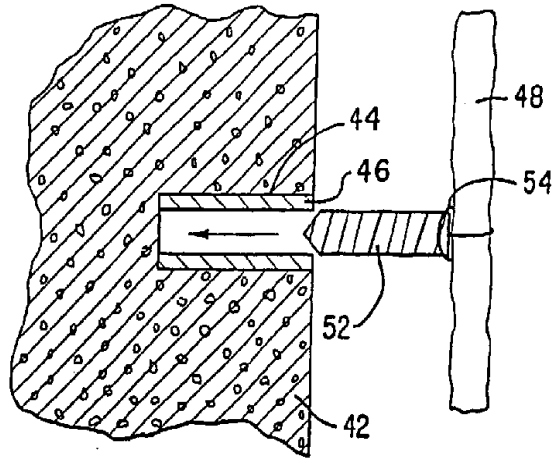


FIG. 4

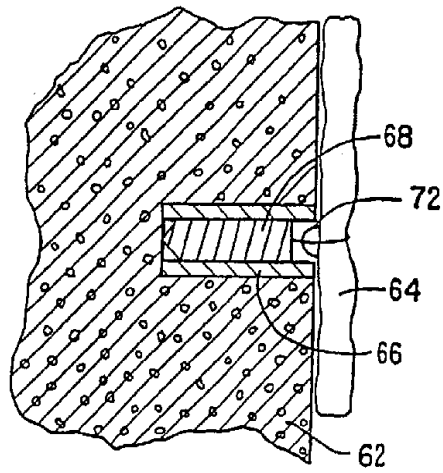
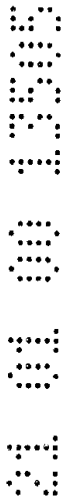


FIG. 5

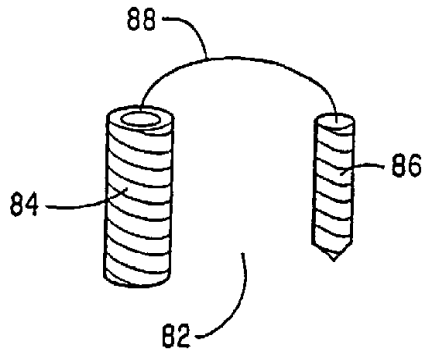


FIG. 6

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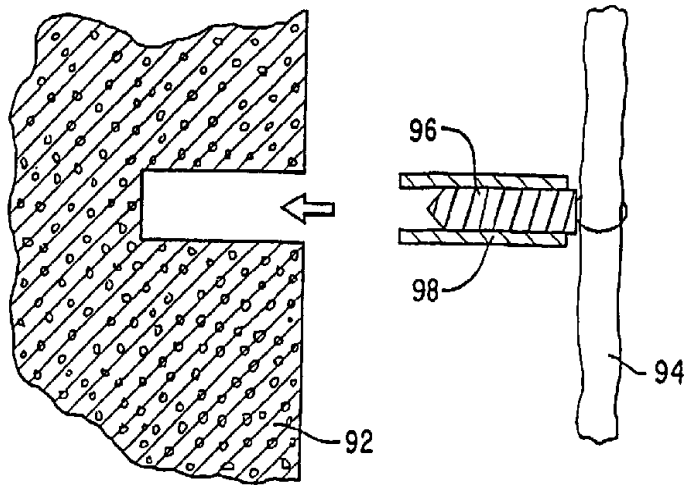


FIG. 7

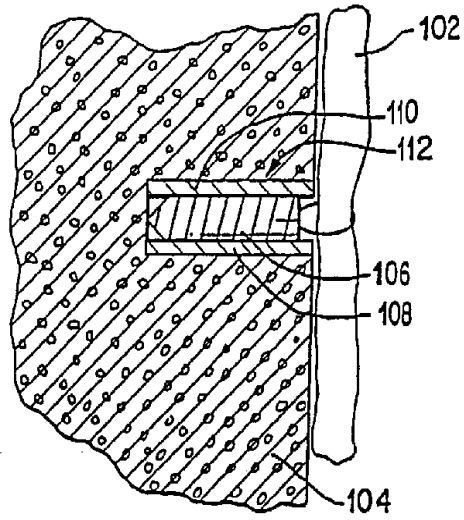


FIG. 8

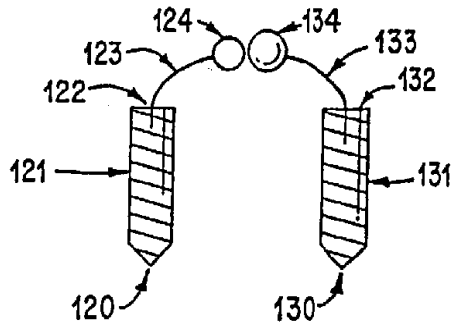


FIG. 9

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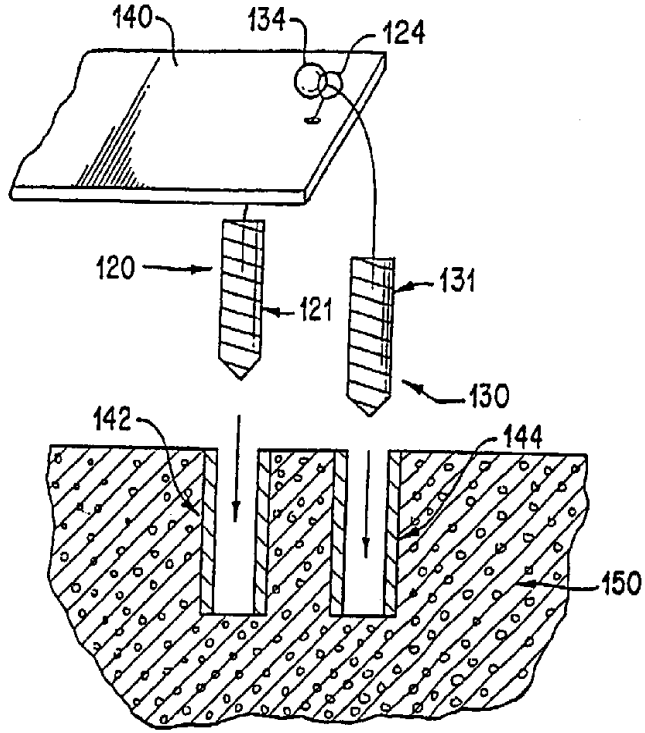


FIG. 10

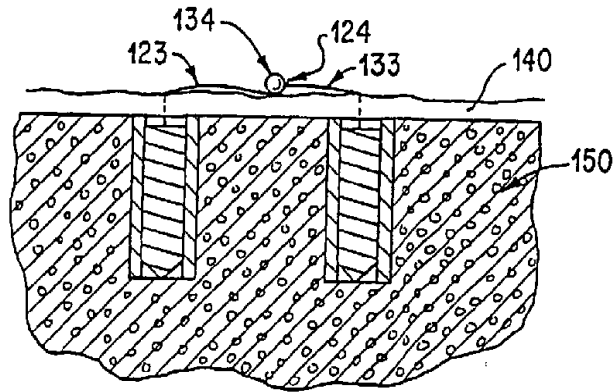


FIG. 11

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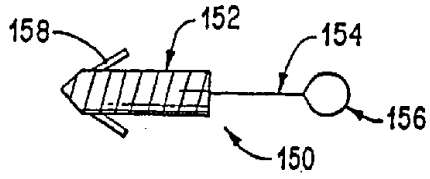


FIG. 12

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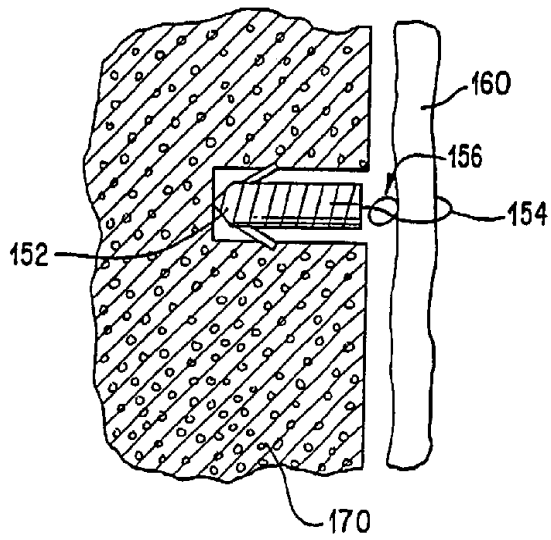


FIG. 13



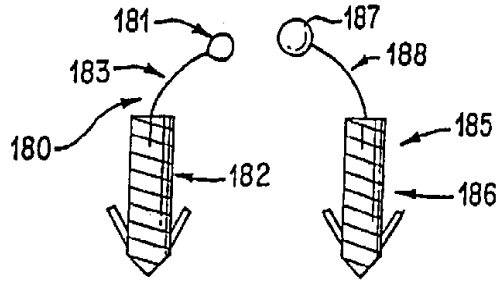


FIG. 14

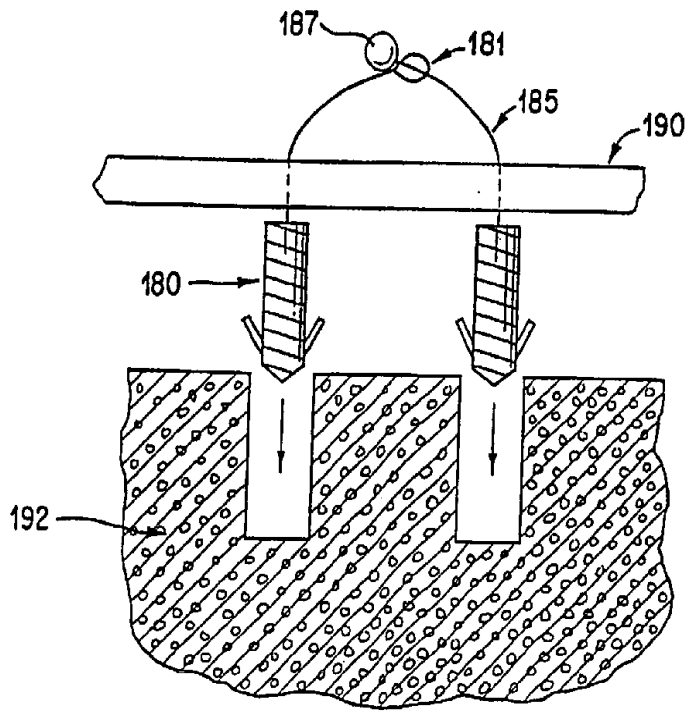


FIG. 15

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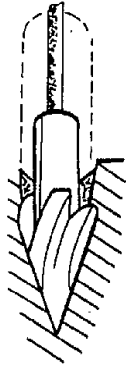


FIG. 16

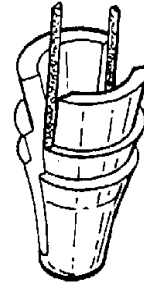


FIG. 17

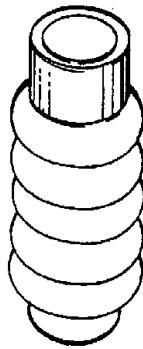


FIG. 18

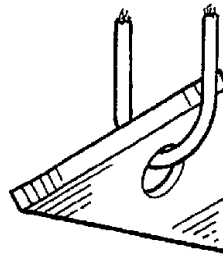


FIG. 19

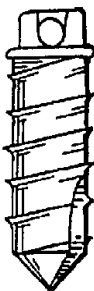


FIG. 20

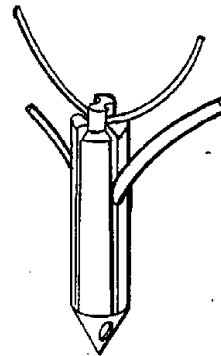


FIG. 21

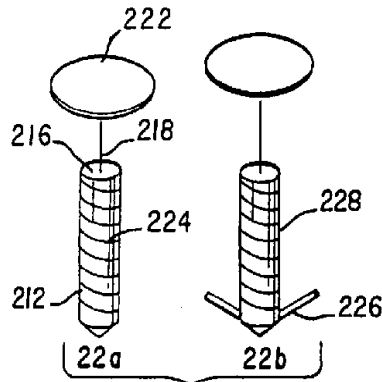


FIG. 22

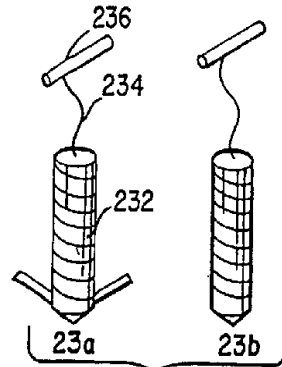


FIG. 23

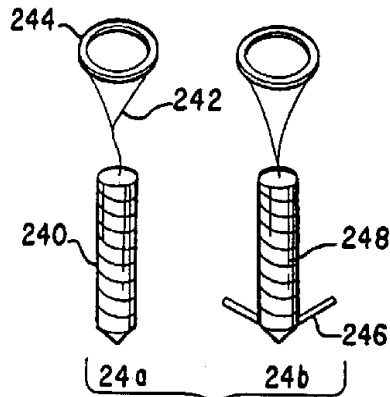


FIG. 24

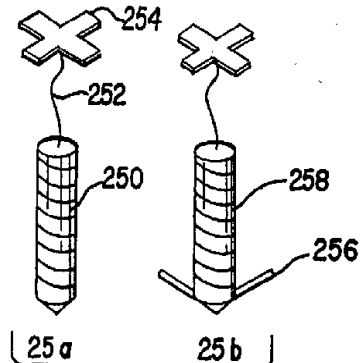


FIG. 25

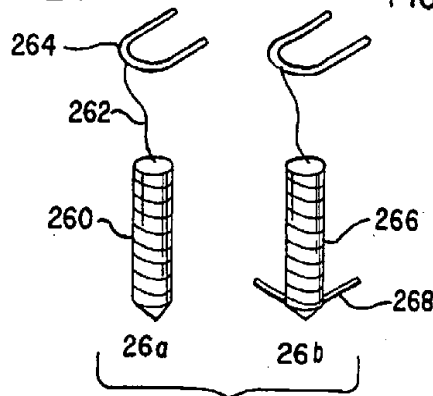


FIG. 26



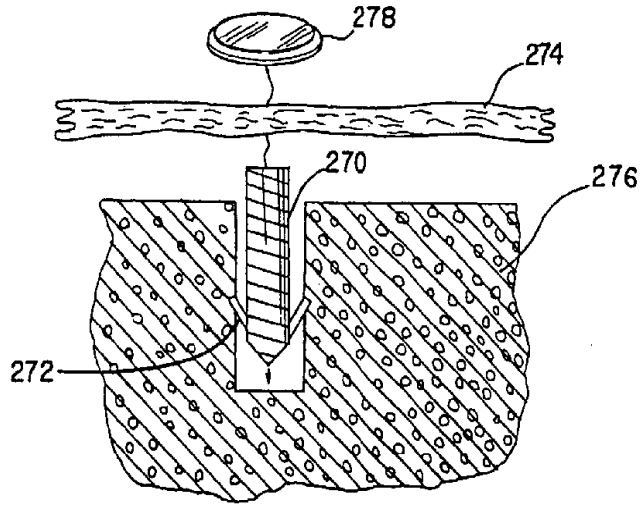


FIG. 27

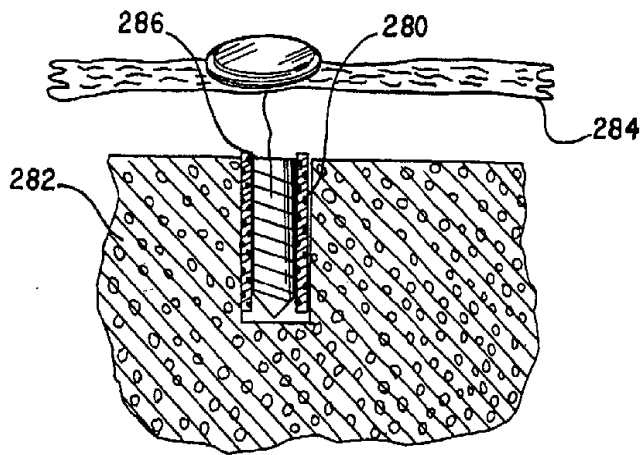
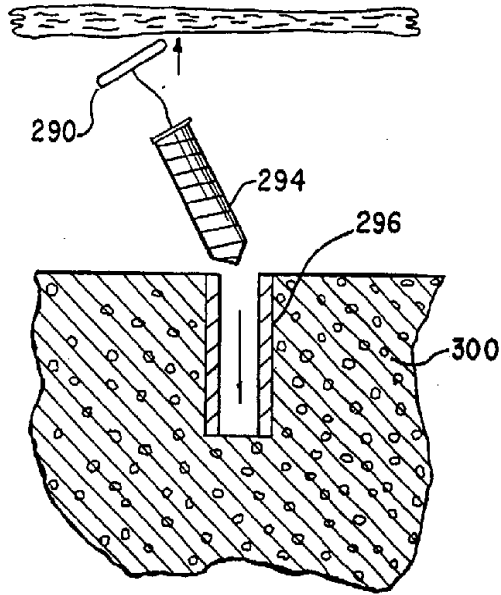


FIG. 28

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FIG. 29