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(54) Title: SUTURE ATTACHMENT METHOD AND APPARATUS

(57) Abstract: A bone anchor has a central bore allowing for uniquely attaching a suture thereto. The bore is shaped so that it is wider at the bottom of the anchor than at the top of the anchor. A peg fits within the bore. The suture is looped around the peg and the peg is inserted into the bore. Friction between the bore, peg and suture holds the suture in place. A suture for use with the bone anchor may be formed by fusing together the ends of a plurality of fibers to form a loop.
SUTURE ATTACHMENT METHOD AND APPARATUS

TECHNICAL FIELD (field of the invention)

The present invention relates to a bone screw and a method and apparatus for attaching sutures to a bone screw or bone anchor. More particularly, it relates to a method and apparatus for attaching a suture to a bone screw or bone anchor having a central hole.

BACKGROUND OF THE INVENTION

There are a variety of anchors used to fix the ends of an ACL prosthesis into bones. Most commonly, they are so-called interference screws, designed to be inserted along the prosthesis (transplanted tendon or ligament, or an artificial ligament) within an anchor hole, or tunnel, drilled in the bone. The interference screw jams the prosthetic tissue against the bone within the anchor hole. Another common technique is so-called cross-pin used to anchor a loop of the prosthetic tissue within a hole drilled in the femoral condyle. In all cases, prosthetic tissue exits the tunnel by bending over the edge of the bone; healing/remodeling of the bone is expected to fill the gaps and to result in a natural-like anchorage of the ligament in the bone. Neither of these techniques is suitable for a permanent anchorage of an artificial ACL replacement.

Bending of the prosthesis over the edge of the hole will lead to both, bone loss due to contact resorption and mechanical damage —ultimately failure —of the prosthesis due to bending and wear at the edge of the hole.

The present inventor has an improved apparatus and method for fixing the ends of an ACL prosthesis. The bone anchor is disclosed in U.S. Patent Application Serial No. 12/107,070 filed on April 21, 2008. The bone anchor includes a central hole through which the ACL prosthesis is passed. A knot is tied in the end of the ACL prosthesis to retain it within the central hole. The central hole is sized to prevent the knot from pulling through. However, sometimes the knot may pass through the central hole causing the ACL prosthesis to loosen or fail. Additionally, tying the knot can be difficult while retaining the ACL prosthesis taut.
Accordingly, an improved method for retaining the ACL prosthesis within the central hole would be advantageous.

Additionally, a bone screw may be used for attaching a suture to bone for other purposes. A lateral suture screw for attaching a suture is disclosed in U.S. Patent Application No. 12/107,071 filed on April 21, 2008 by the present inventor. The lateral suture screw includes a post extending above the screw. An attachment hole is formed in the head of the post for attaching the suture. The suture is connected to the attachment hole with a knot. As with the bone anchor the knot may pull through the attachment hole. Therefore, a need exists for an improved suture screw and mechanism for attaching the suture to the screw.

DISCLOSURE OF INVENTION

According to one aspect of the invention, a later suture screw includes a central axis hole. The lateral suture screw includes a post extending above the screw and a head above the post. The head includes a slot between the central axis hole and the post. A suture is connectable within the central axis hole.

According to another aspect of the invention, the central axis hole is shaped to retain the suture therein. A first portion of the central axis hole is cylindrical with parallel sides; a second portion has angled sides. According to another aspect of the invention, a bone anchor for an ACL prosthesis has a central axis hole shaped to retain the ACL prosthesis therein. A first portion of the central axis hole is cylindrical with parallel sides; a second portion has angled sides.

A peg is insertable within the central axis hole. According to an aspect of the invention, the peg is shaped similarly to the interior of the central axis hole. According to another aspect of the invention, the peg has indented sides to accommodate the suture.

According to another aspect of the invention, the suture is looped around the peg. The suture is passed through the central axis hole of the screw and the peg is pulled within the
central axis hole. The peg holds the suture within the central axis hole. According to another aspect of the invention, the ends of the suture are passed through a central axis hole of a bone screw. A peg is inserted into the central axis hole between the ends of the suture. The peg holds the suture within central axis hole. According to another aspect of the invention, the ends of the suture are tied in a knot around the peg. The knot retains the suture and peg in place.

According to another aspect of the invention, a suture is formed for use with the bone screw and peg of the present invention. According to an aspect of the invention, the suture is formed into a loop. The filaments are fused together to maintain the loop of the suture. According to another aspect of the invention, one or more filaments are longer than the remaining filaments. The filaments are fused so that the longer filaments extend beyond the fused portion.

DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a bone screw and peg according to an embodiment of the present invention.

Fig. 2 is a side view of a bone screw according to an embodiment of the present invention.

Fig. 3 is a cross sectional view of a bone screw according to an embodiment of the present invention.

Fig. 4 is a top view of a bone screw according to an embodiment of the present invention.

Figs. 5-6 are sides view of a peg according to an embodiment of the present invention.

Fig. 7 is an end view of a peg according to an embodiment of the present invention.

Fig. 8 is side view of formation of a suture according to an embodiment of the present invention.
Fig. 9 is an end view of a device for forming a suture according to an embodiment of the invention.

Fig. 10 is a side view of formation of a suture according to an embodiment of the invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Fig. 1 illustrates a bone screw or anchor 1 and peg 2 for holding a suture according to an embodiment of the present invention. Figs. 2-4 are various views of bone screw. Figs. 5-7 are various views of the peg.

The bone screw 1 of the present invention allows for attachment of a lateral suture. The bone screw includes a body 10 having threads thereon. The body 10 can be threaded into a hole drilled into a bone. A suture can be attached to the bone screw 1 as set forth herein. At the top of the body 10 is a base 20. When screwed into the bone, the base 20 abuts the surface of the bone. A post 30 extends from the base 20. A head 40 is positioned on the post opposite the base 30. The base 20 and head 40 have a diameter wider than the post 30. The suture wraps around the post 30 and is held in place by the base 20 and head 40. A central axis hole 50 extends within the head 40, post 30, base 20 and body 10 of the screw 1. A slot 60 is formed in the head 40 from the central axis hole to the edge of the head 40. The suture is positioned within the central axis hole 50 and the slot 60 so that it can extend around the post 30 between the head 40 and the base 20.

The central axis hole 50 is shaped to retain the suture therein. The central axis hole 50 includes a first portion 51 which is cylindrical having parallel sides. The first portion 51 of the central axis hole 50 is sized to accommodate the size of the suture. A second portion 52 of the central axis hole 50 has angled sides. The angled sides of the second portion 52 are wider at the outside end than at the first portion 51.
A peg 2 can be positioned within the central axis hole 52 to hold the suture in place. An embodiment of the peg is illustrated in Figs. 5-7. Figs. 5 and 6 are perpendicular side views of the peg 2. The peg 2 includes three portions. A first portion 120 is substantially cylindrical. It is narrower than the first portion 51 of the central axis hole 50. A second portion 110 of the peg 2 has a circular cross section with angled sides. A third portion 130 is rounded. It includes an indentation 131 in one direction. The suture can fit within the indentation 131. Fig. 7 is a end view of the third portion 130 of the peg 2. Indentations 140, 141 on the sides of the peg 2 correspond to the indentation 131 in the end. The suture is positioned around the peg within the indentations 131, 140, 141. The suture is looped around the peg 2 and inserted within the central axis hole 50 of the screw 1. When the suture is pulled within the screw 1, it pulls the peg 2 into the central axis hole 50 of the screw 1. The peg 2 holds the suture in place. Friction between the central axis hole 50, peg 2 and suture keeps the suture in place.

Figs. 8-9 relate to formation of a suture 200 for use with the screw 1 and peg 2 of the present invention. The suture 200 made from a plurality 210 of high performance polymeric fibers. According to one aspect of the invention, the suture is formed of a plurality of independent filaments or fibers. Such fibers may include oriented, high modulus, ultra high molecular weight polyethylene available from either DSM, Netherlands as DYNEEMA, or from Honeywell, USA as SPECTRA. A plurality of fibers 210 are positioned together. According to an embodiment of the invention, two of the fibers 211, 212 are longer than the other fibers and extend past the others. One fiber may be longer in both directions. According to an embodiment of the invention, the fibers have length of approximately 300-500 mm. The longer fibers extend approximately 300 mm past the ends of the other fibers.

The fibers are fused together at their ends 220, 221. To fuse the fibers, each end is fused in a semi-circle. Fig. 9 illustrates a device for fusing the ends. The device includes a base 300 having a semi-circular indentation therein. A press 310 fits within the indentation. An end 220,
221 of the fibers 210 is positioned within the indentation. The end is heated, to approximately 143 degrees C and pressed in order to fuse them together. Once both ends have been fused, a loop is made in the suture. The two ends 220, 221 are fused together as illustrated in Fig. 10. Once fused, the suture is in the form of a loop fused at its end. Extensions are positioned beyond the fused portions. To use the suture, the extensions 211, 212 can be passed through the central axis hole 50 of the screw. The extensions 211, 212 are used to pull the suture into the hole. The peg 2 can be positioned within the suture loop. For the other end of the suture, the extensions are again passed through a central axis hole of the screw. When the suture is pulled taut, a peg 2 is pressed into the central axis hole to hold the suture in place. Friction retains the suture and peg in place. The ends of the suture may be tied in a knot below the peg to help retain the suture in place.

Having disclosed at least one embodiment of the present invention, various adaptations, modifications, additions, and improvements will be readily apparent to those of ordinary skill in the art. Such adaptations, modifications, additions, and improvements are considered part of the invention which is only limited by the several claims attached hereto.
CLAIMS

What is claimed is:

1. A bone anchor assembly comprising:
   an anchor having a top, a bottom, and a bore therethrough on the central axis thereof, wherein the bore is wider towards the bottom of the anchor than towards the top of the anchor; and
   a peg, having a top and a bottom, the peg being insertable in the bore of the anchor from the bottom of the anchor, wherein the peg is wider at the bottom than at the top thereof and the bottom of the peg is wider than the top of the bore.

2. The bone anchor assembly according to claim 1, wherein the bore includes:
   a first portion towards the top of the anchor, the first portion being cylindrical with substantially constant diameter along the length of the first portion; and
   a second portion towards the bottom of the anchor, the second portion being wider towards the bottom of the anchor than towards the top of the anchor.

3. The bone anchor assembly according to claim 2, wherein the peg includes:
   a first portion towards the top of the peg, the first portion being cylindrical with substantially constant diameter along the length of the first portion; and
   a second portion towards the bottom of the peg, the second portion being wider towards the bottom of the peg than towards the top of the peg.

4. The bone anchor assembly according to claim 1, wherein the peg is narrower in a first direction than in a second direction substantially perpendicular to the first direction.

5. The bone anchor assembly according to claim 4, wherein the bottom of the peg includes an indentation extending across the bottom thereof in the first direction.
6. The bone anchor assembly according to claim 1, wherein the anchor includes a head at the top thereof, the head including a circumferential channel.

7. The bone anchor assembly according to claim 6, wherein the head includes a slot in the top extending from the bore to the channel.

8. The bone anchor assembly according to claim 1, wherein the anchor is cylindrical and includes threads on the exterior thereof.

9. The bone anchor assembly according to claim 1 further comprising a suture in the form of a loop, wherein the loop abuts the bottom of the peg and the suture extends through the bore of the anchor.

10. The bone anchor assembly according to claim 9, wherein the suture is formed of a plurality of fibers.

11. The bone anchor assembly according to claim 10 wherein the plurality of fibers are fused together at the ends thereof.

12. The bone anchor assembly according to claim 9 wherein the loop in the suture includes a knot positioned at the bottom of the peg.

13. A suture being attachable to a bone anchor, the suture comprising a plurality of fibers being fused together at the ends thereof to form a loop.

14. The suture according to claim 13 further comprising at least one fiber extending from the fused ends of the loop.

15. The suture according to claim 13, wherein the fibers are formed of oriented, high modulus, ultra high molecular weight polyethylene.

16. A method for forming a suture comprising the steps of:

   forming a bundle of a plurality of fibers of substantially similar length so that the ends are aligned; and

   fusing the ends of the plurality of fibers to form a loop.
17. The method for forming a suture according to claim 16 wherein each of the fibers includes a first end and a second end, and wherein the fusing step includes the steps of:

fusing the first end of each of the plurality of fibers together;

fusing the second end of each of the plurality of fibers together; and

fusing the fused first ends of the plurality of fibers to the fused second ends of the plurality of fibers.

18. The method for forming a suture according to claim 17, wherein the step of fusing the first end of each of the plurality of fibers together includes the step of fusing the fibers to have a semicircular cross section;

wherein the step of fusing the second end of each of the plurality of fibers together includes the step of fusing the fibers to have a semicircular cross section; and

wherein the step of fusing the first ends to the second ends includes the step of fusing the fibers to have a circular cross section.

19. The method for forming a suture according to claim 17 wherein at least one first fiber extends beyond the first ends of the plurality of fibers and is fused to the first ends at a location away from an end of the at least one first fiber; and wherein at least one second fiber extends beyond the second ends of the plurality of fibers and is fused to the second ends at a location away from an end of the at least one second fiber.
INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/031656

According to International Patent Classification (IPC) or to both national classification and IPC

A CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61B 17/04, 17/60 (2010.01)
USPC - 606/104

B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - A61B 17/04, 17/60 (2010 01)
USPC - 606/104, 144, 148, 232

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent

C DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category*</th>
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<td>Y</td>
<td>US 5,957,953 A (DI POTO et al) 28 September 1999 (28 09 1999) entire document</td>
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<td>US 5,571,139 A (JENKINS, JR) 05 November 1996 (05 11 1996) entire document</td>
<td>1-15</td>
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Further documents are listed in the continuation of Box C

Date of the actual completion of the international search
09 August 2010

Date of mailing of the international search report
23 AUG 2010

Name and mailing address of the ISA/US
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
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Facsimile No 571-273-3201

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Blame R. Copenhaver
PCT Helpdesk, 571-272-4300
PCT OSP 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)
International application No
PCT/US2010/031656

Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

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<td>1</td>
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<td>because they relate to subject matter not required to be searched by this Authority, namely</td>
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<td>because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically</td>
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<td>because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)</td>
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Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows

Group I. claims 1-15 are drawn to a bone anchor assembly

Group II. claims 16-19 are drawn to a method of forming a suture

<table>
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<td>As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims</td>
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<tr>
<td>2</td>
<td>As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees</td>
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<tr>
<td>3</td>
<td>As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos</td>
</tr>
<tr>
<td>4</td>
<td>No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims, it is covered by claims Nos 1-15</td>
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Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation
- No protest accompanied the payment of additional search fees