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(54) **ARTHOSCOPIC METHOD AND APPARATUS FOR TISSUE ATTACHMENT TO BONE**

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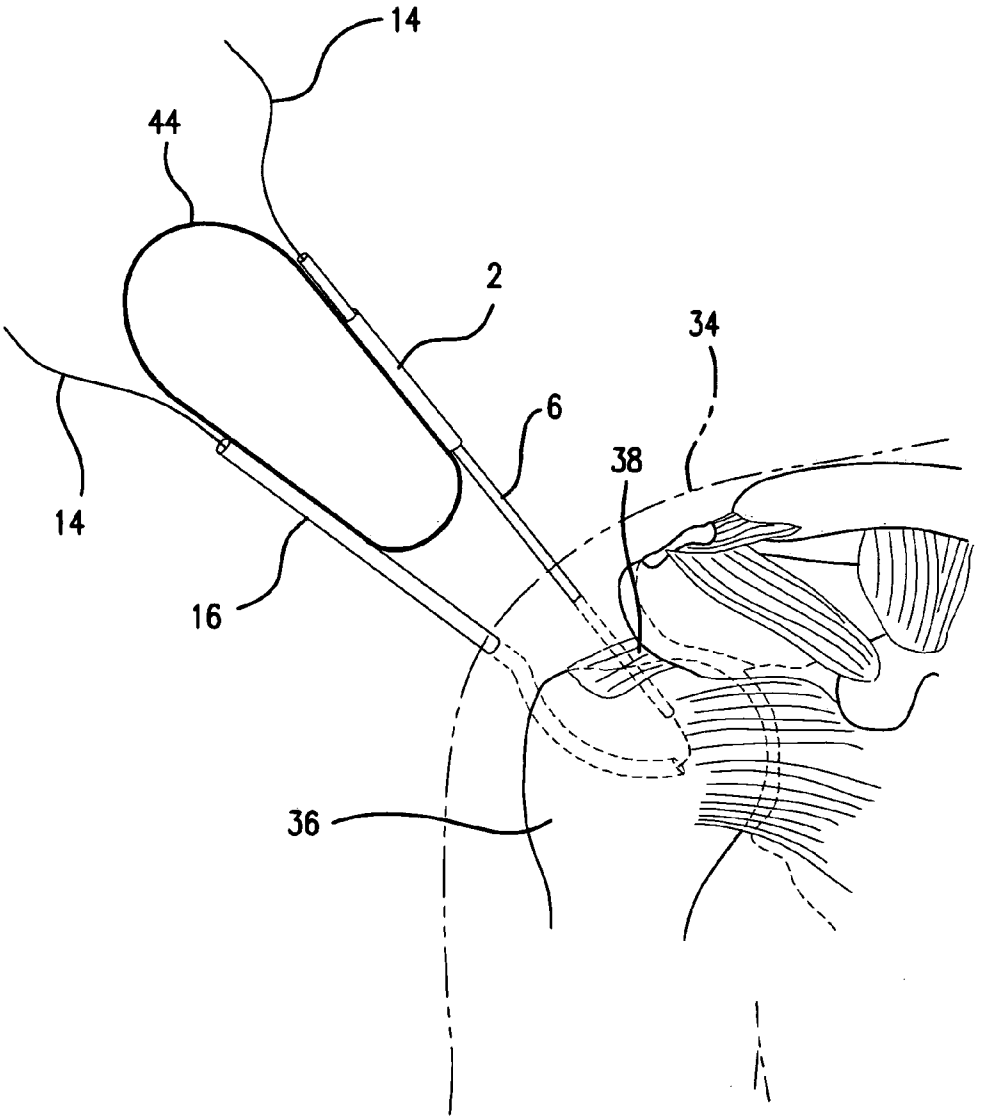
(57) **ABSTRACT**

Bone constructs of a patient are used to arthroscopically attach sutures to torn or dysfunctional tissue. Suture is passed through intersecting tunnels formed in the bone. An end of the suture extends from each of the tunnels, and the ends are used to secure the tissue to the bone, such as by arthroscopic tying of the ends, and pulling the tissue against the bone. Devices for achieving the process are also described.



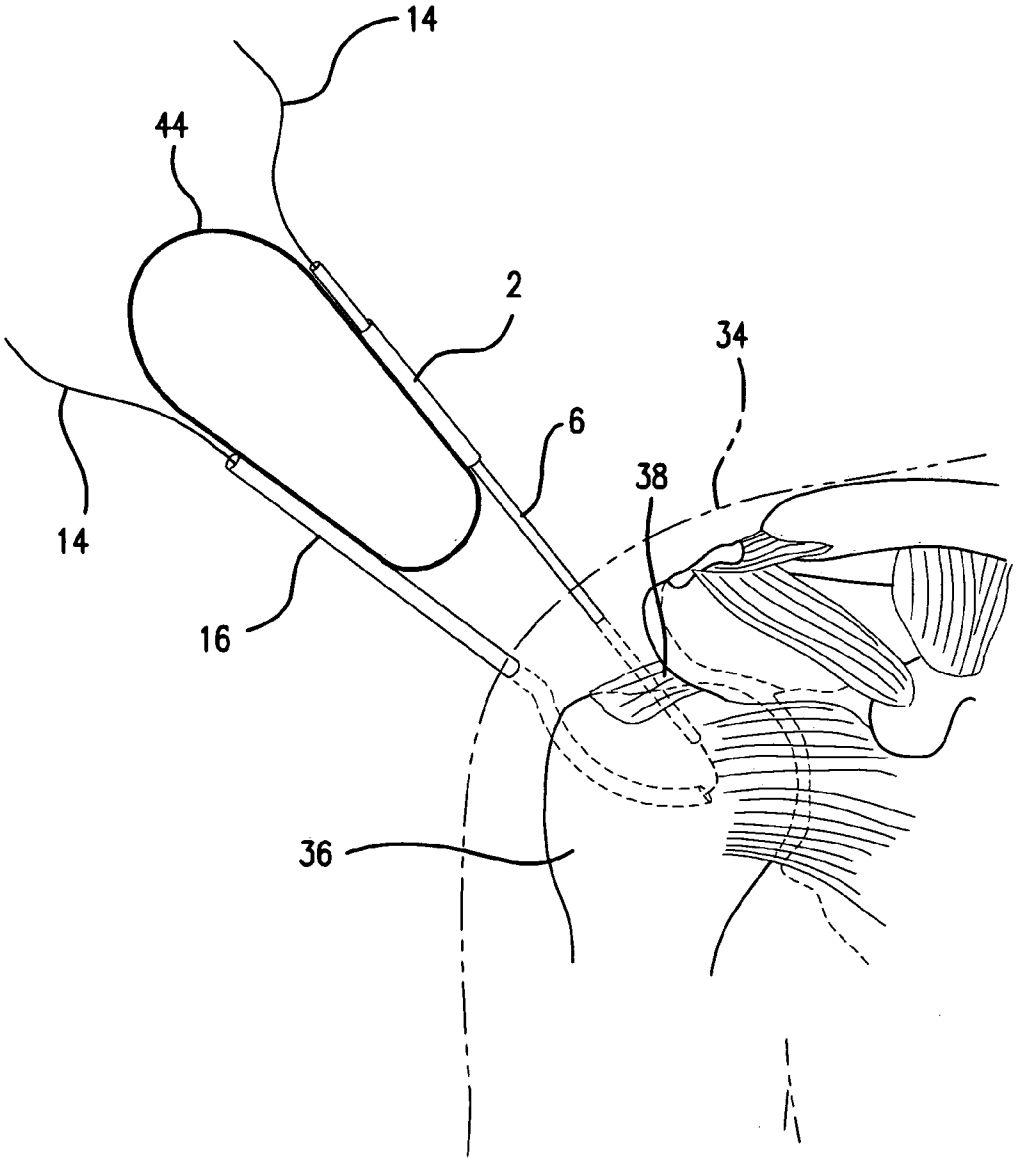


FIG. 1

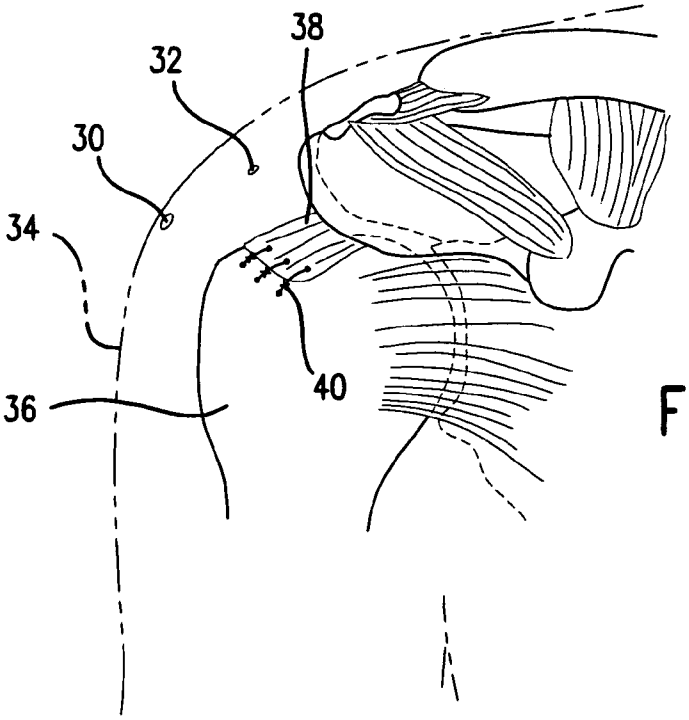


FIG.2

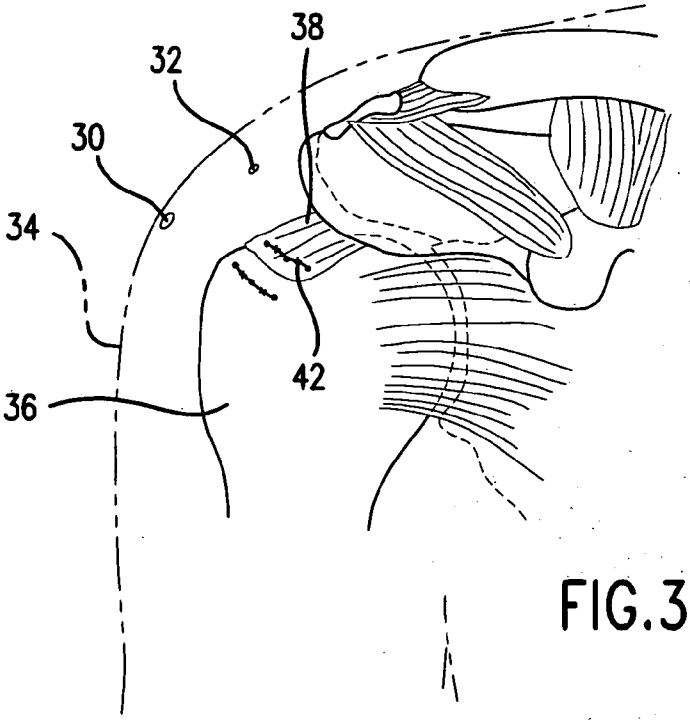


FIG.3

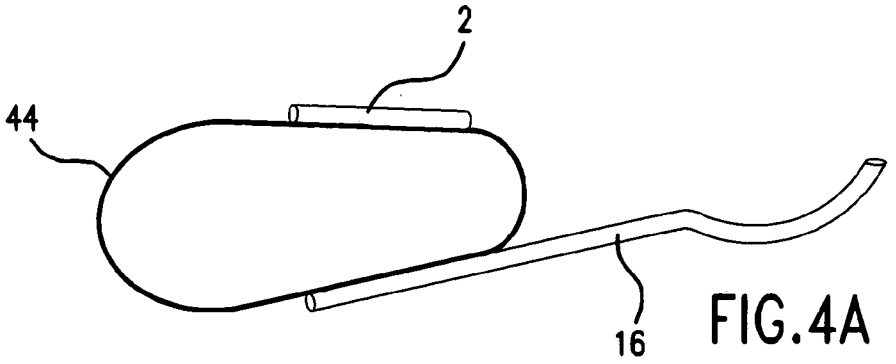


FIG.4A

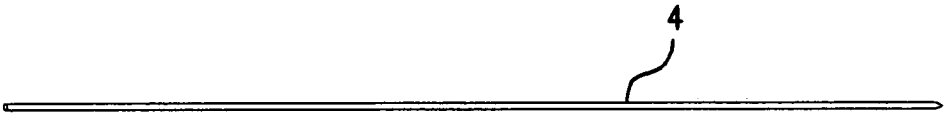


FIG.4B

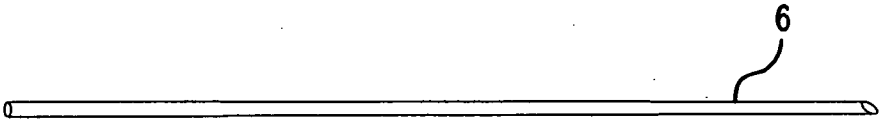


FIG.4C

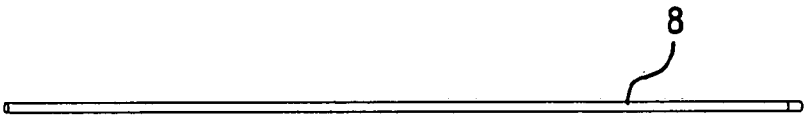


FIG.4D

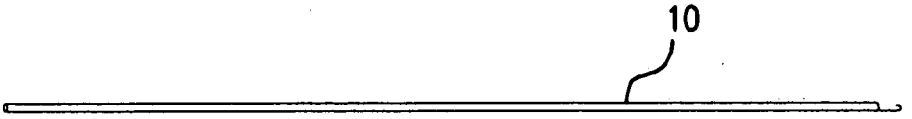


FIG.4E

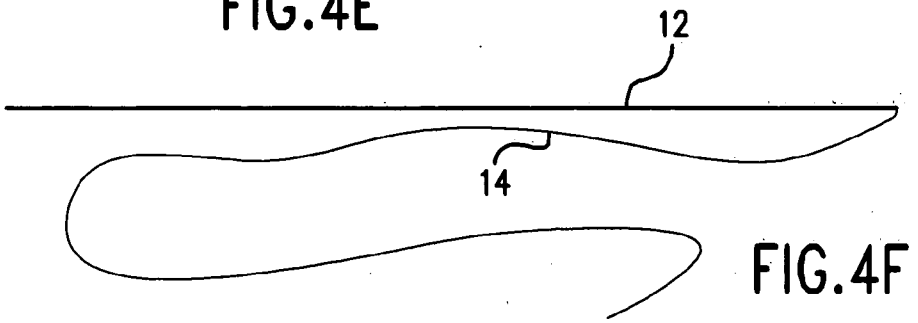


FIG.4F

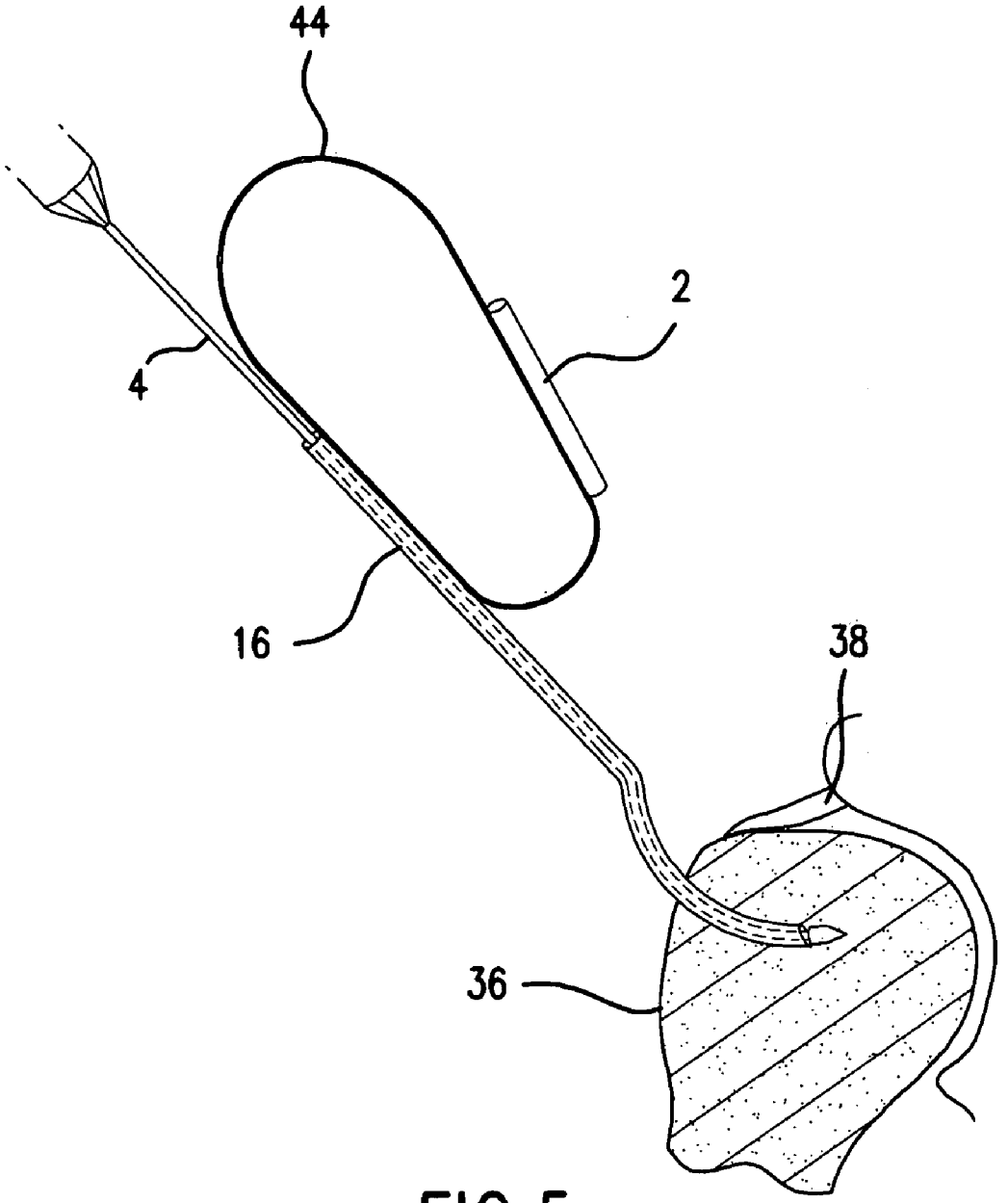


FIG.5

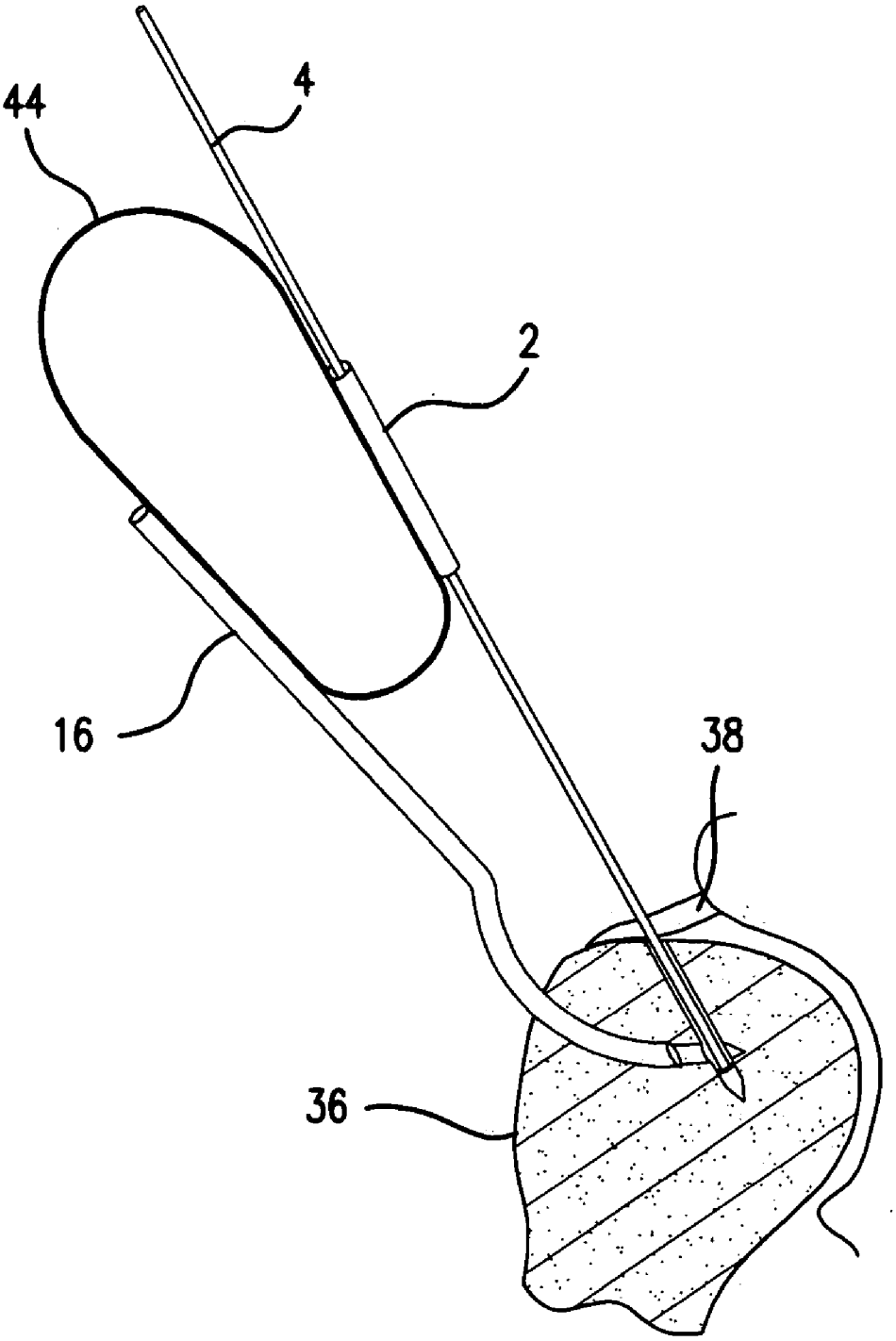


FIG.6

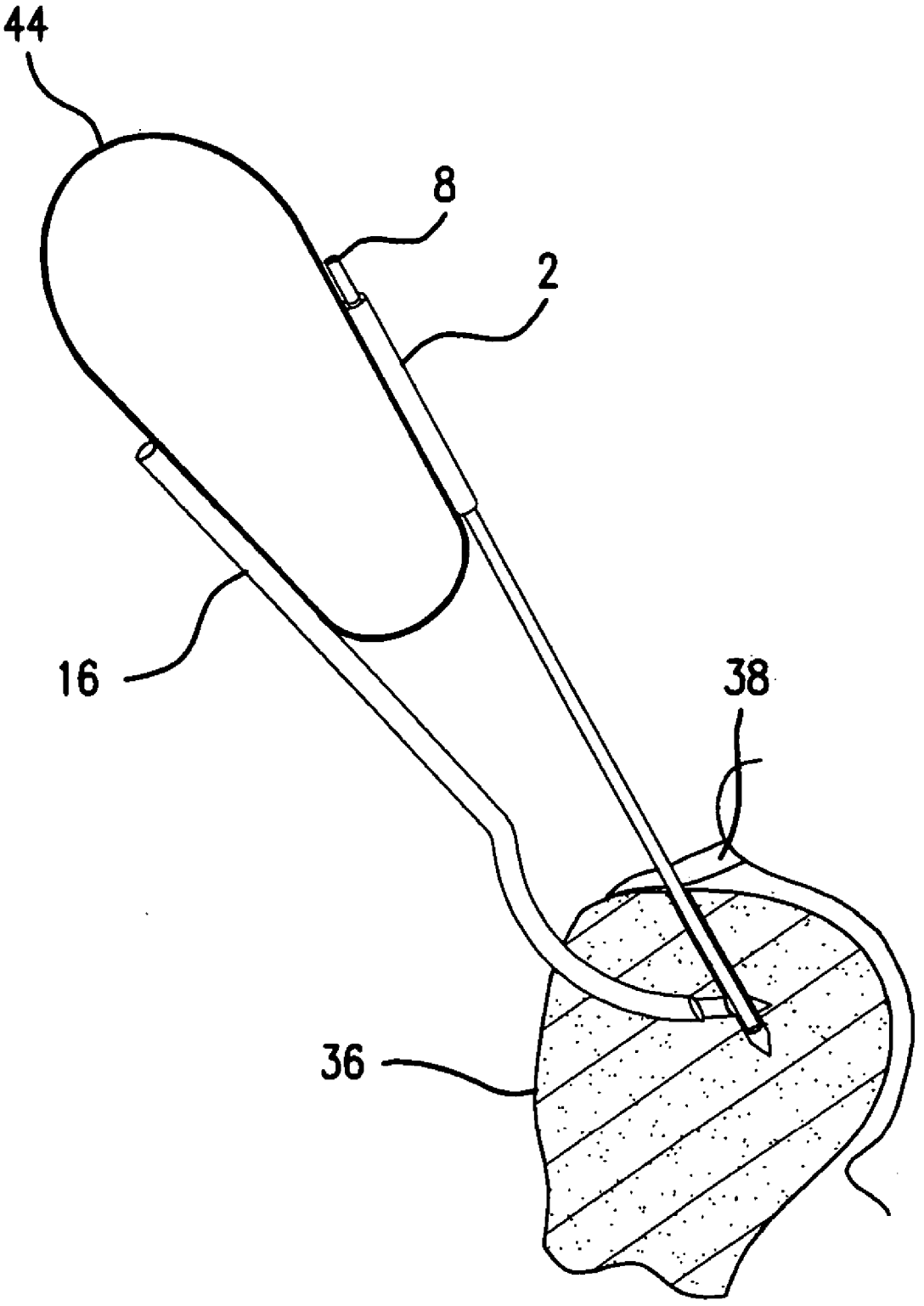


FIG.7

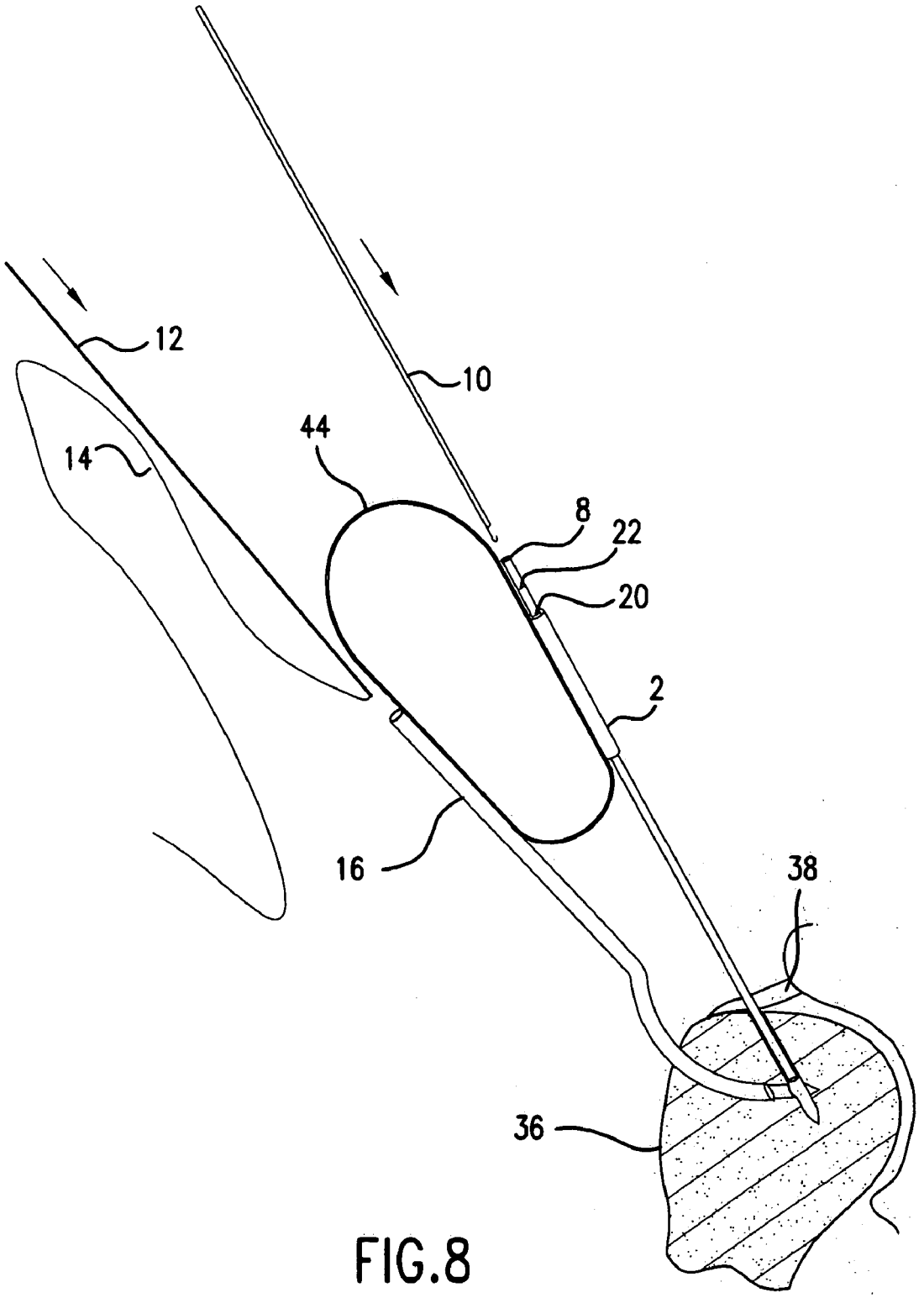


FIG.8

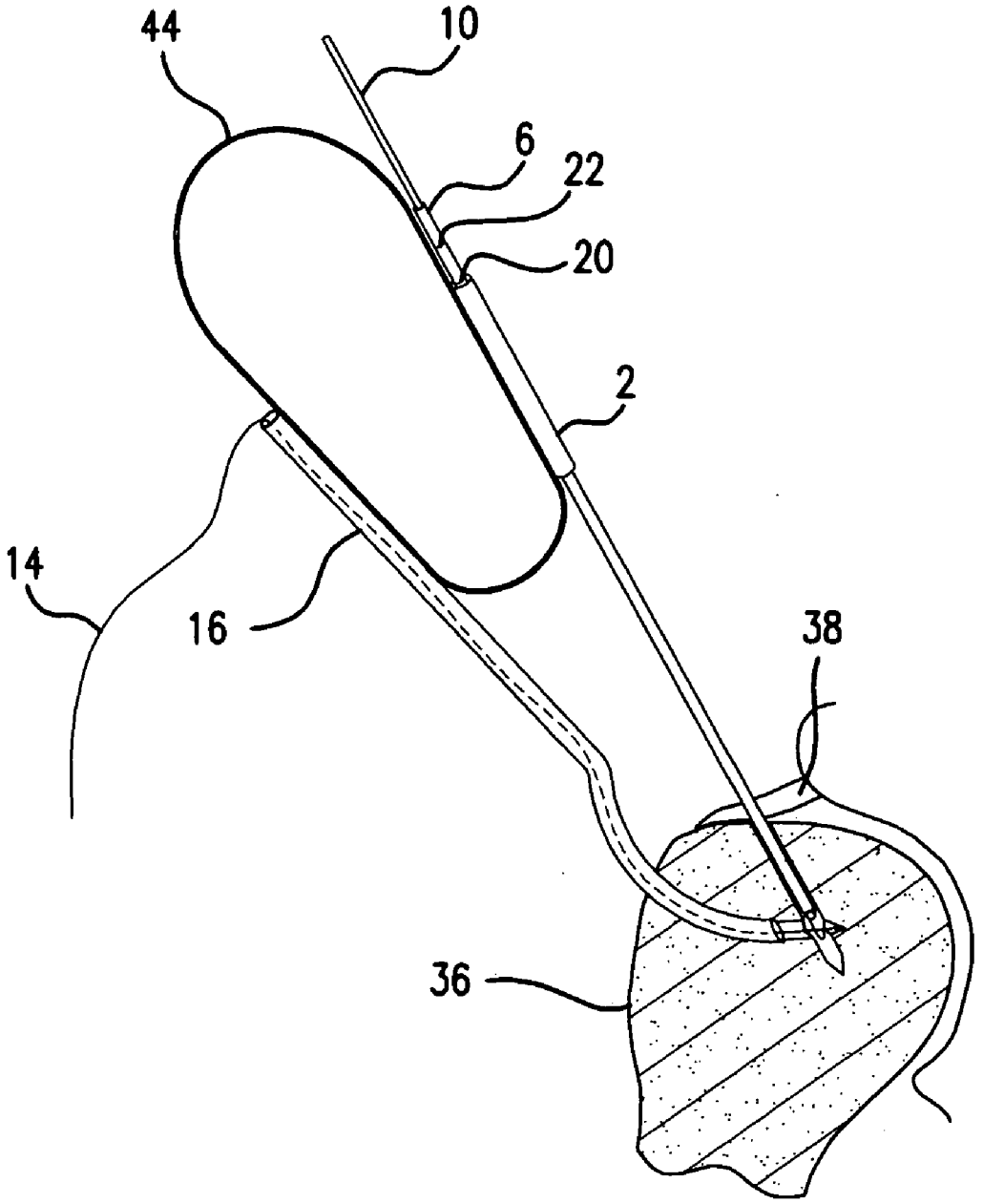


FIG.9

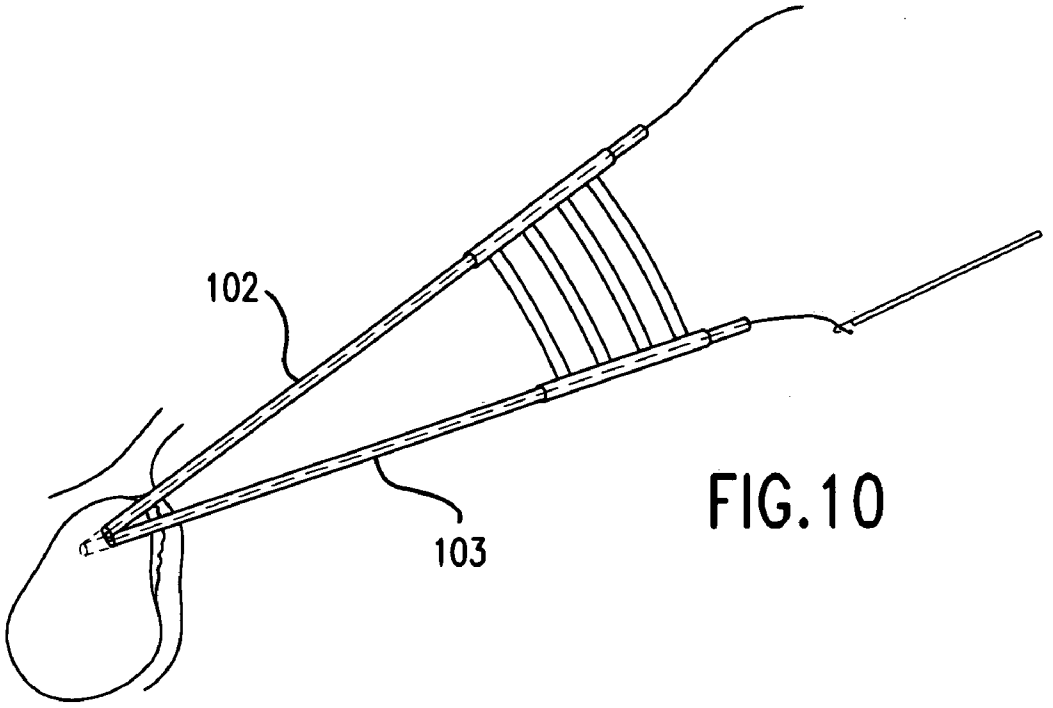


FIG.10

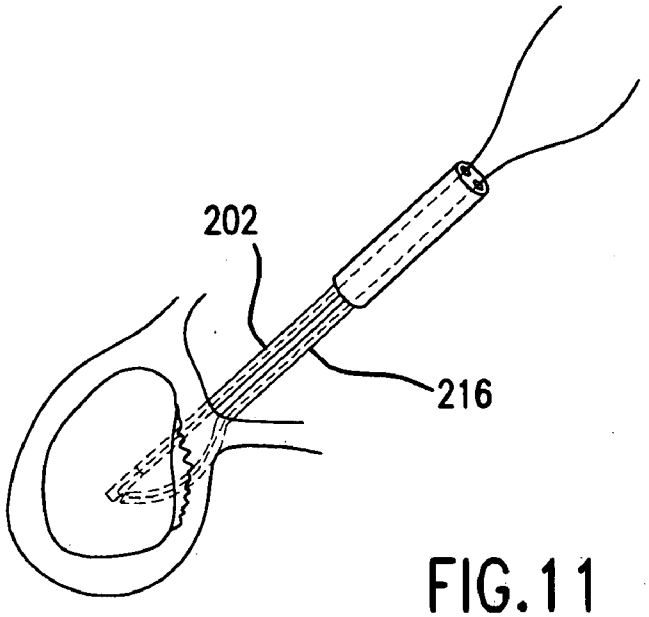


FIG.11

ARTHOSCOPIC METHOD AND APPARATUS FOR TISSUE ATTACHMENT TO BONE

FIELD OF THE INVENTION

[0001] The invention relates to methods and devices and more specifically relates to the arthroscopic fixation of tissue to bone using sutures.

BACKGROUND OF THE INVENTION

[0002] Invasive and open surgery methods of attachment of tissue to bone to repair tissue is known and used. An example of this method is rotator cuff surgery. In some processes, foreign objects, such as suture anchors, staples or screws, are implanted and used to connect tissue to bone.

SUMMARY OF THE INVENTION

[0003] The present invention overcomes the invasive nature of tissue repairs by open surgical processes, and reduces the reliance on implants associated with arthroscopic repairs. The invention uses the bone constructs of the patient to attach sutures to torn or dysfunctional tissue. Suture is passed through intersecting tunnels formed in the bone. An end of the suture extends from each of the tunnels, and the ends are used to secure the tissue to the bone, such as by arthroscopic tying of the ends, and pulling the tissue against the bone.

DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** illustrates a rotator cuff drill guide in place with a trephine piercing a torn rotator cuff. A single stand of suture is shown passing through the drill guide, rotator cuff tissue, into and out of the humeral head, and exiting the central lumen of the trephine.

[0005] FIG. **2** illustrates three arthroscopic simple stitches, a repaired rotator cuff, and two lateral vertical portals.

[0006] FIG. **3** illustrates two arthroscopic mattress stitches where the initial suture in the center bone tunnel was used to pass two sutures.

[0007] FIG. **4**A is the drill guide assembly having an arcuate drill guide, a straight drill guide and a handle.

[0008] FIG. **4**B is the stylus for the arcuate drill guide lumen.

[0009] FIG. **4**C is the trephine guide pin that will fit into the straight drill guide lumen with enough clearance for the trephine.

[0010] FIG. **4**D is the arthroscopic trephine.

[0011] FIG. **4**E is an offset hook probe that will pass into the trephine.

[0012] FIG. **4**F is a suture stylus with suture loosely attached.

[0013] FIG. **5** illustrates insertion of the arcuate lumen rotator cuff drill guide leading with the stylus.

[0014] FIG. **6** illustrates the stylus that has been passed through the straight drill guide lumen.

[0015] FIG. **7** illustrates the trephine inserted to a calibration point that advances the tip past the bone void left by the stylus.

[0016] FIG. **8** illustrates the trephine partially retracted to a second calibration mark, the suture stylus with suture being advanced and the hook probe in a readied position.

[0017] FIG. **9** illustrates the suture lodged in the bone void left by the stylus after being left behind by the suture stylus, and the hook probe which has been passed through the trephine to capture the suture.

[0018] FIG. **10** demonstrates an embodiment of the device using straight, but non-parallel drill guides.

[0019] FIG. **11** demonstrates an embodiment of the device showing an additional configuration of an arcuate drill guide.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0020] A preferred embodiment of the invention is demonstrated in repairing a rotator cuff. Two arthroscopic portals **30**,**32** are formed in the shoulder **34**, such as by a scalpel. The humeral head **36** and rotator cuff tendons **38** are present. An arcuate drill guide **16** having a central lumen is inserted into one of the portals. If required, cortical bone may be removed prior to insertion of the arcuate drill guide.

[0021] The central lumen of the arcuate drill guide has a protruding flexible stylus **4** therein that is advanced into the humeral head lateral of the torn rotator cuff. The stylus may be formed of nitinol. The stylus may have a cutter formed in an end thereof, such as a drill or mill type cutter. In this embodiment, the forward end of the arcuate drill guide is curved. Advancement of the arcuate drill guide may be by manual pressure or by assisted manual force using, for example, a mallet, or by a power tool, such as a drill. The arcuate drill guide forms an arcuate tunnel in the bone. After the arcuate drill guide is fully advanced, the drill guide stylus is withdrawn, leaving a small void in the bone that is present beyond the leading edge of the arcuate drill guide. FIG. **6**.

[0022] As shown in FIG. **1**, straight drill guide **2** is placed through the other portal. The straight drill guide has a lumen therein. A stylus is **24** positioned within this lumen. The stylus may be formed of nitinol. Sufficient space is present within the lumen for placement of the trephine **6**, so that the stylus has a sloppy fit within the drill guide. The stylus pierces the tissue.

[0023] The trephine is inserted into the lumen of the straight drill guide. The trephine has a larger diameter than the stylus, but will rotate within the lumen. The trephine enlarges the tunnel, and is moved past the arcuate shaped tunnel formed using the arcuate drill guide. FIG. **7**.

[0024] The trephine is retracted. As shown in FIG. **8** the trephine may have calibration marks **20**, **22** to indicate the depth of insertion and retraction of the trephine. The bone tunnels intersect as shown.

[0025] With the trephine in place, but with the styli removed from the drill guides, one or more strands of suture **14** are passed through the lumens of the drill guides, through a reapproximated rotator cuff tear, and through the two converging bone tunnels. The suture also passes through the humeral head (bone), and exits the central lumen of the trephine. The suture is advanced through the arcuate drill guide by the suture stylus **12**. The hook probe **10** is inserted

through the lumen of the trephine to hook the suture advanced by the suture stylus at approximately the intersection of the tunnels. FIG. **9**.

[**0026**] Removal of the drill guides **2**,**16** leaves the suture in place for tying. Multiple suture passes allow for tying of the suture material. For example, three (3) suture passes allow tying three (3) simple stitches **40** as shown in FIG. **2**.

[**0027**] FIG. **3** shows two arthroscopic mattress stitches **42** where the initial suture in the center bone tunnel was used to pass two sutures. The two sutures were tied twice with their adjacent sutures to form mattress stitches. Alternatively, the outside suture strands could have been used to pull the corresponding central suture into the outside tunnel, resulting in one less knot left in the patient, and the opportunity to use a sliding knot.

[**0028**] The arcuate drill guide and the straight drill guide may be connected by a handle **44**. The handle positions the relative angles of the drill guides for forming the tunnels as described. The drill guides are positioned by the handle so that intersecting tunnels are formed as disclosed herein. Both drill guides could be straight, with the drill guides angled in a non-parallel fashion to form intersecting tunnels. The handle may also be used to receive and transfer a force for advancing the drill guides, such as by striking the handle with a mallet.

[**0029**] Benefits of the present invention over the use of suture anchors include the introduction of minimal foreign material in the patient, a larger "healing footprint" (which is variable with the distance between lumens) and the use of lumens as injection ports for plate rich/poor blood/growth factors. This method of arthroscopic bone/suture tunnel creation also has applications in shoulder laberal repair and posterior cruciate ligament and anterior cruciate ligament repair, without, or at least reducing, the requirement of suture anchors, staples or screws. The geometry of the apparatus relates to an arthroscopic creation of bone tunnels and simultaneous suture passing to repair a torn or partially torn rotator cuff.

[**0030**] FIG. **10** shows the method of arthroscopic attachment of tissue to bone where different drill guide configurations are used to address the anatomic structure of the genohumeral joint, which are different that rotator cuff repair. FIG. **10** shows parallel drill guide lumens **102**,**103** that are useful for superior labrum deficiencies or tears.

[**0031**] FIG. **11** shows a drill guide that is similar to the rotator cuff guide, having one arcuate lumen **216** and one straight lumen **202** but having a different converging angle for inferior laberal repair. Aside from these differences in the apparatus, the method of arthroscopic securing tissue to the glenoid is the same as described for attaching the rotator cuff to the humeral head.

What is claimed is:

1. A method of attachment of tissue to bone, comprising the steps of:

a) arthroscopically forming a first tunnel in a bone;

b) arthroscopically forming a second tunnel in said bone, wherein said first tunnel intersects said second tunnel;

c) passing a suture though said first tunnel and said second tunnel, wherein an end of said suture extends from an opening to said first tunnel and an opposite end of said suture extends from an opening to said second tunnel; and

d) securing said first end of said suture and said second end of said suture over tissue to pull said tissue against said bone.

2. A method of attachment of tissue to bone as described in claim 1, wherein at least a portion of said first tunnel is not parallel to said second tunnel.

3. A method of attachment of tissue to bone as described in claim 1, wherein said first tunnel is not linear.

4. A method of attachment of tissue to bone as described in claim 1, wherein said first tunnel does not pass through to an opposite side of said bone from a side of entry into said bone.

5. A method of attachment of tissue to bone as described in claim 1, wherein said first tunnel does not pass through to an opposite side of said bone from a side of entry into said bone, and said second tunnel does not pass through to an opposite side of said bone from said side of entry into said bone.

6. A method of attachment of tissue to bone as described in claim 1, wherein said first tunnel and said second tunnel intersect within said bone.

7. A method of attachment of tissue to bone as described in claim 1, wherein a portion of said first tunnel is not parallel to said second tunnel at a point of intersection of said first tunnel and said second tunnel.

8. A method of attachment of tissue to bone, comprising the steps of:

a) arthroscopically forming a first tunnel in a bone using a first drill guide;

b) arthroscopically forming a second tunnel in said bone using a second drill guide, wherein said first tunnel intersects said second tunnel;

c) passing a suture though said first tunnel and said second tunnel, wherein an end of said suture extends from an opening to said first tunnel and an opposite end of said suture extends from an opening to said second tunnel; and

d) securing said first end of said suture and said second end of said suture over tissue to pull said tissue against said bone.

9. A method of attachment of tissue to bone as described in claim 8, wherein said first tunnel is formed using an arcuate drill guide having a lumen therein.

10. A method of attachment of tissue to bone as described in claim 9, wherein said second tunnel is formed using a drill guide having a lumen therein.

11. A method of attachment of tissue to bone as described in claim 8, wherein said first tunnel is formed by a flexible stylus that is inserted through said drill guide.

12. A method of attachment of tissue to bone as described in claim 8, wherein said second tunnel is formed by a stylus that is inserted through said drill guide.

13. A method of attachment of tissue to bone as described in claim 8, wherein said second tunnel is formed by a trephine that is inserted through said drill guide.

14. A method of attachment of tissue to bone as described in claim 11, wherein said flexible stylus has a cutter formed on an end thereof.

15. A method of attachment of tissue to bone as described in claim 13, wherein said suture is passed through a lumen in said trephine.

16. A method of attachment of tissue to bone as described in claim 15, wherein, after said trephine is fully advanced to form said second tunnel, and prior to passing said suture through said lumen in said trephine, said trephine is partially retracted.

* * * * *