J Shoulder Elbow Surg (2013) 22, 1558-1566

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Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

# Induction of bone ingrowth with a micropore bioabsorbable suture anchor in rotator cuff tear: an experimental study in a rabbit model

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**Background:** The bioabsorbable suture anchor is probably one of the most commonly used tools in arthroscopic shoulder operations. However, there is controversy about whether the bioabsorbable anchor is replaced by bone. The object of this study is to evaluate bone ingrowth into the micropore bioabsorbable suture anchor and the differences in the biomechanical properties of a micropore anchor and a nonpore anchor.
**Materials and methods:** A total of 16 microsized holes (diameter, 250 ± 50 μm; depth, 0.2 mm) were made on the bioabsorbable anchors with a microdrill. Twelve adult New Zealand White rabbits were randomly divided into two groups: group A (n = 6), the nonpore bioabsorbable suture anchor group, and group pA (n = 6), the micropore bioabsorbable suture anchor group. Microcomputed tomography was used at 4 and 8 weeks postoperatively to evaluate ingrowth by bone volume fraction (BVF), which was measured by calculating the ratio of the total volume of bone ingrowth to that of the region of interest. For pullout strength testing, 3 additional rabbits (6 limbs) were used for mechanical testing.
**Results:** The mean BVF was higher in group pA (0.288 ± 0.054) than in group A (0.097 ± 0.006). The micropore anchor had a higher pullout strength (0.520 ± 0.294 N) than the nonpore anchor (0.275 ± 0.064 N).
**Conclusion:** Micropore bioabsorbable suture anchors induced bone ingrowth and showed higher pullout strength, despite processing.
**Level of evidence:** Basic Science, Biomechanics/Imaging, Animal Model.


**Keywords:** Bioabsorbable anchor; pullout strength; micropored; rotator cuff; humeral head

Suture anchors are probably one of the tools most commonly used to assist in various types of labral, tendon, and ligament repairs around the wrist, elbow, and shoulder. The first suture anchor material was nonabsorbable metal. Despite good initial reports regarding these kinds of anchors, later investigations reported multiple complications,

This study was approved by the Inje University Busan Paik Hospital Investigational Review Board (No. 2011-058).

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1058-2746/$ - see front matter © 2013 Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2013.01.034

especially around the shoulder.[9,19,26] Because of the reported complications involving the metal anchors, bioabsorbable tissue fixation devices were produced as an alternative, and these are now used much more frequently than metal anchors.[18] One of the main advantages of absorbable suture anchors is their absorption over time, theoretically minimizing or avoiding the problems of migration or interference during revision surgery.[3] In addition, the effectiveness of these sutures in creating a secure tendon-to-bone repair is comparable to that of metallic suture anchors.[28] However, there is controversy regarding whether bone ingrowth is induced after the degradation of the bioabsorbable anchor.[1,15,16] Although product development continues with newer composites, such as polyetheretherketone (PEEK) and calcium ceramics (tricalcium phosphate), in an effort to create a mechanically stable construct and improve the biocompatibility of the implant, bioabsorbable anchors remain a safe, reproducible, and consistent implant to use in securing soft tissue to bone in and around the shoulder.[6]

Under the theoretic assumption that bone ingrowth into the bioabsorbable suture anchor enables more rigid fixation, we developed a micropore bioabsorbable suture anchor and attempted to influence bone ingrowth into the micropore.

## Materials and methods

### Micropore anchor processing

In this study, to minimize the changes in the characteristics of the bioabsorbable suture anchor, we manufactured surface micropores on 2.4-mm Bio-Corkscrew FT Suture Anchors (Arthrex Inc, Naples, FL, USA) by using only a microdrill and not the usual method of inducing micropore change in the polymer by thermoplastic processes. The holes were made with a microhand drill with a drill bit diameter size of 250 ± 50 μm. The depth of the hole was 200 μm. First, 4 holes were made on a circumference; each hole was separated by 90°. Then, 3 other circumferences were set, and again, 4 holes were made on each circumference in the same manner. The distance between each set of 2 circumferences was measured to be 300 ± 50 μm. Consequently, a total of 16 holes were distributed evenly on the surface of the anchor. The characteristics of the anchor screws, such as the thread, lead, and pitch, were not changed in the surface micropore processing. We disinfected all anchors with ethylene oxide after processing and sterilized them for 5 hours at 50% to 60% or 40% to 60% humidity.

### Animal study design and surgery

All procedures in this study were approved by the Institutional Animal Care and Use Committee. The study used 12 adult male New Zealand White rabbits, with an average age of 15 weeks and an average weight of 4.1 ± 0.4 kg. The rabbits were randomly divided into 2 groups: group A, the nonpore bioabsorbable anchor group and control group (n = 6), and group pA, the micropore bioabsorbable anchor group and experimental group (n = 6; Table I).

**Table I** Group classification*

| Group | Rabbits |
|---|---|
| A | 1, 2, 3, 4, 5, 6 |
| pA | 7, 8, 9, 10, 11, 12 |

*A,* nonpore bioabsorbable suture anchor; *pA,* pore bioabsorbable suture anchor.

* The rabbits were divided into 2 groups: group A (nonpore anchor) was the control group (n = 6), and group pA (micropore anchor) was the experimental group (n = 6).

The animals were anesthetized by intramuscular injections of a 1:1 mixture of Zoletil (Virbac, Carros, France) and Rompun (Bayer, Leverkusen, Germany). Before surgery, the left shoulder of each rabbit was shaved and disinfected for proper aseptic surgical technique. A 5-cm incision was made parallel to the scapular spine and the supraspinatus tendon. Blunt dissection was carried out through the deltoid muscle, and the supraspinatus was visualized. The release of the supraspinatus tendon was performed with a sharp blade (No. 11) at the base of the tendon insertion area. An anchor was inserted into the junction area of the articular cartilage, and the greater tuberosity of the humeral head and detached cuff were repaired using the single-row method (Fig. 1).

Antibiotics were used for 3 days after surgery, and the dressing of the surgical site was performed at 3-day intervals. Two rabbits in each group were euthanized at 4 weeks, and the remaining rabbits were euthanized at 8 weeks postoperatively (Table II).

### Microcomputed tomography radiologic evaluation

Microcomputed tomography (micro-CT) scans were performed at the humeral head where the absorbable suture anchors were embedded (Fig. 2). The presence of bone ingrowth was measured by using the CT40 micro-CT system (Scanco Medical, Bassersdorf, Switzerland). The scanner was set to a voltage of 55 kV and a current of 431 μA to allow for the use of sufficient energy. The samples were scanned at a 25-μm voxel (3-dimensional pixel) resolution with an integration time of 125 ms. The images were acquired in the axial plane, coronal plane, and sagittal plane. The acquisition and reformatted images were sent to a picture archiving and communication system, and the bony ingrowth into the micropore anchor on the micro-CT images was evaluated by using Image J 1.38 software (Research Services Branch, National Institute of Mental Health, Bethesda, MD, USA) with the Bone J plug-in. The plug-in automatically attempts to find the optimized threshold of bone that results in minimal connectivity and displays the corresponding threshold portion in the region of interest (ROI). In addition, this program calculates the bone volume fraction (BVF) by using a voxel-based method.[8]

Because the anchors were the same diameter (2.4 mm) and circular-shaped at the axial cut of the micro-CT, the ROI was defined as a circle (2.4-mm diameter) and set equally at the axial image.[7] We measured the total counts of voxels in the ROI and the total counts of voxels in the bone ingrowth portion within the ROI in all axial cut images (220 slices) that contained an anchor. The total volume of the ROI was obtained by summing the counts of the voxels in the ROI from all slides, and the total volume of the bone ingrowth was obtained by summing the counts of the voxels in bone ingrowth portion of all slides. The BVF was measured by