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Cytotoxicity and biomechanics of suture anchors used in labral repairs

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Background: Biodegradable suture anchors are associated with higher redislocation rates. This study examined whether the biocompatibility and/or biomechanical properties of suture anchors contribute to the increase in complications.

Methods: Human glenohumeral capsule cells were cultured with 4 types of suture anchors, Opus LabraFix (titanium alloy; ArthroCare, Austin, TX, USA), PushLock (poly-ether-ether-ketone; Arthrex, Naples, FL, USA), BioKnotless (poly-L-lactic acid; DePuy Mitek, Warsaw, IN, USA), and Suretac II (polyglycolic acid; Smith & Nephew, London, UK), to measure cell viability and pH. Four groups of 6 ovine shoulders were used to repair the labrum, which was completely detached from the glenoid rim anteroinferiorly and reattached with 2 suture anchors and subject to failure load testing.

Results: In cell culture, BioKnotless at 48 and 72 hours (85.2% ± 2.1% and 84.5% ± 3.6%) and Suretac II groups (33.9% ± 3.1% and 42.8% ± 6.4%) had fewer viable cells compared with control ($P = .048$). The pH of Suretac II was lower than control (7.51 to 7.65) at 24 hours (7.31 ± 0.08, $P = .049$), 48 hours (7.25 ± 0.02, $P = .046$), and 72 hours (7.29 ± 0.04, $P = .04$). During mechanical testing, 83% of repairs failed by the capsule tearing. Among the anchors, the BioKnotless repair group had a significantly lower failure load (37 ± 5 N) compared with the PushLock (61 ± 7 N), Opus (60 ± 6 N), and Suretac II (57 ± 7 N) groups ($P = .038$).

Conclusion: BioKnotless and Suretac II anchors are cytotoxic. The BioKnotless biodegradable anchor has significantly lower failure load. Absorbable suture anchors may cause higher redislocation of arthroscopic Bankart repair.

Glenohumeral instability is a common condition associated with a labral tear where the anterior labrum tears at the middle inferior glenohumeral capsule (Bankart lesion).[4,27] Labral repair (Bankart repair) can be performed either open or arthroscopically, and potential complications include postoperative instability and redislocation.[32] In particular, increased redislocation rates are associated with higher rate of revision surgery, diminished shoulder function, and in turn, worse prognosis.[6,42]

Arthroscopic surgeries use suture anchors made from either nonabsorbable or absorbable materials to secure the labrum back to the glenoid.[4,10,25] When it comes to redislocation and clinical outcomes, both nonabsorbable and absorbable anchors have been reported to be similar with recurrence rate ranging from 0% to 35% depending on the type and manufactures.[2,5,9,12,14–18,20,21,23,24,35–38] Thal et al[37] compared metallic Knotless and absorbable BioKnotless (DePuy Mitek, Warsaw, IN, USA), and Tan et al[36] rivalled an absorbable knotted anchor (Panalok; DePuy Mitek) to a nonabsorbable knotted anchor (G II; DePuy Mitek). Milano et al[28] compared metal (FASTak; Arthrex, Naples, FL, USA) against poly-L/D-lactic acid biodegradable (Bio-FASTak; Arthrex), and Warme et al[41] compared nonabsorbable polyacetyl vs absorbable polyglycolic acid (PGA) and trimethylene carbonate. These studies did not find any differences in redislocation rates or clinical outcomes in Rowe, American Shoulder and Elbow Surgeons standardized assessment, Oxford Instability Shoulder Score, and visual analog score between nonabsorbable and absorbable anchors. However, more recently, Peters et al[31] compared 2 absorbable, Suretac absorbable Tac made of PGA (Smith & Nephew; London, UK) and BioKnotless absorbable suture anchor made of poly-L-lactic acid (PLLA) (DePuy Mitek), and 2 nonabsorbable anchors, OPUS Labrafix knotless anchor (ArthroCare, Austin, TX, USA) made from stainless steel and Pushlock knotless anchor made from poly-ether-ether-ketone (Arthrex), and reported that absorbable anchors had a significantly higher rate of redislocation and prolonged impairments

Ethics approval was obtained from the South-Eastern Health Service Human Research Committee (HREC: 96/55, 14/130).

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on mobility and function evident by lower Rowe scores and diminished patient-reported overall shoulder function.

This difference in recurrent dislocation rates and recovery of function between absorbable and nonabsorbable anchors reported by Peters et al[31] can be attributed to multiple factors. The disparities in biomechanical functions of these anchors can lead to higher redislocation rates and variable functional recovery and/or the degradation of the anchor materials, and their interactions with the surrounding tissue can contribute to variable rates of wound healing. Poor labral healing, osteolysis, synovitis, and cartilage loss have been reported as consequences of using bioabsorbable anchors in the shoulder.[1,3,7,8,13,33]

The purpose of this study was to investigate the contributing causes of increased redislocation and impaired functional recovery. We hypothesized that absorbable and nonabsorbable anchors would have different biomechanical properties and/or the absorbable anchors would be cytotoxic to human capsular tissue.

Materials and methods

Glenohumeral capsule tissue was obtained using biopsy forceps from a 72-year-old man who underwent open rotator cuff repair.

Experiment 1: biocompatibility testing

Human glenohumeral capsule collection and culture

The glenohumeral capsule sample was washed in a sterile phosphate buffered solution (PBS), cut into approximately 8 mm^3 pieces, and digested overnight in 100 mL of 0.025% collagenase suspended in 0.02 M 4-(2-hydroxyethyl) piperazine-1-ethanesulfonic acid, 2% antibiotics (penicillin/streptomycin), and Hank's balanced salt solution. Cells were cultured with 10 mL of Dulbecco's modified Eagle medium, 10% fetal calf serum, and 1% antibiotic in a 60 mL culture flask incubated at 37°C, 100% humidity, and 5% CO_2. Passage was performed once during 24 days of culture, which provided two 60 mL culture flasks at 95% confluence.

Cells cultured with anchors

The primary cultured cells from each flask were trypsin digested and combined. The cells were seeded into 6-well culture plates (Greiner Bio-One, Frickenhausen, Germany) at a density of 1×10^5 cells/well. After incubation overnight, sterile anchors were added to 10 of 12 wells, 2 containing Opus LabraFix (ArthroCare), 2 containing PushLock (Arthrex), 2 containing BioKnotless (DePuy Mitek), 2 containing Suretac II (Smith & Nephew), and the remaining 2 wells with no anchor as control.

One set of plates was then incubated for 48 hours and the other for 72 hours. At each time point, the corresponding plate was removed to perform the light microscopy, trypan blue exclusion assay and 3-(4,5-dimethylthiazol-2-yl)-5-(3-carboxymethoxyphenyl)-2-(4-sulfophenyl)-2H-tetrazolium (MTS) assay.

Light microscopy

The superior periphery of each well in each plate was viewed under a Leica (DMLB; Leica Mikroskopie & Systeme, Wetzlar, Germany) inverted microscope, and cultures were imaged by a digital Leica camera at magnifications of 10×, 20×, and 40×. Analysis involved observations of cell shape, cell size, intracellular features (eg, cytoplasmic vacuoles), intercellular features (eg, cell fragments), and cell density.

Trypan blue exclusion assay

The contents in the 2 wells of the same group were resuspended into 1 mL of fresh culture media. This resulted in 5 suspensions that represented (1) control, (2) Opus, (3) PushLock, (4) BioKnotless, and (5) Suretac II groups.

Six 20 μL aliquots were taken from each suspension. To each aliquot, 20 μL of 0.4% (w/v) trypan blue was added, which stained dead cells blue while living cells were pale with a dark outline. A small sample of the mixture was applied on a Bright-line Hemacytometer (Sigma-Aldrich, St. Louis, MO, USA). This counting chamber was used to determine the percentage of total cells that were viable.

MTS assay

Each of the 5 suspensions was seeded into a column of 8 wells in a 96-well plate (200 μL per well). After incubation of the plate overnight, 20 μL of MTS was added to each well. Succinate dehydrogenase, a mitochondrial enzyme in living cells, cleaves the yellow water-soluble tetrazolium salt, MTS, into insoluble dark-blue formazan crystals. Formazan crystals absorb light of wavelength 490 nm, and the absorbance measured is proportional to the formazan concentration, which is proportional to the total number of viable cells. After the addition of MTS to each well, the plates were incubated for 2 hours and then placed in a SpectraMax 250 spectrophotometer (Molecular Devices, Sunnyvale, CA, USA) to measure absorbance at 490 nm in optical density units.

The pH of media

Six Suretac II and 6 BioKnotless anchors were placed in 12 sterile tubes (1 anchor per tube) each with 5 mL of fresh culture media. There were also 6 control tubes each with 5 mL of fresh culture media without anchor. After incubation for 24 hours, 2 tubes from each group were taken for pH measurement at 48 hours, and again at 72 hours using a pH meter (HI8417; Hanna Instrument Pty. Ltd., Woonsocket, RI, USA).

Experiment 2: biomechanical testing

Twenty-four fresh-frozen ovine shoulders (12 right and 12 left) were randomly allocated to 4 experimental groups of 6 shoulders (3 left and 3 right shoulders in each group). All soft tissues were completely dissected while care was taken to preserve the labrum and capsule. The anterior inferior labrum was cut circumferentially from its attachment to the glenoid using a No. 22 scalpel. The glenoid fossa depth and anterior capsule thickness of the specimens in each group were measured using a digital caliper (Mitutoyo, Kanagawa, Japan).

The humerus was carefully secured to the central pillar of an Instron 8874 Testing System (Instron, Buckinghamshire, UK) with a guiding plate. A 10-mm screw was passed through the humeral head at the center of the infraspinatus footprint, into 1 end of the guiding plate, and secured to the central pillar. An 8-mm screw was passed through the midshaft of the humerus and secured to the guiding plate. The glenoid was parallel to the ground, with its anterior surface facing up (Fig. 1).

Markings were made on the glenoid rim at 12, 6, 3, and 5 o'clock positions in right shoulders (and 12, 6, 9, and 7 o'clock in left shoulders) using a surgical marker (DYNJSM01; Medline Industries Inc., Northfield, IL, USA). The scapula was secured in an angled vice clamp fixed to the mounting table of the testing system (Fig. 1). The glenoid fossa was positioned on the humeral head without contact pressure, and with the shoulder positioned in 0° external rotation and 0° abduction.

An anteroinferior labral repair was performed on the secured shoulder. Suture anchors were placed anteriorly (3 o'clock in right shoulders and 9 o'clock in left shoulders) and inferiorly (5 o'clock in right shoulder and 7 o'clock in left shoulders) with one of the 4 anchors, Opus LabraFix (ArthroCare), PushLock (Arthrex), BioKnotless

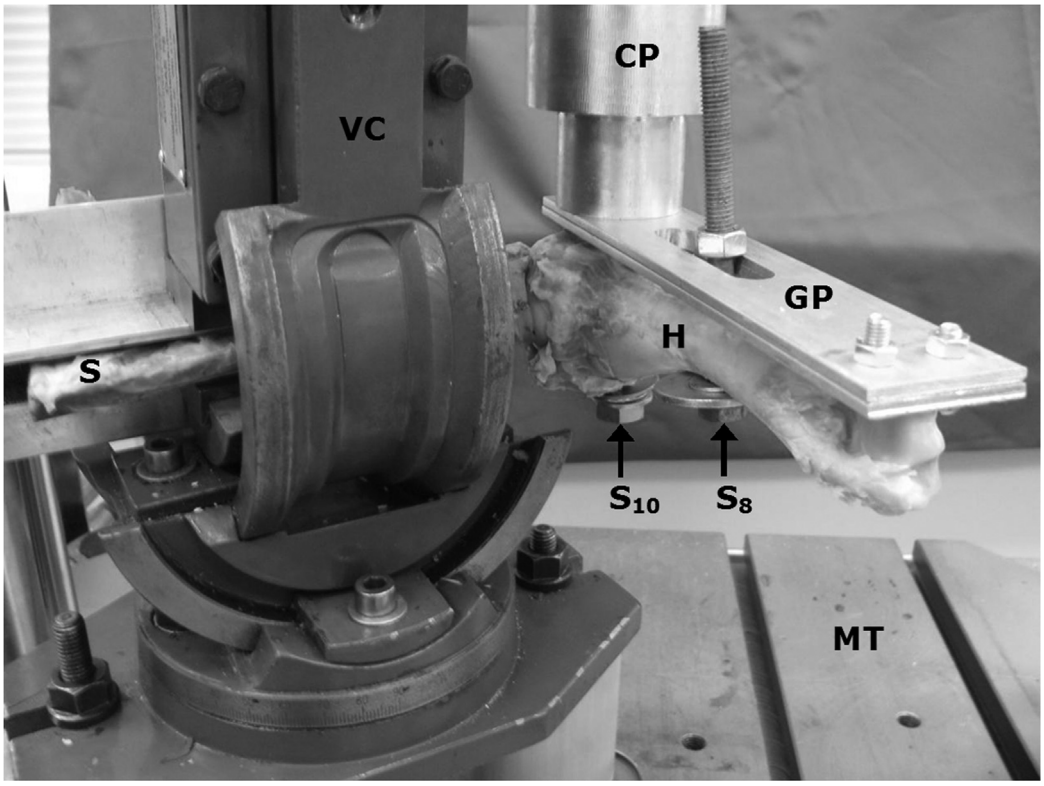

Figure 1 Positioning and attachments of the ovine shoulder. A left humerus (H) and scapula (S) were at 90° to each other, with the glenoid fossa and humeral head in close contact. The humerus was parallel to the ground with its anterior surface facing up. The humeral head was screwed to the central pillar (CP) of the Instron 8874 with a 10-mm screw (S_{10}). The humeral shaft was screwed to a guiding plate (GP) with an 8-mm screw (S_8). The scapula was secured in a vice clamp (VC) with subscapular fossa facing up. The VC was fixed on the mounting table (MT) of the Instron machine.

(DePuy Mitek), and Suretac II (Smith & Nephew). A fellowship trained orthopedic surgeon performed the repairs according to the manufacturers' instructions.

At each repair site on the glenoid, a hole, diameter and depth of each hole specific to each suture anchor system, was drilled through the glenoid rim without violating its articular surface using an appropriate drill guide (Table I). With Opus, PushLock, and BioKnotless, the anchor was embedded in the hole, a corresponding suture was passed through the capsule 3 mm from its cut edge once, and a simple suture configuration was used for the repair. With the Suretac II anchor, as there are no sutures, the device was passed directly through the capsule 3 mm from the torn capsule edge and into the predrilled hole.

A 10 N preload was applied on the humerus by placing vertically upward traction for 1 minute using the Instron machine. The humerus was then pulled vertically upward at 20 mm/min to mimic an anterior translation/dislocation. The load on the humeral head and the anterior distance translated were continuously measured and recorded with the use of Instron Fast-track software sampling at 100 Hz (Instron). Stiffness, peak energy, and total energy were calculated from the data acquired. Video recording of each test was performed to analyze the mode and sites of failure.

Statistical analysis

Data analyses were performed using 1-way analysis of variance with multiple comparisons, and Turkey's post hoc adjustment was used to compare multiple groups, using SPSS version 15 (IBM, Armonk, NY, USA). A *P* value of less than .05 was set for statistical significance. Results are shown as mean ± standard error.

Results

Glenoid fossa depths and anterior capsule thicknesses were comparable between the experimental groups. Glenoid fossa depths were Opus: 9.50 ± 0.27 mm, PushLock: 9.42 ± 0.21 mm, Suretac II: 9.49 ± 0.18 mm, and BioKnotless: 9.27 ± 0.18 mm, and anterior capsule thicknesses were 0.46 ± 0.07 mm, 0.38 ± 0.03 mm, 0.53 ± 0.10 mm and 0.44 ± 0.08 mm, respectively.

Biocompatibility testing

Cell morphology

The morphology of cells at 24, 48, and 72 hours was analyzed. At 24 hours, there were no differences in cell morphology between the 4 groups. Most of the cells in each group were healthy, spindle

Table I
Experimental groups and suture anchors specifications

Group	Anchor	Drill hole diameter(mm)	Material	Suture	Manufacturer
1	2.8-mm Opus LabraFix	3.0	Titanium (nonabsorbable)	Magnum wire (nonabsorbable)	ArthroCare; Austin, Texas, USA
2	3.4-mm PushLock	3.5	Poly-ether-ether-ketone (nonabsorbable)	Fiber wire (nonabsorbable)	Arthrex; Naples, Florida, USA
3	BioKnotless	2.8	Poly-L-lactic acid (bioabsorbable)	Pancryl braided (absorbable)	DePuy Mitek; Warsaw, Indiana, USA
4	8-mm Suretac II	3.2	Polyglycolic acid (bioabsorbable)	No suture	Smith & Nephew; London, UK

shaped, adherent to the culture dish, and semiconfluent. At 48 and 72 hours, cells cultured with Opus, PushLock, and BioKnotless anchors continued to have similar morphology to the spindle-shaped control cells; however, cells exposed to the Suretac II anchor at 48 and 72 hours demonstrated cellular fragments, rounded cells with cytoplasmic vacuoles, and cell shrinkage (Fig. 2, *N, O*). In addition, the Suretac II group had lower cell density compared with the control group (Fig. 2, *C*) and had evidence of cells detached from the culture dish consistent with cell injury and/or apoptosis.

MTS assay

At 48 hours, there was significantly less cellular activity as demonstrated by the MTS assay in the BioKnotless group (54.42 ± 1.64) and the Suretac II group (59.65 ± 3.03) compared with the control group (100 ± 2.44, $P = .001$, Fig. 3, *A*). At 72 hours, the BioKnotless group's viable cell numbers were similar to the control group (105.20 ± 2.54), but Suretac II viable cell numbers (121.74 ± 4.21) were significantly higher than the control group (100 ± 2.94, $P = .001$).

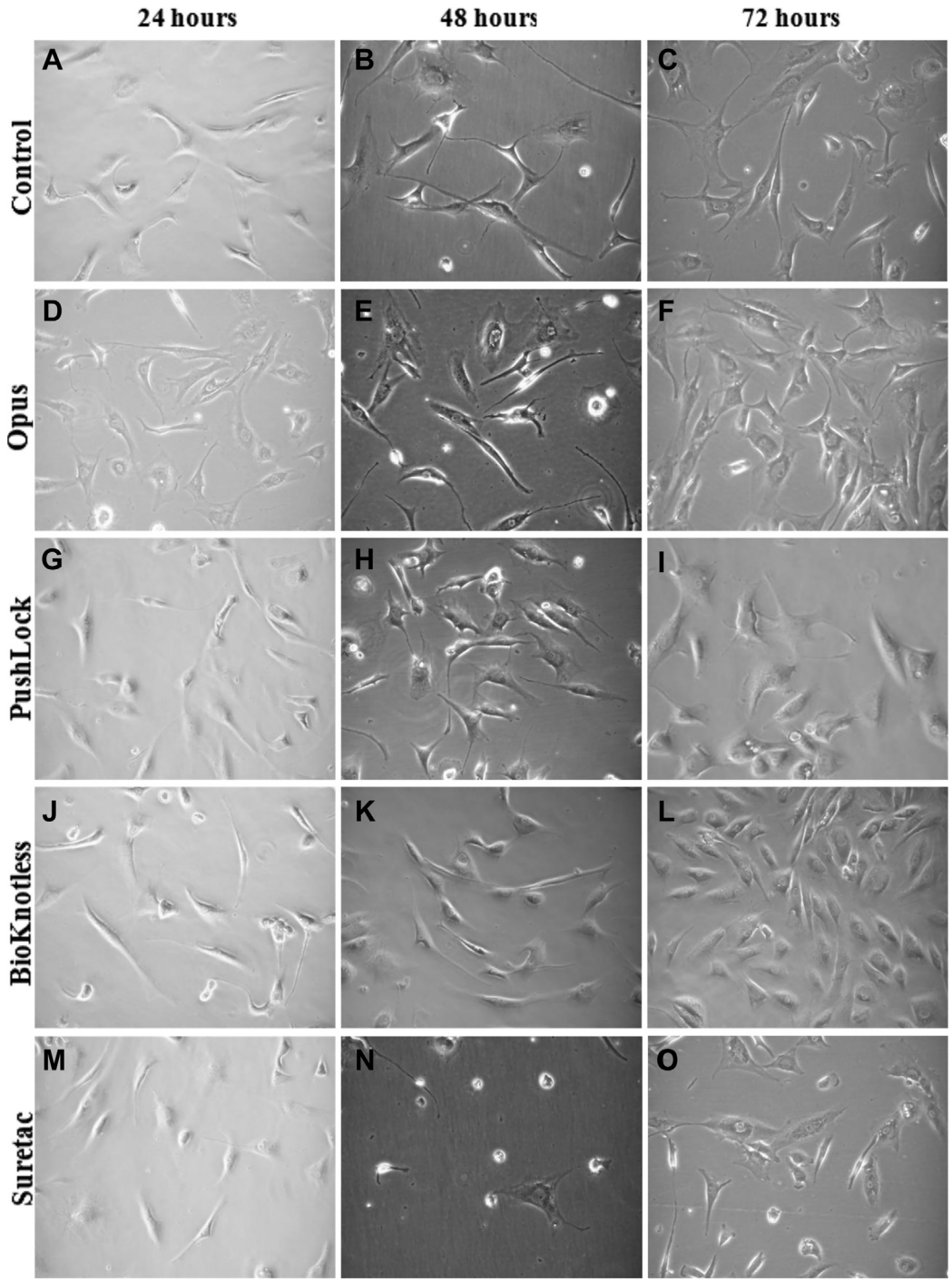

Figure 2 Morphology of glenohumeral capsule cells cultured with 4 types of suture anchors. The images were taken at a magnification of 20×. Images in rows 1, 2, 3, 4, and 5 show cells cultured with no anchor (control), Opus, PushLock, BioKnotless, and Suretac II. Images in columns 1, 2, and 3 show cells cultured with anchors for 24, 48, and 72 hours. At 48 and 72 hours, Suretac II wells had cellular fragments, rounded cells with cytoplasmic vacuoles, and cell shrinkage (N, O).

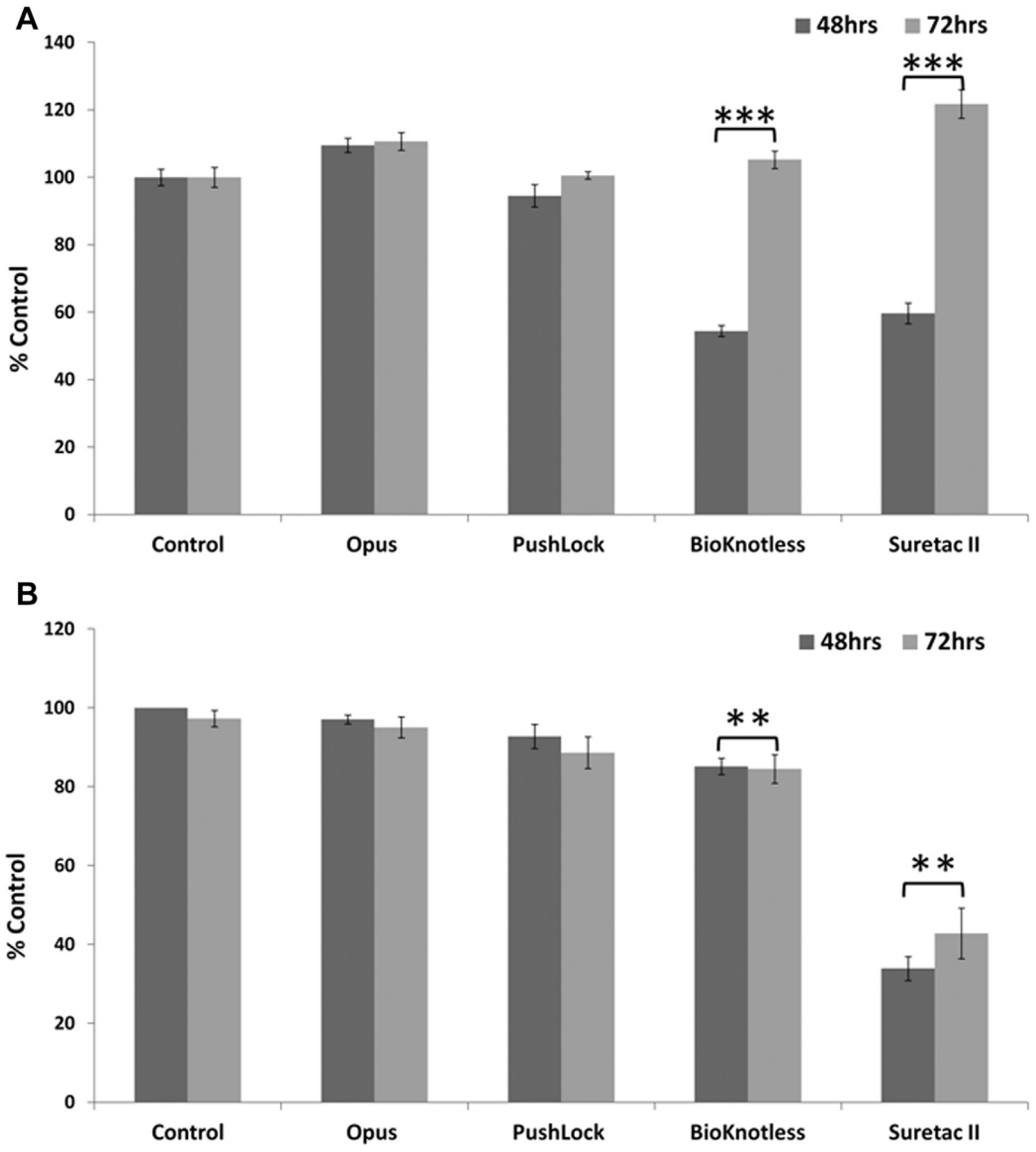

Figure 3 (**A**) Live cell count. Cell proliferation evaluated by the MTS assay after 48 and 72 hours of exposure. Cell proliferation in the BioKnotless and Suretac II groups was significantly lower than the control at 48 hours (***$P < .001$). Cell proliferation in the Suretac II group was significantly higher than the control at 72 hours ($P < .001$). (**B**) Cell viability according to the trypan blue exclusion assay. At 48 and 72 hours, cell viability in the BioKnotless (*$P < .05$) and Suretac II (**$P < .01$) groups was significantly lower compared with the control (mean ± standard error, n = 8 for each group; Turkey's tests in conjunction with analysis of variance).

Trypan blue exclusion assay

At 48 and 72 hours, the proportion of living cells in the BioKnotless group were 85.2% ± 2.1% and 84.5% ± 3.6% and in the Suretac II group 33.9% ± 3.1% and 42.8% ± 6.4%, respectively. Both anchors were significantly lower than the control group at 48 and 72 hours (Fig. 3, *B*). The Opus group and the PushLock group were similar to the control group at 48 ($P = .019$) and 72 hours ($P = .048$).

The pH of media

The pH of control, Suretac II, and BioKnotless media was 7.65 at 0 hours and remained above 7.5 at 24, 48, and 72 hours. The control pH ranged from 7.51 to 7.65. The BioKnotless pH ranged from 7.65 to 7.7 and was similar to the control at each time point; however, pH of the media exposed to the Suretac II anchor was significantly lower with pH of 7.31 ± 0.08, 7.25 ± 0.02, and 7.29 ± 0.04 compared with the control at 24 ($P = .044$), 48 ($P = .046$), and 72 hours ($P = .04$), respectively (Table II).

Biomechanical testing

Video assessment revealed that in each ovine specimen failure occurred at the superior repair site followed by the inferior repair site in 20 of 24 shoulders (83%). Forty-six of 48 repair sites (96%) failed because of tearing of the capsule, whereas 2 of 48 repair sites (4%) failed by anchor pullouts involving the 3 o'clock repair in a right shoulder and the 9 o'clock repair in a left shoulder with Bioknotless anchors. In the Opus, PushLock, and BioKnotless groups, the capsule tore at the insertion of the suture. In the Suretac II group, the capsule tore under and around the head of the Suretac II anchor.

The failure load of the BioKnotless group (37 ± 5 N) was significantly lower compared with the PushLock (61 ± 7 N), Opus (60 ± 6 N), and Suretac II (57 ± 7 N) groups ($P = .038$) (Fig. 4, *A*). The repair stiffness for the Opus group was 2.1 ± 0.4 N/mm, PushLock 2.7 ± 0.7 N/mm, Suretac II 2.6 ± 0.4 and 2.1 ± 0.3 N/mm,

Table II
pH of unconditioned (control) and conditioned media at 24, 48, and 72 h of exposure

Time (h)		BioKnotless	Suretac II	Control
24	pH	7.67 (0.04)	7.31 (0.08)	7.58 (0.06)
	P value	.331	.049*	
48	pH	7.66 (0.05)	7.25 (0.02)	7.51 (0.06)
	P value	.156	.046*	
72	pH	7.70 (0.05)	7.29 (0.04)	7.59 (0.08)
	P value	.293	.040*	

Data shown as mean (standard error); n = 6. The pH of the Suretac II-containing media at each time point was significantly different to both the pH of the control and the pH at 24, 48, and 72 h.
* Indicates a significant difference compared with the control at that time point (*$P < .05$).

and peak energy values were 1435 ± 364, 880 ± 89, 1206 ± 324, and 555 ± 139 N mm, respectively. There were no statistically significant differences in repair stiffness or peak energy between the groups (Fig. 4, *B, C*). The PushLock group (1838 ± 403 N mm) and the BioKnotless group (2104 ± 396 N mm) had significantly lower total energy to failure than both Opus group (3701 ± 349 N mm, $P = .0097$) and Suretac II group (5101 ± 570 N mm, $P = .0016$) (Fig. 4, *D*).

Discussion

This study evaluated the biocompatibility and biomechanical properties of 4 types of suture anchors, Opus, PushLock, BioKnotless, and Suretac II. Biocompatibility studies show that both biodegradable anchors, BioKnotless and Suretac II, were associated with less viable cells at 48 and 72 hours after incubation and higher acidic culture medium at 24, 48, and 72 hours. Repairs with BioKnotless anchors demonstrated significantly lower failure load, whereas repairs with the other 3 anchor systems had comparable strength. The Suretac II anchor system had the highest total energy to failure, significantly higher than PushLock and BioKnotless. Total energy to failure for Opus was also significantly higher compared with PushLock and BioKnotless.

To our knowledge, this is the first study to investigate cell viability and pH changes of different types of suture anchors within human glenohumeral capsule tissue. Results from this study show that absorbable anchors, BioKnotless and Suretac II, were cytotoxic, whereas nonabsorbable suture anchors, Opus and PushLock, were biologically inert. Both biodegradable groups had significantly fewer live cells compared with control at 48 and 72 hours, indicating low levels of cell proliferation and/or a relatively high level of cell mortality. The biocompatibilities of PLLA (Bioknotless) and PGA

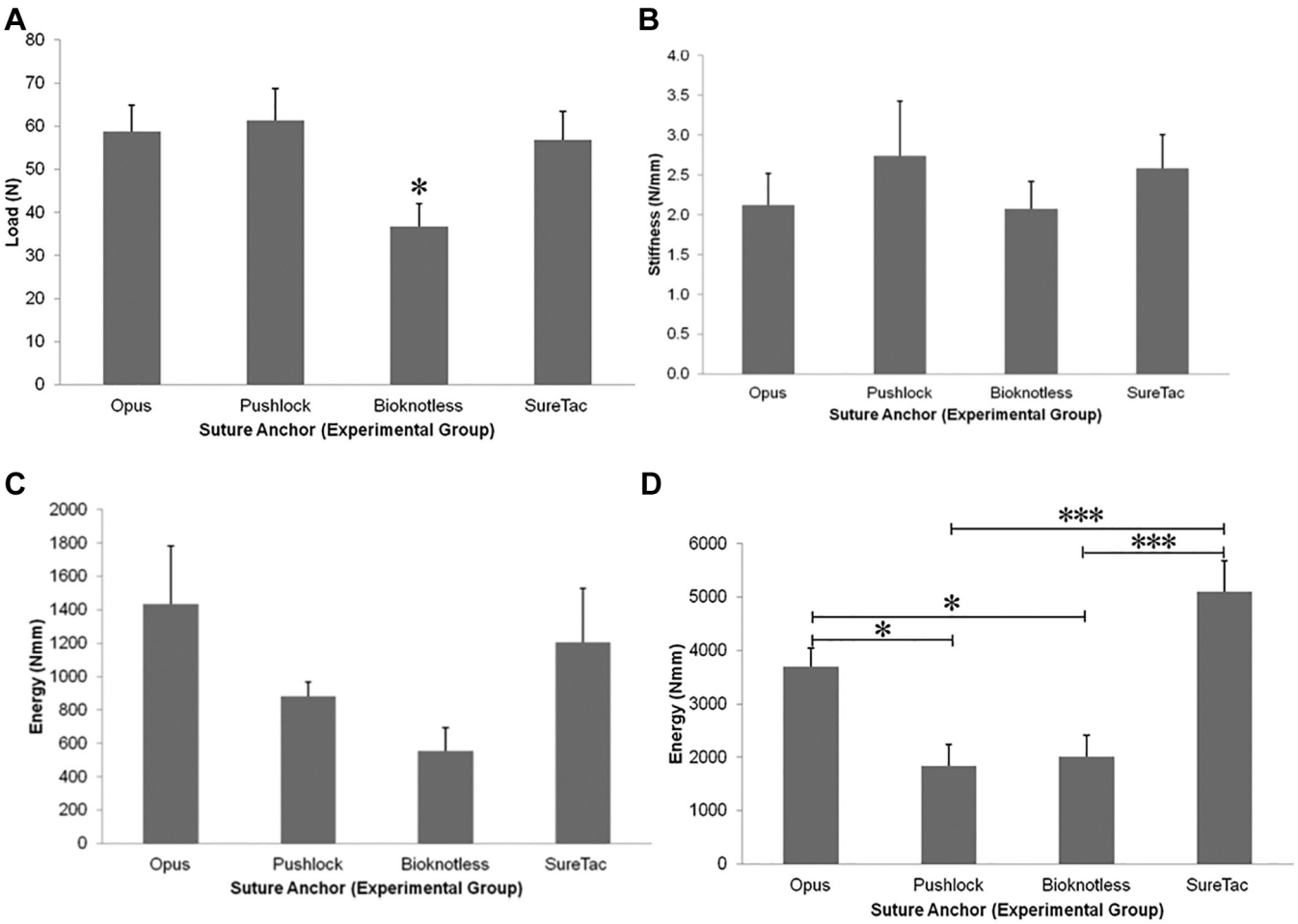

Figure 4 (**A**) Failure load of capsulolabral repairs using various suture anchors. BioKnotless had a significantly lower mean failure load compared with each of the other experimental groups (*$P < .05$). (**B**) Stiffness of capsulolabral repairs using 4 different suture anchors in ovine shoulders. There were no significant differences. (**C**) Peak energy of capsulolabral repairs. There were no significant differences between the groups. (**D**) Total energy of capsulolabral repairs. Opus also had a mean total energy significantly higher than both PushLock and BioKnotless. Suretac II had a mean total energy significantly higher than both PushLock and BioKnotless (*$P < .05$, ***$P < .001$, mean ± standard error, n = 6 for each group).

(Suretac) material were studied by Kobayashi et al[22] by implanting these biopolymers in the cornea of rabbits for 3 weeks. The authors found significant PGA-induced vascular invasion, whereas PLLA caused no inflammation over a 3-week period. Ignatius and Claes[19] investigated poly-lactide-co-glycolide (PLGA) degradation products, which include PLLA and PGA degradation products. Five different concentrations of PBS conditioned with PLGA at 70°C for 10 days were used as media to culture L929 mouse fibroblasts for 72 hours. The MTS assay and DNA synthesis of fibroblast activity in the conditioned media groups were significantly lower compared with control (unconditioned PBS). This difference was proportional to the concentration of PLGA; therefore, PLLA and PGA degradation products exhibit concentration-dependent cytotoxicity, supporting our findings with BioKnotless and Suretac II cell viability at 48 hours. This study also shows that, in the MTS assay, absorbable suture systems have equivalent viable cells at 72 hours. In fact, Suretac II has more cells compared with control at 72 hours. This discrepancy may be due to the reliability of the MTS assay, as it has been reported to overestimate cell viability and to be unreliable compared with the trypan blue exclusion assay.[26,40]

In the pH study, Suretac II media was significantly more acidic compared with control in all time points. On the other hand, the pH of BioKnotless media demonstrated no significant differences. We attribute this to the relatively rapid degradation of Suretac II releasing substances that cause a reduction in pH. A study by Vert et al[39] has shown that on hydrolytic degradation, PLLA and PGA release monomers of lactic acid and glycolic acid causing a decrease in pH. PGA degrades more rapidly compared with PLLA, causing an earlier reduction in pH.[29] Furthermore, glycolic acid is a stronger acid than lactic acid that contributes to a greater drop in pH.[22]

Clinically, a change in pH, cell survival, and proliferation may influence labral tissue healing and the health of intra-articular tissue. Currently, as there are no other studies that investigated pH changes associated with absorbable anchors in vivo or in a clinical setting, it is difficult to know exactly how the pH changes affect healing. There are clinical studies that report osteolysis, synovitis, cartilage loss, and poor labral healing after Suretac II and BioKnotless repairs.[1,13] Edwards et al[11] and Segmüller et al[34] showed that in 5% and 4.2% of cases after Suretac II SLAP repairs, the synovium was infiltrated by phagocytic cells with engulfed polymer fibers. Taken together, we postulate that an absorbable anchors system causes higher redislocation rates.

All suture anchors performed similarly regarding mode and sites of failure. For Opus, PushLock, and BioKnotless, failure consistently involved suture pulling through the connective tissue of the capsule. Therefore, the properties of the sutures are important determinants of the failure load of these suture anchors. For example, the low failure load of BioKnotless might be due to the Panacryl braided suture, whereas Opus sutures are magnum wire and PushLock sutures are fiber wire. Because the repair failure was due to suture cutting through the capsule rather than suture failure, suture material may have contributed to the lower force of failure. The failure load of Suretac II was not different compared with nonabsorbable sutures, and in fact, the total energy required for failure was highest in the Suretac II group. These results are likely due to differences in repair mechanism, as Suretac II anchors do not involve suture and the anchor attaches the capsule directly to the bone. Failure mode of Suretac II repair began with capsule fibers progressively tensioned, gradually tearing circumferentially around the anchor head, attributing a progressive decline in load after failure. In contrast, the other suture anchors demonstrated rapid decreases in load after failure. These results were similar to a study by Mueller et al[30] on human cadaver shoulders. Anchor cracking and suture breakage were not observed in this study, but 2 BioKnotless anchors were pulled out of the bone tunnel. It is worthwhile to point out that although there is a difference in biomechanical parameters for these suture anchors, the failure forces reported in this study are far greater than the physiological forces that would be exerted on the shoulders after repair.

Although results from this study showed differences in both biocompatible and biomechanical parameters between absorbable and nonabsorbable suture anchors, there are a few limitations. In the biocompatibility study, we made the assumption that Opus, a titanium anchor, and PushLock, a poly-ether-ether-ketone anchor, would not change the pH of the medium in the time frame that were tested; therefore, we did not investigate the pH effects of these 2 anchors. Second, we used ex vivo ovine shoulder joints for our biomechanical experiment. Although ovine shoulder joints are commonly used as a surrogate for human, the biomechanical properties of ovine Bankart lesions repairs will be different compared with human repairs. Differences in size of the joint, size of bones, surface area, and differential capsular properties should all be taken into account, when interpreting these data. Lastly, the glenohumeral capsule tissue sample that was used for cell culture was from a 72-year-old male human subject who underwent an open rotator cuff repair. We recognize that the sample was not from the typical age range that suffers instability; however, the sample was what we had available at the time of the experiment, and as cells were cultured successfully, we proceeded with the experiment.

Conclusion

Exposure of human capsule cells to absorbable suture anchors (Suretac II) creates an acidic surrounding and reduced cell survival (BioKnotless and Suretac II), indicating that absorbable anchors are cytotoxic. Biomechanical testing of ovine labral repairs demonstrated that BioKnotless repairs were significantly weaker compared with repairs with Opus, PushLock, and Suretac II anchors. These results will help to understand etiologies of redislocation, variable functional recovery after surgery, and discourage the use of biodegradable anchors for Bankart repair.

Disclaimer

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