EXPERIMENTAL STUDY

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Comparison of repair techniques in small and medium-sized rotator cuff tears in cadaveric sheep shoulders

Ulaş ONAY[1], Sercan AKPINAR[2], Rahmi Can AKGÜN[3], Cenk BALÇIK[4], İsmail Cengiz TUNCAY[3]

[1]*Department of Orthopedics and Traumatology, Dr. Sami Ulus Training and Research Hospital, Ankara, Turkey;*
[2]*Department of Orthopedics and Traumatology, Adana Practice and Research Center, Başkent University, Adana, Turkey;*
[3]*Department of Orthopedics and Traumatology, Faculty of Medicine, Başkent University, Ankara, Turkey;*
[4]*Department of Mechanical Engineering, Faculty of Engineering, Başkent University, Ankara, Turkey*

Objective: The aim of this study was to compare new knotless single-row and double-row suture anchor techniques with traditional transosseous suture techniques for different sized rotator cuff tears in an animal model.

Methods: The study included 56 cadaveric sheep shoulders. Supraspinatus cuff tears of 1 cm repaired with new knotless single-row suture anchor technique and supraspinatus and infraspinatus rotator cuff tears of 3 cm repaired with double-row suture anchor technique were compared to traditional transosseous suture techniques and control groups. The repaired tendons were loaded with 5 mm/min static velocity with 2.5 kgN load cell in Instron 8874 machine until the repair failure.

Results: The 1 cm transosseous group was statistically superior to 1 cm control group ($p=0.021$, $p<0.05$) and the 3 cm SpeedBridge group was statistically superior to the 1 cm SpeedFix group ($p=0.012$, $p<0.05$). The differences between the other groups were not statistically significant.

Conclusion: No significant difference was found between the new knotless suture anchor techniques and traditional transosseous suture techniques.

Key words: Knotless suture anchor; rotator cuff repair; traditional transosseous suture.

Rotator cuff tears can be classified as acute or chronic, partial or full-thickness and traumatic or degenerative. In addition, rotator cuff tears are classified according to tear size; small-sized tears (<1 cm), medium-sized tears (1 to 3 cm), large-sized tears (3 to 5 cm), and massive tears (>5 cm).[1]

The goal of rotator cuff repair is to achieve high initial fixation strength, minimize gap formation and optimize the tendon-bone biological healing.[2] There are many surgical suture configurations in current clinical use, including transosseous, single-row, double-row and transosseous equivalent double-row sutures. New knotless suture techniques are available that secure tendon fixation until biological healing occurs.

The aim of this study was to compare the new knotless single-row suture anchor technique (SpeedFix; Arthrex Inc., Naples, FL, USA) and double-row suture anchor technique (SpeedBridge; Arthrex Inc., Naples, FL, USA) with the transosseous suture techniques in different sized rotator cuff tears in cadaveric sheep

Correspondence: Ulaş Onay, MD. Dr. Sami Ulus Eğitim ve Araştırma Hastanesi, Ortopedi ve Travmatoloji Kliniği, Babür Caddesi No: 44, 06080 Altındağ, Ankara, Turkey.

Tel: +90 312 - 305 60 00 e-mail: ulaso@mynet.com

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shoulders. We hypothesized that knotless suture anchor techniques would provide more secure fixation.

Materials and methods

Fifty-six cadaveric sheep shoulders (14 right, 42 left) between the ages of 8 to 12 months with similar tendon width were used in this study. Shoulders were stored at -20°C 6 to 12 hours after death and thawed at room temperature 4 to 6 hours before testing. The humerus was cut transversely just above the elbow and the scapula was left intact. Muscles were dissected carefully by the same surgeon and the supraspinatus, infraspinatus and subscapularis muscles and tendons were left intact. Specimens were kept moist with saline solution. 1-cm sized cuff tears were made in the supraspinatus tendon and 3-cm sized cuff tears were made in the supraspinatus and infraspinatus tendons together as the supraspinatus and infraspinatus tendons of sheep are alone not wide enough. The infraspinatus tendon was used because of its similar biomechanical, anatomic and histological properties to the human supraspinatus tendon.[3]

The supraspinatus tendon was cut sharply at its insertion side on the greater tubercle to create 1-cm sized tears (Fig. 1).

The supraspinatus and infraspinatus tendons were cut sharply at their insertion sides to create the 3-cm sized tears (Fig. 2).

The knotless suture anchor technique (SpeedFix) is designed for small, non-retracted tears and was used for the 1 cm rotator cuff tears in our study. The anchor system has a 2-mm wide fiber tape and is fully threaded 5.5 mm diameter bioabsorbable peek anchor body and peek eyelet.

In the SpeedFix technique, first both tails of the fiber tape were passed from the undersurface from inside to outside at 10 mm medial to the tendon edge with a free needle. The fiber tape tails were preloaded through the anchor eyelet. A bone socket was created using a punch at a 45° angle to the bone surface and the anchor body was inserted through the bone socket until the anchor body was buried below the bone cortex (Fig. 1).

In the SpeedBridge technique, first the fiber tape was preloaded into two anchor eyelets and bone sockets were prepared to use as a medial row anchor. Later, both tails of the fiber tape were passed from undersurface from inside to outside at 10 mm medial to tendon edges with a free needle. One fiber tape tail from each medial anchor was then retrieved diagonally and preloaded through the two anchor eyelets. Finally, the anchor eyelets were inserted into the prepared lateral bone sockets at 10 mm lateral to the edge of the tuberosity at a 45° angle to the bone surface until the anchor body was buried below the bone cortex (Fig. 2).

For the transosseous technique, the tendon edges were similarly prepared. Tears were repaired with similar sized fiber wire through one bone tunnel with one primary simple suture in the 1-cm sized tears and through two bone tunnels with two primary simple sutures in the 3-cm sized tears. Bone tunnels of 6-mm diameter were opened through freehand drilling.

The scapula was fixed with a 3-holed handmade clamp with 3 screws. The humerus was fixed with an external fixator with two 6.5-mm diameter Schanz screws to simulate a 135° angle between the scapula and humerus. Repaired tendons were loaded with 5 mm/min static velocity with 2.5kgN load cell in an Instron 8874 machine until the repaired tendons or sutures failed

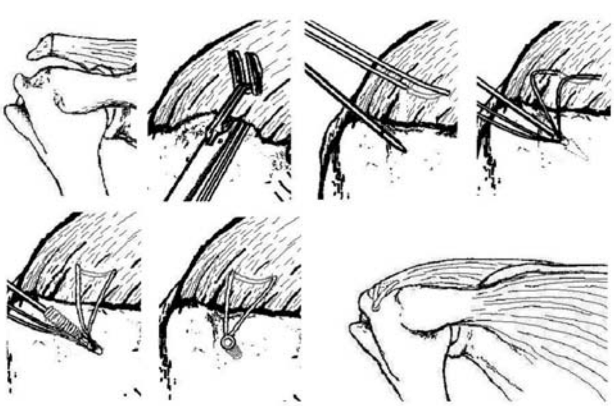

Fig. 1. Dissection of supraspinatus tendon for 1-cm sized tears and knotless single-row suture anchor technique for 1-cm sized tears.

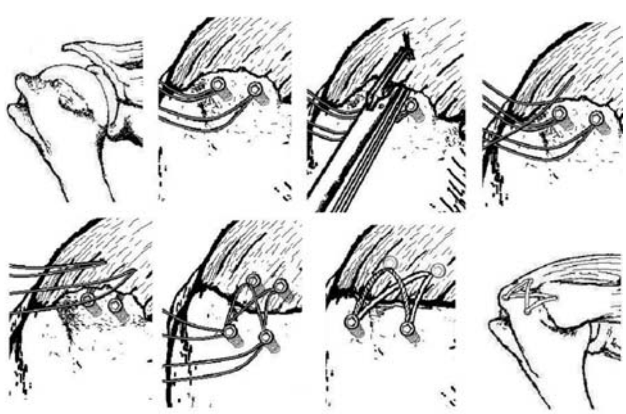

Fig. 2. Dissection of supraspinatus and infraspinatus tendons for 3-cm sized tears and knotless double-row suture anchor technique for 3-cm sized tears.

(Fig. 3). Load-to-failure testing was made to analyze the strength of the rotator cuff repairs.

Shoulders were divided into 5 groups. In Group 1 (n=16), the SpeedFix technique was used in 1-cm sized supraspinatus tendon tears. In Group 2 (n=11), the SpeedBridge technique was used in 3-cm sized supraspinatus and infraspinatus tendons tears. In Group 3 (n=9), the transosseous technique was performed for 1-cm sized tears. In Group 4 (n=9), the transosseous technique was performed for 3-cm sized supraspinatus and infraspinatus tendons tears. In the control groups, the intact supraspinatus tendon strength (n=3) and supraspinatus and infraspinatus tendons strengths together (n=3) were tested.

Data were analyzed with the SPSS v.15 (SPSS Inc, Chicago, IL, USA) software and Mann-Whitney U test was used to determine the statistical significance between groups. Statistical significance was set at $p<0.05$.

Results

Fifty-six cadaveric sheep shoulders were included in this study. In Group 2, 4 shoulders were disqualified due to muscle failures and one due to scapula fracture during testing.7

Load failures were observed as mean value±SD. Group 1 had mean load failure values of 176.4±121.9 N, Group 2 341.7±173.8 N, Group 3 229.3±187.3 N, and Group 4 408.6±235.0 N. The load failures for the 1 cm control group were 46.7±4.05 N and 108.4±8.5 N for 3 cm control group (Table 1, Fig. 4).

There was no statistically significant difference between the 1 cm SpeedFix group and the 1 cm transosseous group ($p=0.610$, $p>0.05$) or between the 1 cm SpeedFix and 1 cm control groups ($p=0.094$, $p>0.05$).

However, the 1 cm transosseous group was statistically superior to the 1 cm control group ($p=0.021$, $p<0.05$).

The differences between the 3 cm SpeedBridge group and the 3 cm transosseous group ($p=0.425$, $p>0.05$), the 3 cm SpeedBridge group and 3 cm control group ($p=0.086$, $p>0.05$), and the 3 cm transosseous group and 3 cm control group ($p=0.052$, $p>0.05$) were not statistically significant.

Discussion

Rotator cuff injuries are common and most cases can be treated with a nonoperative program including anti-inflammatory drugs, activity modification and stretching and strengthening exercises. Surgery is indicated for most full-thickness rotator cuff tears and partial-thickness tears when conservative treatment fails. The aim of rotator cuff repair surgery is to restore the shoulder to a pain-free state with normal motion, strength and function. The most common postsurgical complication is repair failure.[4,5] Clinical studies using postoperative imaging have determined high rates of recurrent tears or residual defects.[6,7] The most common component of the tear is the detachment of the tendon from its normal insertion on the proximal humerus.[8] Therefore, the reattachment of the tendon to the humerus until biological healing is an important component of rotator cuff repair. Many surgical techniques are available, such as transosseous sutures or single- or double-row suture anchor techniques.

We compared the knotless single-row suture anchor and transosseous techniques in 1-cm sized supraspinatus tendon tears. There were no statistically significant differences between the 1-cm SpeedFix and transosseous groups ($p=0.610$, $p>0.05$). In the 16 specimens in the

Fig. 3. The photograph of cadaveric sheep shoulder on Instron 8874 machine. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

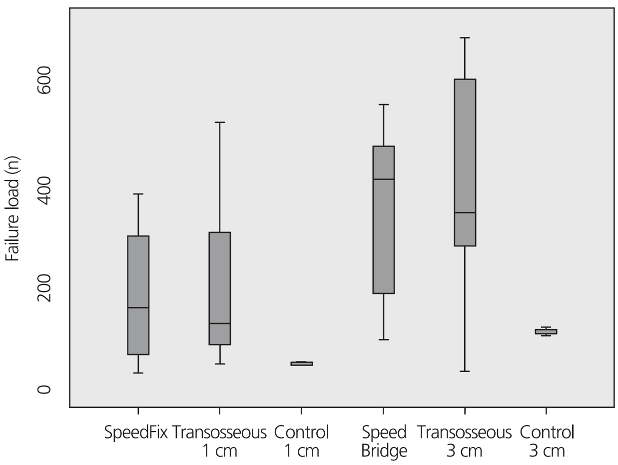

Fig. 4. Graphic demonstration of failure loads.

Table 1. The mean, minimum and maximum failure loads in groups.

Group	Number	Mean (Newton)	Standard deviation	Minimum (Newton)	Maximum (Newton)
SpeedFix	16	176.4	121.9	28	379
Transosseous 1 cm	9	229.3	187.3	47	517
Control 1 cm	3	46.7	4.0	43	51
SpeedBridge	11	341.7	173.8	92	551
Transosseous 3 cm	9	408.6	235.0	32	684
Control 3 cm	3	108.4	8.5	100	117

SpeedFix group, the mean failure load was 176.4 N and the most likely failure site was the tendon-suture interface.[9] Five failures were caused by the suture cutting through the tendon and 11 failures by suture breakage in this study. In the 1 cm transosseous group, the mean failure load was 229.3 N. Three failures occurred at low loads after the fiber wire sutures cut the bony tunnel. No suture anchor failure was observed. This result may be considered a superior biomechanical characteristic of the knotless suture anchor. Additionally, while there was no statistically significant difference between the 1 cm SpeedFix and control groups (p=0.094, p>0.05), the 1 cm transosseous group was statistically superior to the control group (p=0.021, p<0.05). Therefore, the transosseous suture techniques may be considered biomechanically superior to the knotless suture anchor technique.

The knotless double-row suture anchor technique (SpeedBridge) is designed for medium to large tears and is thought to be equivalent to transosseous techniques. Therefore, we compared the knotless double-row suture anchor and transosseous techniques in 3-cm sized rotator cuff supraspinatus and infraspinatus tears. Mean failure load in the 11 specimens in the SpeedBridge group was 341.7 N and 408.6 N in the 9 specimens in the 3 cm transosseous group. There was no statistically significant difference between the 3 cm SpeedBridge transosseous groups (p=0.425, p>0.05). We believe that as the SpeedBridge technique maximizes the contact between the tendon and bone and may protect the healing zone from the synovial environment by bridging, using both supraspinatus and infraspinatus tendons with an anatomical gap between the tendons may have been a disadvantage. The SpeedBridge technique may have superior biomechanical characteristics in clinical use for single medium- and large-sized tears. Additionally, there was no statistically significant difference between the 3 cm SpeedBridge and control groups (p=0.086, p>0.05) and between the 3 cm transosseous and control groups (p=0.052, p>0.05).

Comparisons between the 1 cm and 3 cm control groups and the other groups could not be made due to insufficient numbers and low mean failure loads due to musculotendinous failures occurring before intact tendon failure.

The SpeedBridge technique was superior to the SpeedFix technique (p=0.012, p<0.05), a similar result to previous studies comparing single- versus double-row suture anchor techniques.[10-13]

Cummins et al.[8] reported no significant differences between transosseous sutures and suture anchors in their biomechanical study of 60 fresh frozen sheep shoulder infraspinatus tendons. Additionally, they reported that the rotator cuff repair strength may be enhanced by increasing the number of suture anchors that pass frequently through the tendon by increasing the number of sutures per anchor or using different suture patterns.

Burkhart et al.[14] compared suture anchors with transosseous suture techniques in rotator cuff tears in 16 cadaveric shoulders and reported that bone fixation with suture anchors was less prone to failure than bone tunnels. In our study, there were 7 failures at low loads due to the fiber wire sutures cutting the bony tunnel in the transosseous groups. There was no suture anchors failure.

The most important factors behind failure following rotator cuff surgery are the breaking up of the suture anchors from the humerus, suture anchor failure, and the unraveling of anchor knots.[15] Another study attributed these failures to the width of the tear size, the retraction and atrophy of the tendon, and the amount of substantial tissue of the shoulder.[10] We studied knotless suture anchors in different sized rotator cuff tears in a shoulder model with anatomic humerus, scapula, supraspinatus, infraspinatus and subscapularis tendons and did not observe any breaking up of suture anchors.

Another study comparing the conventional double-row suture anchor technique with transosseous equivalent double-row technique in 20 cadaveric sheep shoulders reported no statistically significant difference between the two groups and recommended future research on knotless suture anchors.[16]

A review of the literature revealed no significant difference between the single-row and double-row groups in terms of postoperative clinical outcome and that patients with large to massive tears who had double-row fixation performed better than those who had single-row fixation.[17]

Another clinical study reported no difference in functional outcomes between single-row and double-row suture anchor techniques. The authors added that double-row repair is more technically demanding, expensive and time-consuming than single-row repair, without providing a significant improvement in clinical results.[18]

In conclusion, no significant difference was found between the new knotless suture anchor techniques and traditional transosseous suture techniques in different sized rotator cuff tears. We believe that suture bridging techniques may provide better suture tensioning and suture locking to ensure secure attachment of the tissues to the bone. However, the cost of the new suture anchors should be taken into consideration and additional biomechanical and clinical studies are needed.

Conflicts of Interest: The suture anchors were provided by Arthrex MR Medical Company free of charge.

References

1. Cofield RH. Rotator cuff disease of the shoulder. J Bone Joint Surg Am 1985;67:974-9.
2. Cole BJ, ElAttrache NS, Anbari A. Arthroscopic rotator cuff repairs: an anatomic and biomechanical rationale for different suture-anchor repair configurations. Arthroscopy 2007;23: 662-9.
3. Gerber C, Schneeberger AG, Beck M, Schlegel U. Mechanical strength of repairs of the rotator cuff. J Bone Joint Surg Br 1994;76:371-80.
4. Gazielly DF, Gleyze P, Montagnon C. Functional and anatomical results after rotator cuff repair. Clin Orthop Relat Res 1994;(304):43-53.
5. Mansat P, Cofield RH, Kersten TE, Rowland CM. Complications of rotator cuff re-pair. Orthop Clin North Am 1997;28:205-13.
6. Harryman DT 2nd, Mack LA, Wang KY, Jackins SE, Richardson ML, Matsen FA 3rd. Repairs of rotator cuff. Correlation of functional results with integrity of the cuff. J Bone Joint Surg Am 1991;73:982-9.
7. Galatz LM, Ball CM, Teefey SA, Middleton WD, Yamaguchi K. The outcome and re-pair integrity of completely arthroscopically repaired large and massive rotator cuff tears. J Bone Joint Surg Am 2004;86:219-24.
8. Cummins CA, Appleyard RC, Strickland S, Haen PS, Chen S, Murrell GA. Rotator cuff repair: an ex vivo analysis of suture anchor repair techniques on initial load to failure. Arthroscopy 2005;21:1236-41.
9. Scheibel MT, Habermeyer P. A modified Mason-Allen technique for rotator cuff re-pair using suture anchors. Arthroscopy 2003;19:330-3.
10. Kim DH, Elattrache NS, Tibone JE, Jun BJ, DeLaMora SN, Kvitne RS, et al. Biome-chanical comparison of a single-row versus double-row suture anchor technique for rotator cuff repair. Am J Sports Med 2006;34:407-14.
11. Ma CB, Comerford L, Wilson J, Puttlitz CM. Biomechanical evaluation of arthro-scopic rotator cuff repairs: double-row compared with single-row fixation. J Bone Joint Surg Am 2006; 88:403-10.
12. Demirhan M, Atalar AC, Kilicoglu O. Primary fixation strength of rotator cuff repair techniques: a comparative study. Arthroscopy 2003;19:572-6.
13. Ozbaydar M, Elhassan B, Esenyel C, Atalar A, Bozdag E, Sunbuloglu E, et al. A com-parison of single- versus double-row suture anchor techniques in a simulated repair of the rotator cuff: an experimental study in rabbits. J Bone Joint Surg Br 2008;90:1386-91.
14. Burkhart SS, Johnson TC, Wirth MA, Athanasiou KA. Cyclic loading of transosseous rotator cuff repairs: tension overload as a possible cause of failure. Arthroscopy 1997;13:172-6.
15. Cummins CA, Murrell GA. Mode of failure for rotator cuff repair with suture anchors identified at revision surgery. J Shoulder Elbow Surg 2003;12:128-33.
16. Spang JT, Buchmann S, Brucker PU, Kouloumentas P, Obst T, Schröder M, et al. A biomechanical comparison of 2 transosseous-equivalent double-row rotator cuff repair techniques using bioabsorbable anchor: cyclic loading and failure behavior. Arthro-scopy 2009;25:872-9.
17. Saridakis P, Jones G. Outcomes of single-row and double-row arthroscopic rotator cuff repair: a systematic review. J Bone Joint Surg Am 2010;92:732-42.
18. Aydin N, Kocaoglu B, Guven O. Single-row versus double-row arthroscopic rotator cuff repair in small-to medium-sized tears. J Shoulder Elbow Surg 2010;19:722-5.