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Suture tape anchors for enhancing healing in rotator cuff tears: a retrospective cohort study

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Abstract

Background Rotator cuff injuries are common, particularly among older adults, and are often treated with arthroscopic repair. However, retear rates remain high. This study compares clinical and structural outcomes between arthroscopic double-row suture bridge repairs using either suture tape anchors (STAs) with knotless medial fixation, or traditional knotted suture anchors (TSAs) with knotted medial fixation.

Methods This retrospective cohort study compared arthroscopic double-row suture bridge repairs performed from January 2021 to July 2023 using either knotless STAs or knotted TSAs. Eligible patients had medium (1–3 cm), large (3–5 cm), or massive (> 5 cm) full-thickness rotator cuff tears (DeOrio-Cofield classification) with no greater than Goutallier grade 3 fatty infiltration. Clinical outcomes were measured using VAS, Constant, UCLA, and ASES scores, both preoperatively and at 1-year postoperative follow-up. Muscle strength was assessed using manual muscle testing (0–5 scale) with the arm positioned at 30° scapular elevation. Structural outcomes were evaluated via MRI, where two trained surgeons assessed tendon thickness using the Sugaya classification and identified retears according to the Cho classification. Statistical analysis was conducted using SPSS.

Results The study included 86 consecutive patients undergoing arthroscopic rotator cuff repair, with 36 patients in the STA group (median follow-up 15.0 months, range 12–19 months) and 50 patients in the traditional suture anchor (TSA) group (median follow-up 16.5 months, range 12–20 months). Both groups showed significant improvements in functional scores (VAS, Constant, UCLA, ASES) postoperatively ($P < 0.05$), with no significant differences between the two groups ($P > 0.05$). The STAs group had significantly lower tendon thinning and higher tendon thickness and supraspinatus muscle strength compared to the TSAs group ($P < 0.05$). The retear rate was similar between the two groups (12.0% for TSAs and 11.1% for STAs, $P > 0.05$).

Conclusions At 1 year, both STAs and TSAs showed favorable clinical outcomes, but STAs were more effective in preserving tendon thickness and improving muscle strength. Although retear rates were similar, STAs may offer advantages in tendon healing and functional recovery.

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Clinical trial number Not applicable.

Keywords Rotator cuff tear, Suture tape anchor, Traditional suture anchor, Arthroscopic repair, Tendon healing, Retear rate, Functional recovery

Background

With the increasing number of individuals engaging in physical activities and the aging population, the incidence of rotator cuff injuries has been steadily rising [1]. According to literature reports, the prevalence of rotator cuff injuries can reach up to 10% in the general population, 20% in individuals aged 60 and above, and as high as 62% in those aged 80 and above [1–3]. Arthroscopic rotator cuff repair surgery which could alleviate pain and restore shoulder joint function, is one of the primary treatment methods. Despite continuous advancements in the performance of implant materials and surgical techniques, the retear rate following rotator cuff repair still remains quite high, ranging from 20 to 82% [4].

Rotator cuff repair retear rates are influenced by factors such as surgical technique, postoperative rehabilitation, and patient characteristics, including age, tear size, and tendon quality [5, 6]. The double-row suture bridge technique is widely adopted due to its biomechanical advantages, such as increased structural integrity, load strength, and tendon-to-bone contact area, which promote better biological healing [7–10]. However, this technique has been associated with a higher risk of Type II retears, potentially due to compromised blood supply caused by knots in the medial row [11–14]. To address these limitations, the knotless tape suture bridge technique has emerged as a next-generation approach, eliminating medial row knots to preserve blood supply. Studies suggest this technique enhances compression and load distribution at the bone-tendon interface while maintaining comparable repair strength [15–17]. Nevertheless, the superiority of either technique remains debated, with some studies highlighting a higher Type II retear risk in traditional methods [11, 14], while others report no significant differences in clinical outcomes or retear rates [18, 19]. Therefore, further exploration of this issue is needed.

Additionally, Sugaya et al. found that although some patients have good postoperative continuity of the rotator cuff, the tendon thickness is suboptimal [4]. There are currently no reports on whether there is a difference between the two techniques in improving tendon thickness after rotator cuff healing. This study aims to compares clinical and structural outcomes between arthroscopic double-row suture bridge repairs using either suture tape anchors (STAs) with knotless medial fixation, or traditional knotted suture anchors (TSAs) and investigate the impact of the STAs technique on rotator cuff tendon thickness after healing.

We hypothesized that compared to TSAs, STAs would result in better preservation of postoperative tendon thickness and improved muscle strength, while maintaining comparable clinical outcomes and retear rates.

Methods

This study was approved by the institutional review board of our hospital. A retrospective review was conducted on 188 patients diagnosed with rotator cuff injuries treated at the author's practicing hospital from January 2021 to July 2023 (Fig. 1). Inclusion criteria were as follows: (1) medium tears (1–3 cm), large tears (3–5 cm), and massive tears (> 5 cm) were classified according to the DeOrio and Cofield classification system; [20] (2) rotator cuff fatty infiltration not exceeding Goutallier grade 3; (3) follow-up duration of at least 1 year. Exclusion criteria were: (1) patients with isolated injuries to the subscapularis; (2) patients with shoulder stiffness; (3) patients who underwent single-row or traditional double-row repair; (4) patients with irreparable rotator cuff injuries. Finally, 86 patients with medium to severe rotator cuff tears who underwent repair using either the TSAs technique or the STAs technique were included.

Preoperative assessment

All cases underwent demographic information collection, physical examination, and imaging evaluation preoperatively. The Constant score [21], University of California Los Angeles(UCLA) scores [22], and American Shoulder and Elbow Surgeons Score (ASES) scores [23] were used to quantitatively assess the shoulder joint function of patients. Additionally, subjective pain scores were assessed preoperatively using the visual analog scale (VAS). Preoperative shoulder flexion range of motion and supraspinatus strength grading were recorded, strength taken at 30° elevation in scapular plane and maximal internal rotation [21, 24].

Surgical technique

All surgeries were performed by the same senior surgeon under general anesthesia and brachial plexus block, with patients in the beach chair position. After standard preparation, arthroscopic examination was conducted. Based on the condition of the long head of the biceps tendon, tenotomy or tenodesis was performed. For patients with shoulder impingement and Bigliani type 2 or 3 acromion, subacromial decompression or acromioplasty was conducted. Rotator cuff remnants were debrided, preserving good-quality tissue, and tear morphology was

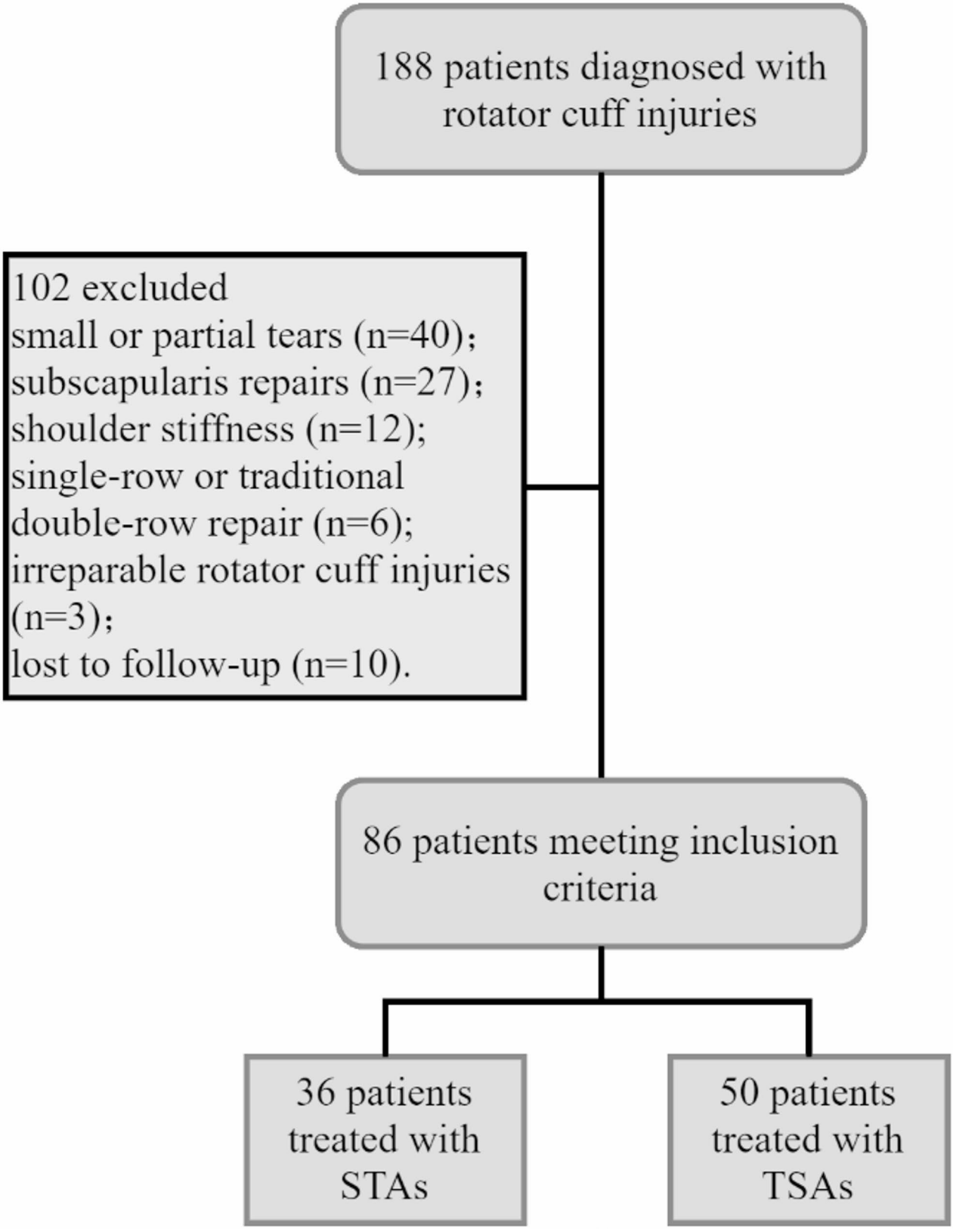

Fig. 1 Flowchart of eligible patients after inclusion/exclusion criteria

assessed. The double-row suture bridge technique was used if the tendon tension was low and sufficient footprint coverage was achievable. Depending on the surgeon's preference and available implants (Rejoin, Arthrex, or Smith & Nephew), TSAs or STAs (Rejoin, China or Smith & Nephew, USA) were used for the medial row. TSAs involved tying medial row sutures through the tendon(Fig. 2A), while STAs utilized tape passed through the tendon and secured laterally without tying (Fig. 2B). In cases of poor tendon quality, size 2 suture from the suture tape anchor is utilized to place additional knots at the anterior or posterior edges of the tear to enhance fixation stability.

Postoperative rehabilitation

All patients followed a standardized rehabilitation protocol of our institute. Passive exercises (e.g., pendulum, forward flexion, external rotation) began on day 1 and continued for 3 weeks. Assisted active exercises (e.g., wall climbing) were introduced at 3–6 weeks, with active exercises starting around 6 weeks as range of motion improved. Muscle strength training began at 2–3 months, and partial shoulder activities or labor resumed after 6 months.

Postoperative follow-up

Follow-up visits were scheduled at 1month, 3 months, 6 months, 1 year, and 2 years postoperatively. The VAS scores, Constant scores, UCLA scores, and ASES scores, shoulder flexion range of motion, and muscle strength grading were reassessed at the final postoperative follow-up by two trained surgeons. Shoulder joint MRI was performed to evaluate rotator cuff healing and the presence of retears at 1month and 1year postoperative follow-up. Rotator cuff healing and thickness were assessed by two trained surgeons according to the Sugaya classification for rotator cuff repair integrity [25], while retears were classified according to the classification proposed by Cho et al. [12] The follow-up duration for all included patients was at least 1 year.

Statistical analysis

Statistical analysis was conducted using SPSS 27.0 (IBM, USA). Continuous variables age, duration of preoperative symptoms, functional scores, surgical time, number of anchors, and range of motion) were assessed for normality and analyzed using independent t-tests if normally distributed, presented as mean ± SD. Categorical variables (gender, dominant hand, tear size, retear rate, muscle strength grading, and tendon thinning rate) were analyzed with chi-square tests and presented as frequencies (%). Non-normally distributed variables (Goutallier grade, functional scores) were analyzed with the Mann-Whitney U test and presented as median (IQR). Significance was set at $\alpha = 0.05$.

Results

The TSAs group included 50 cases (28 medium, 15 large, 7 massive tears; 22 males, 28 females; mean age 60.60 ± 8.48 years; symptom duration 7.60 ± 2.82 months), while the STAs group had 36 cases (17 medium, 12 large, 7 massive tears; 18 males, 18 females; mean age 60.53 ± 10.63 years; symptom duration 7.56 ± 3.26 months). No significant differences were found between

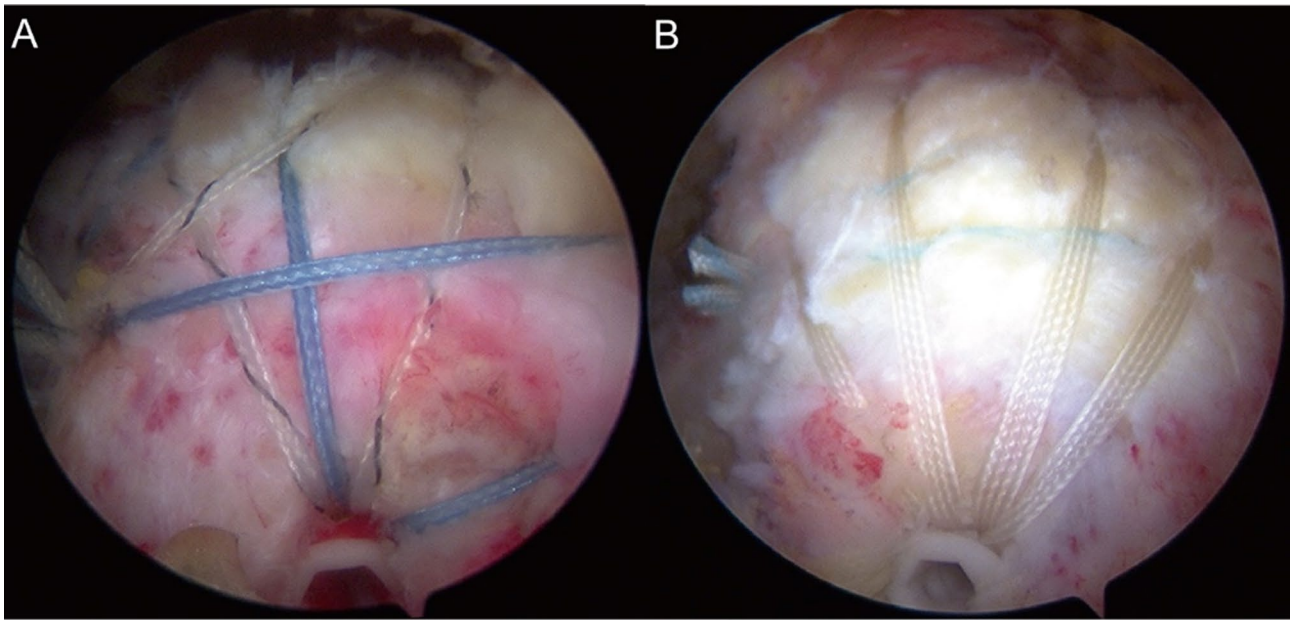

Fig. 2 Arthroscopic images of rotator cuff repairs using TSAs (**A**) and STAs (**B**)

Table 1 Demographic data of participants

	STA ($n=36$)	TSA ($n=50$)	*P* value
Gender, male/female, n	18/18	22/28	0.582[a]
Age, mean ± SD, years	60.53 ± 10.63	60.60 ± 8.48	0.972[b]
BMI, median (IQR)	22.9 (2.7)	23.1 (3.8)	0.459[c]
Dominant hand, right/left, n	33/3	46/4	0.956[a]
Duration of symptoms (month), mean ± SD	7.56 ± 3.26	7.60 ± 2.82	0.946[b]
Tear size classification [n(%)]			
Medium-sized tear	17 (47.2%)	28 (56.0%)	0.683[a]
Large-sized tear	12 (33.3%)	15 (30.0%)	
Massive tear	7 (19.4%)	7 (14.0%)	
Goutallier cuff atrophy grade, median (IQR)	2.0 (1.0)	2.0 (1.0)	0.970[c]
Operative time (min), median (IQR)	85.0 (33.5)	82.5 (27.3)	0.461[c]
Number of anchors, mean ± SD	3.72 ± 0.78	3.58 ± 0.73	0.389[b]
Follow-up time (month), median (IQR)	15.0 (4.0)	16.5 (6.0)	0.620[c]

SD: Standard deviation; BMI: Body Mass Index; IQR: Interquartile range; a: Chi-square test result; b: t-test result; c: Mann-Whitney U test result

groups in gender, age, dominant hand, symptom duration, tear size, surgical time, Goutallier grade, number of anchors, or follow-up time ($P>0.05$, Table 1).

Clinical outcomes

Both TSAs and STAs groups showed significant postoperative improvements in VAS, Constant, UCLA, and ASES scores compared to preoperative values ($P<0.05$, Fig. 3A-D), with no significant differences between groups ($P>0.05$). Postoperative forward flexion range of motion and muscle strength significantly improved in the STAs group ($P<0.001$, Table 2), and muscle strength grading was significantly better in the STAs group than the TSAs group ($P=0.040$), though shoulder flexion range of motion showed no difference between groups ($P>0.05$).

The comparisons of preoperative (Pre) and postoperative (Post) VAS(A), Constant(B), ASES(C), and UCLA scores(D) between the STAs and TSAs groups, as well as within each group. n.s: not statistically significant; *: $P<0.001$.

Structure outcomes

At the final follow-up, retears occurred in 6 cases (12.0%, 1 Type II) in the TSAs group and 4 cases (11.1%, no Type II) in the STAs group, with no significant difference ($P>0.05$, Table 3). Tendon thinning(Sugaya type III) was more common in the TSAs group (34.0%) than in the STAs group (13.9%), with a significant reduction in the STAs group ($P=0.035$). Typical cases are shown

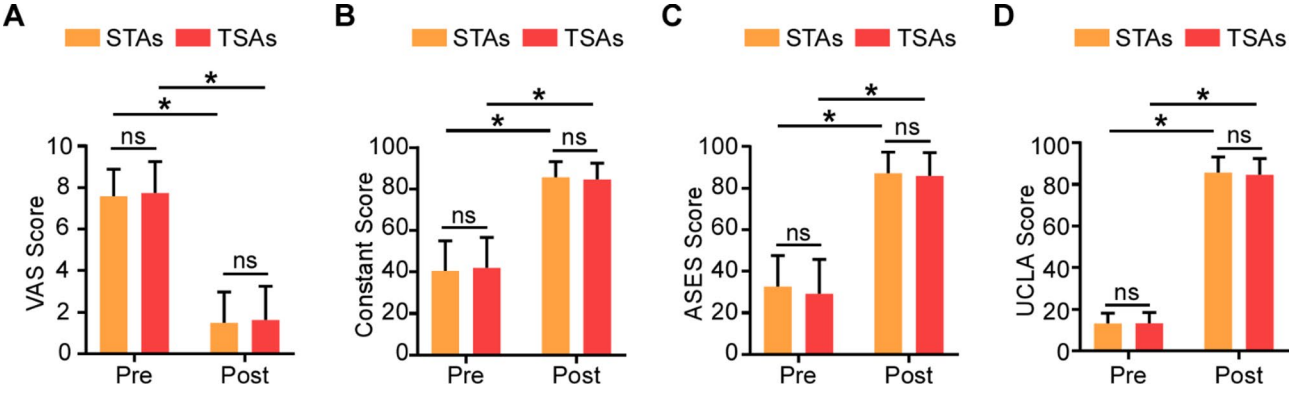

Fig. 3 Functional scores of the TSAs group and the STAs group

Table 2 Comparison of pre- and post-operative function between the STA group and the TSA group

	n	Muscle strength							FF ROM		
		Pre-op, *n* (%)			Final follow-up, *n* (%)			*P* value (within group)	Pre-op, median (IQR)	Final follow-up, median (IQR)	*P* value (within group)
Grading	—	3	4	5	3	4	5	—	100.0 (81.3)	180.0 (10.0)	<0.001[c]
STA group	36	16 (44.4)	20 (55.6)	0	4 (11.1)	12 (33.3)	20 (55.6)	<0.001[a]			
TSA group	50	20 (40.0)	30 (60.0)	0	5 (10.0)	30 (60.0)	15 (30.0)	<0.001[a]	110.0 (83.8)	180.0 (10.0)	<0.001[c]
P value (between groups)	—	0.680[a]			0.040[a]			—	0.273[c]	0.375[c]	—

FF: Forward flexion; ROM: Range of motion; IQR: Interquartile range; a: Chi-square test result; c: Mann-Whitney U test result

Table 3 Comparison of tendon thinning and retear rates between the STAs group and the TSAs group

	n	tendon thinning *n* (%)	retear *n* (%)
STAs group	36	5 (13.9%)	4 (11.1%)
TSAs group	50	17 (34.0%)	6 (12.0%)
P value (between groups)	—	0.035[a]	0.899[a]

a: Chi-square test result

in Fig. 4A-D(large rotator cuff tear) and Fig. 5A-D(large rotator cuff tear).

Male, 65 years old, with large tears in the supraspinatus and infraspinatus muscles of the right shoulder. (A) Preoperative MRI of the right shoulder showing a tear in the supraspinatus muscle. (B) Intraoperative endoscopic view of the tears in the supraspinatus and infraspinatus muscles. (C) Endoscopic appearance after repair with the STAs. (D) MRI of the right shoulder one year postoperatively showing no re-tear.

Male, 55 years old, with large tears in the supraspinatus and infraspinatus muscles of the right shoulder. (A) Intraoperative endoscopic view of the tears in the supraspinatus and infraspinatus muscles. (B) Endoscopic appearance after repair with the TSAs. (C) MRI of the right shoulder one month postoperatively showing good cuff thickness. (D) MRI of the right shoulder one year postoperatively showing reduced cuff thickness.

Discussion

This study compared the clinical and structural outcomes between arthroscopic double-row suture bridge repairs with STAs or TSAs. Our key findings demonstrated that both the STAs group and the TSAs group showed significant improvements in postoperative functional scores, shoulder flexion range of motion, and muscle strength compared to preoperative values. The STAs group exhibited significantly lower rates of tendon thinning and better shoulder muscle strength compared to the TSAs group, although there was no significant difference in the retear rate between the two groups.

The enhanced tendon thickness observed in the STAs group could be attributed to the avoidance or reduction of medial row knots, which may reduce local vascular compromise [4, 11]. Honda et al. also found that knotless medial row suturing can significantly reduce the incidence of incomplete healing after rotator cuff repair [26]. Additionally, thicker tendons likely contribute to better mechanical stability, supporting improved functional outcomes over time. This is particularly important, as prior studies have established a correlation between reduced tendon thickness after rotator cuff repair and poorer functional recovery [25]. These findings underscore the advantage of STAs in enhancing rotator cuff muscle strength, potentially facilitating better recovery of physical function and daily activity performance. The lack of significant differences in final clinical outcomes

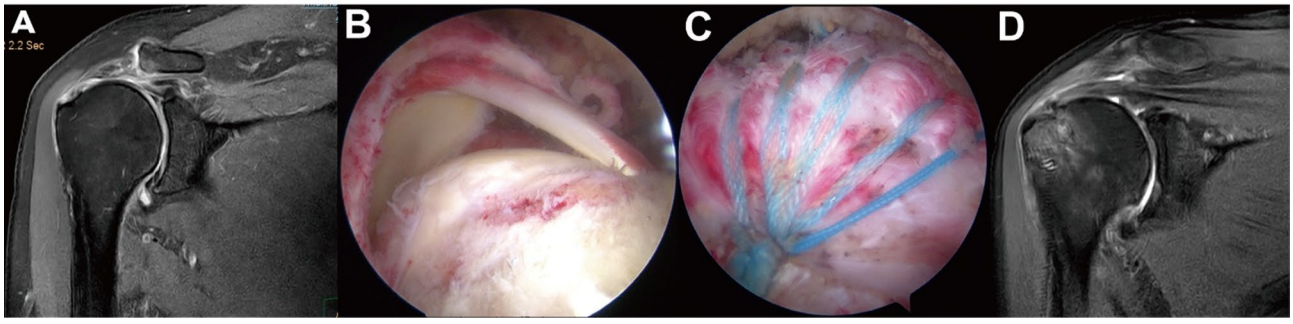

Fig. 4 A representative case of large rotator cuff tear repair using STAs

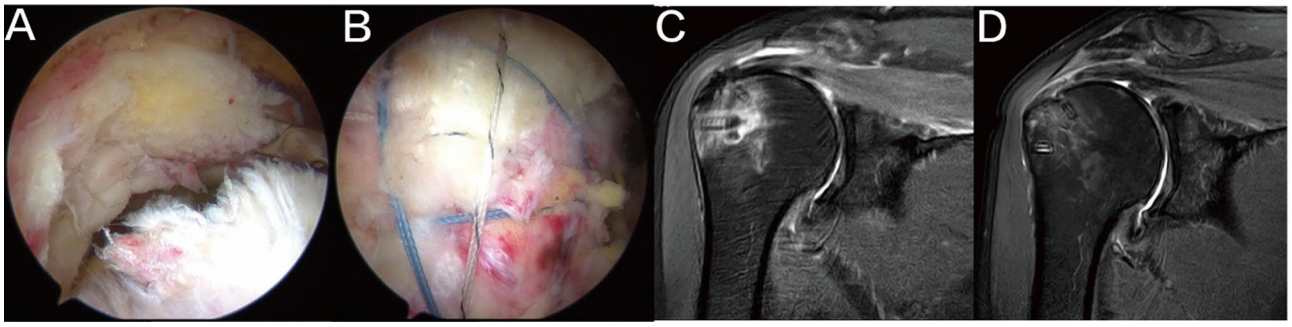

Fig. 5 A typical case example showing postoperative tendon thinning after repair of a large rotator cuff tear with TSAs

between the two groups may be attributed to the relatively short follow-up period.

In this study, knot-tying techniques were used for the internal row anchors in the TSAs group, while knotless techniques were used for the internal row anchors in the STAs group, or knot-tying techniques were selectively applied based on the individualized choice of anchor preloading with size 2 sutures at the torn edge of the rotator cuff tendon. When the rotator cuff quality was poor, knot-tying was not performed on the main body of the rotator cuff tendon, but knot-tying was still applied to the anterior and posterior margins of the torn tendon, where additional sutures were placed for reinforcement. The suture tape anchor used was a combination of traditional suture anchors and traditional suture tape anchors, consisting of one size 2 suture thread and one suture tape. To our knowledge, no previous studies have been conducted on this type of anchor. This repair technique not only provides greater stability for the internal row sutures of the rotator cuff but also reduces or avoids the potential detrimental effects of joint fluid entering the tendon-to-bone interface [27, 28]. Additionally, it avoids the issue of large holes created in the rotator cuff tissue by suture tapes when using traditional suture tape anchors alone [29]. In accordance with the findings of Millett [30], our study showed that the retear rate in the STAs group was comparatively lower than in the TSAs group. However, there was no significant difference between the two groups, which may be attributed to the relatively small sample size of this study. Though Şahin et al. [16] found no significant difference in the overall retear rate between knot-tying and knotless repair techniques in a prospective, randomized controlled study ($P > 0.05$), considering a dropout rate as high as 15% and the potential impact of tear size and tendon retraction on the outcomes which were not considered, the accuracy of the results is controversial.

Cho et al. [12] found that after repairing with the knotted suture bridge technique, recurrent tears of the rotator cuff mainly fell into two categories. Type I occurred at the original repair site of the lateral end of the rotator cuff tendon, while Type II occurred around the inner row anchor suture, which was relatively closer to the inside. Among them, the incidence of Type II tears was relatively higher, accounting for 58.6%. This finding raised concerns in the academic community because Type II tears were near the junction of the tendon belly, making revision significantly more difficult and the surgical outcomes uncertain. Bedeir [11], Shigley et al. [3] suggested that excessive tightening of the knotted sutures in the inner row might lead to obstruction of blood supply to the inner side of the rotator cuff tissue, resulting in ischemic tendon damage and eventually recurrent tearing. In this study, one case of Type II recurrent tearing was found in the TSAs group, while none occurred in the STAs group, which to some extent confirmed this viewpoint. In biomechanical studies of double-row suture bridge repair techniques, Huntington et al. [31] found that when using a three-anchor configuration, the STAs provided greater tendon-to-bone contact pressure and a larger footprint contact area compared to TSAs. They also observed that in a four-anchor configuration, the STAs repair structure exhibited higher ultimate tensile strength compared to TSAs. Similar conclusions were drawn by De Carli et al. [32], Park et al. [10], and Liu et al. [33] in their respective studies. Although there was no significant difference in the overall retear rate between the two techniques, the biomechanical advantages of the STAs technique can provide more reliable initial stability for early rehabilitation exercises after rotator cuff repair, promoting early tendon healing.

This study has certain limitations. Firstly, it is a retrospective study, leading to unavoidable research biases, which may limit the generalizability of the results. Secondly, manual muscle testing has inherent limitations in objectivity compared to instrumented isometric testing. Future studies would benefit from incorporating handheld dynamometry or isokinetic testing. Thirdly, there is a relatively small number of cases in this study, reducing the study's power. Finally, the follow-up period in this study is relatively short, and the differences in long-term clinical outcomes between the two repair techniques remain unknown. Therefore, further long-term follow-up with a larger sample size is still needed.

Conclusion

In conclusion, at 1 year, both techniques demonstrated favorable clinical outcomes, but the STAs can better restore rotator cuff tendon thickness and shoulder joint function compared to TSAs. Thus, the STAs may offer advantages in rotator cuff healing and shoulder function recovery.

Abbreviations

STAs	Suture tape anchors
TSAs	Traditional suture anchors
VAS	Visual analog scale
UCLA	University of California Los Angeles
ASES	American Shoulder and Elbow Surgeons Score

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None.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection was performed by Hao Qin, Hao Tan, Pei Zhao, Wenlong Yan, Aiguo Zhou, and Jian Zhang. Statistical analysis was conducted by Shixin Nie. The first draft of the manuscript was written by Shixin Nie, and modified by Chengjie Lian and Hua Zhang. Chengjie Lian and Hua Zhang provided theoretical supports and revised the manuscript. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability
The data used to support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Ethics Committee of the First Affiliated Hospital of Chongqing Medical University. The informed consent was waived by the Ethics Committee of the First Affiliated Hospital of Chongqing Medical University.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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