Arthroscopic-modified transosseous rotator cuff repair using the giant needle technique and racking hitch knot

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Background
While rotator cuff repairs yield a good outcome, arthroscopic repair using double-row anchors is expensive, especially in large and massive tears. Transosseous repair is a cost-effective way that can lead to excellent results, and modifying a previously described technique makes it reliable, easy to use, and feasible.

Purpose
This study analyzed the midterm functional outcomes of arthroscopic transosseous rotator cuff repair using special needles called giant needles. The aim of revisiting and modifying a previously described technique is to facilitate the passage of the giant needle, making it easier and more reliable. We also enhanced the repair construct by passing the sutures through the tendon in a separate step and applying a strong racking hitch knot.

Patients and methods
Sixty-two patients (41 females and 21 males, mean age 55.16 years) underwent arthroscopic transosseous rotator cuff repair for symptomatic full-thickness tears. Preoperative and postoperative pain severity, the constant shoulder score of the affected shoulders and the subjective value of the shoulders were recorded. Patients were followed up at 3, 6, 12, and 24 months after surgery.

Statistical analysis
Data were statistically described in terms of mean±SD, median and range, or frequencies (number of cases) and percentages when appropriate. IBM SPSS (Statistical Package for the Social Sciences) release 22 for Microsoft Windows was used for all statistical analyses.

Results
The mean pain severity improved from 8.61 preoperatively to 1.73 after 2 years of surgery. Similarly, the mean preoperative constant shoulder score and shoulder subjective value enhanced from 41.29 to 88.72 and 42.85 to 92.15%, respectively. We recorded two cases of postoperative stiffness, and two other cases underwent arthroscopic revision of rotator repair due to traumatic cuff retears.

Conclusion
The transosseous modified technique with a giant needle is reliable and safe, yielding satisfactory midterm outcome scores. This technique combines the minimally invasive advantage of arthroscopic procedures with the cost-effectiveness and biomechanical advantages of open transosseous procedures. Further comparative studies are recommended to support our results.

Keywords:
arthroscopy, giant needle, rotator cuff tears, transosseous

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Introduction

Rotator cuff tear (RCT) is often regarded as one of the most common sources of shoulder pain and disability, especially in elderly patients above the age of 50 years. Patients with RCT may be asymptomatic or complain of an array of symptoms ranging from minimal discomfort up to severe disabling pain, weakness, and limitation of range of movement (ROM) [1,2].

In 1944, McLaughlin [3] described the first open transosseous rotator cuff repair, considered the gold standard technique for RCT repair until the end of the 20th century, when other less invasive techniques were developed.

However, some surgeons use the transosseous method to repair RCTs using open and mini-open approaches.

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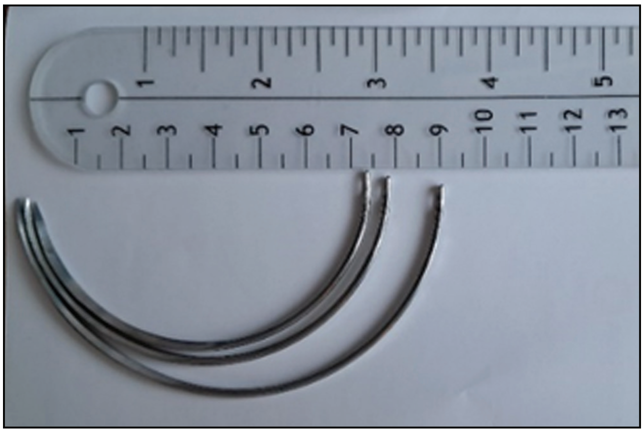
Rotator cuff repair with the open method has been reported to have high success rates, with the repaired tendon exhibiting high pullout strength [4]. However, it is also associated with complications primarily caused by the invasiveness of the approach, such as deltoid dysfunction, rehabilitation issues, and functional limitations [5].

The literature identifies multiple advantages of arthroscopic rotator cuff repair over open surgery. These include examining the entire glenohumeral joint for associated pathologies, better identifying the tear patterns, preserving the deltoid fibers, and decreasing the development of postoperative pain. Different techniques for anchor-based rotator cuff repair have been described, including single-row, double-row, and transosseous equivalent (TOE). Significant improvements in clinical outcomes have been reported using all these techniques [6–11].

Since the early 2000s, arthroscopic transosseous rotator cuff repair without suture anchors has also been described. This technique combines the minimally invasive advantage of arthroscopic procedures with the cost-effectiveness and biomechanical advantages of open transosseous procedures. Early published reports have been promising and similar to anchor-based techniques [12–18].

The giant needle rotator cuff repair was one of the first techniques to perform arthroscopic transosseous rotator cuff repair. It was described by Fleega [14] (Fig. 1). It is passed through the skin, unrestricted by any portal, and then through the tendon and bone in one step as in open repair. However, it was described as a technique with no associated clinical data and no guide for the direction of passing the needle. Furthermore, the needle passage through the cuff and the bone in a single step may not provide accurate anatomical reduction as the tendon is usually retracted. In this study, we introduced new modifications to the basic technique described by Fleega to facilitate the passage and the exit of the needle through the bone. Also, we aimed to pass each end of the suture loops through a healthy part of the retracted tendon and use the racking hitch knot for the final construct. Our study aimed to assess this modified technique's feasibility, clinical outcomes, possible complications, and failure rates.

Figure 1



Giant needle used for making tunnels in arthroscopic TO rotator cuff repair, available in three sizes. TO, transosseous.

Patients and methods

This work was a prospective case series study conducted at a tertiary hospital involving 62 patients, aged 55.16 years, with RCTs who presented to the sports medicine clinic. The rest of the demographic data is shown in Table 1. Our Research Ethics Committee approved the study (Institutional Review Board (IRB) number: MD-44-2021). All patients provided informed consent to participate in this study.

The inclusion criteria were skeletally mature patients with full-thickness RCTs without advanced retraction (Patte grade 1 or 2) or marked fatty infiltration (Fuchs grade 1 or 2) [19,20].

We excluded those with subscapularis tears, advanced glenohumeral osteoarthritis, rotator cuff arthropathy, or frozen shoulders.

The radiographic assessment included the evaluation of shoulder anteroposterior radiographic views and MRI to measure the width and length of tears. The tear shape was determined according to the geometric classification by Davidson and Burkhart [21]: 37 (59.7%) patients had

Table 1 Demographics of the study population

Number of patients	62
Average age in years±SD	55.16±7.91
Sex	
Males	21 (33.9)
Females	41 (66.1)
Degenerative vs. traumatic RCTs	
Degenerative	14 (22.6)
Traumatic	48 (77.4)
Fall to the ground	31
Tractional injury	17
Side	
Right	51 (82.3)
Left	11 (17.7)
Average duration of symptoms in months±SD	6.13±3.83

RCT, rotator cuff tear.

crescent tears, 18 (29%) patients had longitudinal tears, and seven (11.3%) patients had massive tears.

Preoperative data included pain severity using the visual analog scale (VAS) from 0 to 10 and the constant shoulder (CS) score of the affected shoulder, which assesses pain, activities of daily living, range of motion (using a goniometer), the strength of abduction (using a spring balance), and level of external and internal rotation. Shoulder subjective value (SSV) (defined as the subjective evaluation by the patient of shoulder function, expressed as a percentage of a normal shoulder from 0 to 100%) was also obtained from each patient [22–25].

Operative technique

All patients were operated upon under general anesthesia with an interscalene nerve block. The procedure was performed on a standard operating table with a unique beach chair. The patients were placed in an 80° sitting position with their arms hanging freely. Routine skin marking was done for portal placement.

The procedure started with diagnostic arthroscopy of the glenohumeral joint using a posterior viewing portal and an anterior instrumentation portal through the rotator interval lateral to the coracoid process. Depending on its condition, the long-head biceps tendon was treated by tenotomy or preservation.

Once all glenohumeral joint pathologies were evaluated and addressed, the arthroscope was introduced into the subacromial space. An arthroscopic subacromial decompression was performed, and an RCT was inspected using an arthroscopic hook probe to determine its pattern and dimensions.

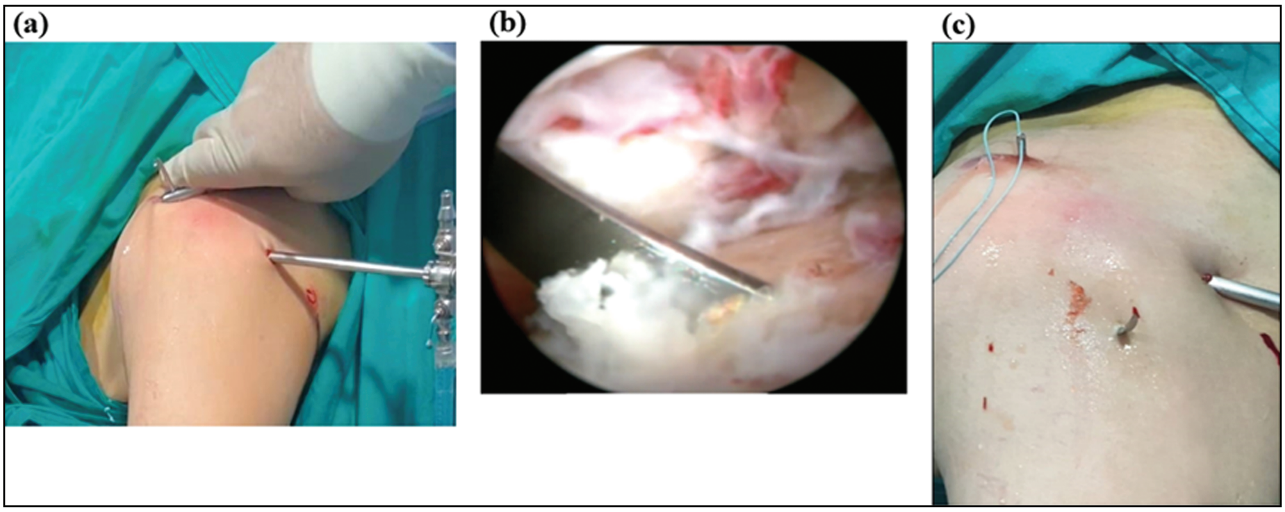
The rotator footprint was prepared using an acromionizer to achieve a bleeding bony surface. The entry holes of the giant needle were made by an awl just lateral to the articular cartilage. The number of holes was planned according to the tear size, a hole for each centimeter.

While the arm was being held in adduction, a unique needle holder introduced the giant needle through the skin in front of the acromion until it showed in the arthroscopic field. Then it was passed through the already made entry hole (Fig. 2). An essential tip for easy passage of the needle through the cancellous bone is the entry angle, making 45–60° medially, to be the reverse of the deadman angle [26] (Figs 2b and 3). That direction will direct the needle's exit within 2–3 cm from the tip of the greater tuberosity to facilitate its exit from the bone. Tips and pearls of the technique are shown in Table 2.

Then, the arm alternates from the elbow while pushing the needle. This was repeated until the needle passed through the lateral cortex.

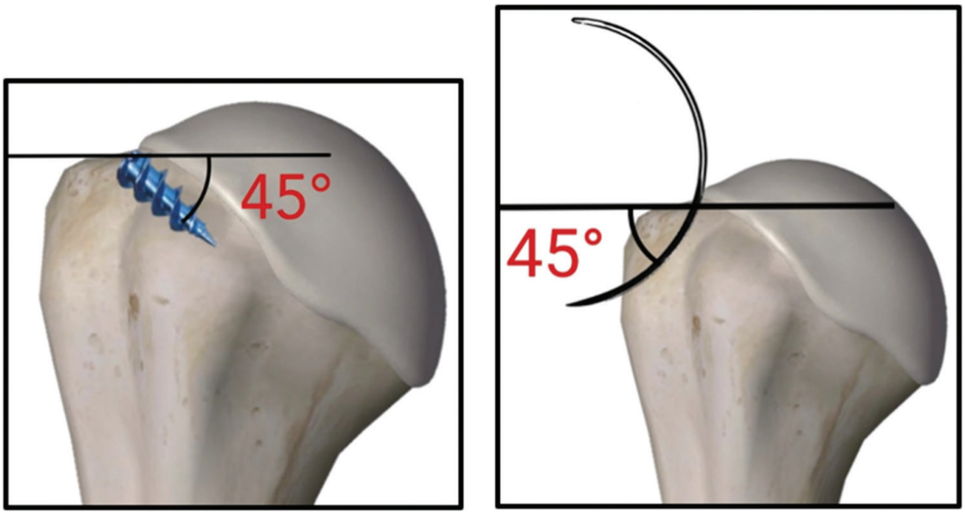
The giant needle was then loaded with a passing suture loop for later shuttling; the tunneling process was repeated to make other tunnels if needed. A high-strength suture loop was shuttled to have the loop exiting from the lateral aspect while the two free ends were left medially to be brought out of the instrumentation portal by a suture retriever. A hook probe brought out the lower

Figure 2



(a) Intraoperative photograph of the needle entry through the skin of a left shoulder. (b) Arthroscopic photograph of the needle entry through the made hole at an angle of 45° (reverse of the deadman angle). (c) Intraoperative photograph of the needle's exit through the skin and the scope in the posterior portal.

Figure 3



Diagrammatic photograph of the deadman angle of anchor insertion (left) and its reverse in the giant needle insertion (right).

Table 2 Tips and pearls for the technique

During subacromial decompression	Cleaning the bursal tissues away from the gutter to avoid soft tissue interposition when tying the knot
The margin convergence suture	Passed before passing the needle in the bone tunnel and tied after the creation of the tunnels so as not to make the tendon in the way of the needle
When passing the needle	Avoid arm abduction as it will make the angle more than 100° with deep penetration, a difficult exit through the cortical bone, and a risk of axillary nerve injury
Before knot tying	Ensure no soft tissue interposition exists between the loop and the free ends

loop. The medial limbs of each loop were passed through the cuff tendon with a suture passer or a bird beak from anterior to posterior. Finally, the medial free ends and lateral loop were tied together using a racking hitch suture configuration (Fig. 4). Demonstration of the steps of the technique was shown on a model (Fig. 5).

In cases with U-shaped or large tears, free fiberwire suture ends were passed transversely through the anterior limb of the cuff and the posterior limb. They were then tied using a Samsung Medical Centre knot for margin convergence and to prevent the longitudinally oriented transosseous free ends from cutting through the tendon [27].

After wound closure, a sterile dressing was applied, and the arm was placed in a shoulder immobilizer.

Postoperative management

Rehabilitation protocol

The postoperative rehabilitation protocol consisted of gentle passive shoulder ROM allowed from the first week till the 6th week, pendulum exercises started at the 3rd week, active assisted shoulder ROM allowed at 6th week, and strengthening exercises started at 3rd month. However, individual changes to the protocol were made according to the tear size, grade of retraction, and tendon quality.

All patients were evaluated at 3, 6, 12, and 24 months postoperatively to assess pain severity, CS score of the affected shoulder, and the SSV.

Statistical method

Data were statistically described in terms of mean±SD, median and range, or frequencies (number of cases) and percentages when appropriate. IBM SPSS (Statistical Package for the Social Sciences; IBM Corp., Armonk, New York, USA) release 22 for Microsoft Windows was used for all statistical analyses.

Results and follow-up

Intraoperative data

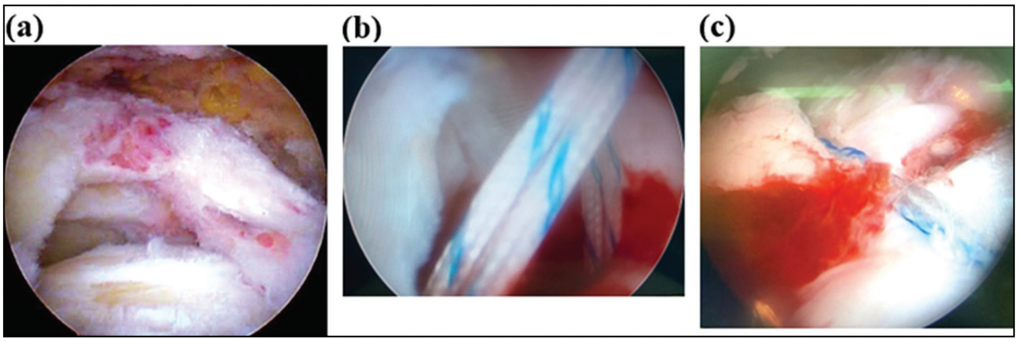
In all, 42 (67.7%) patients with preoperative biceps symptoms or intraoperative pathology underwent long-head biceps tenotomy, preserved in 20 (32.3%) patients. We made two tunnels in 45 (72.6%) patients, three tunnels in nine (14.5%) patients, and only one tunnel in eight (12.9%) patients.

In two patients, intraoperative tunnel failure occurred. A suture cutout from the bone occurred during knot tying and tensioning. The failed tunnels were then revised using the same technique.

Postoperative data

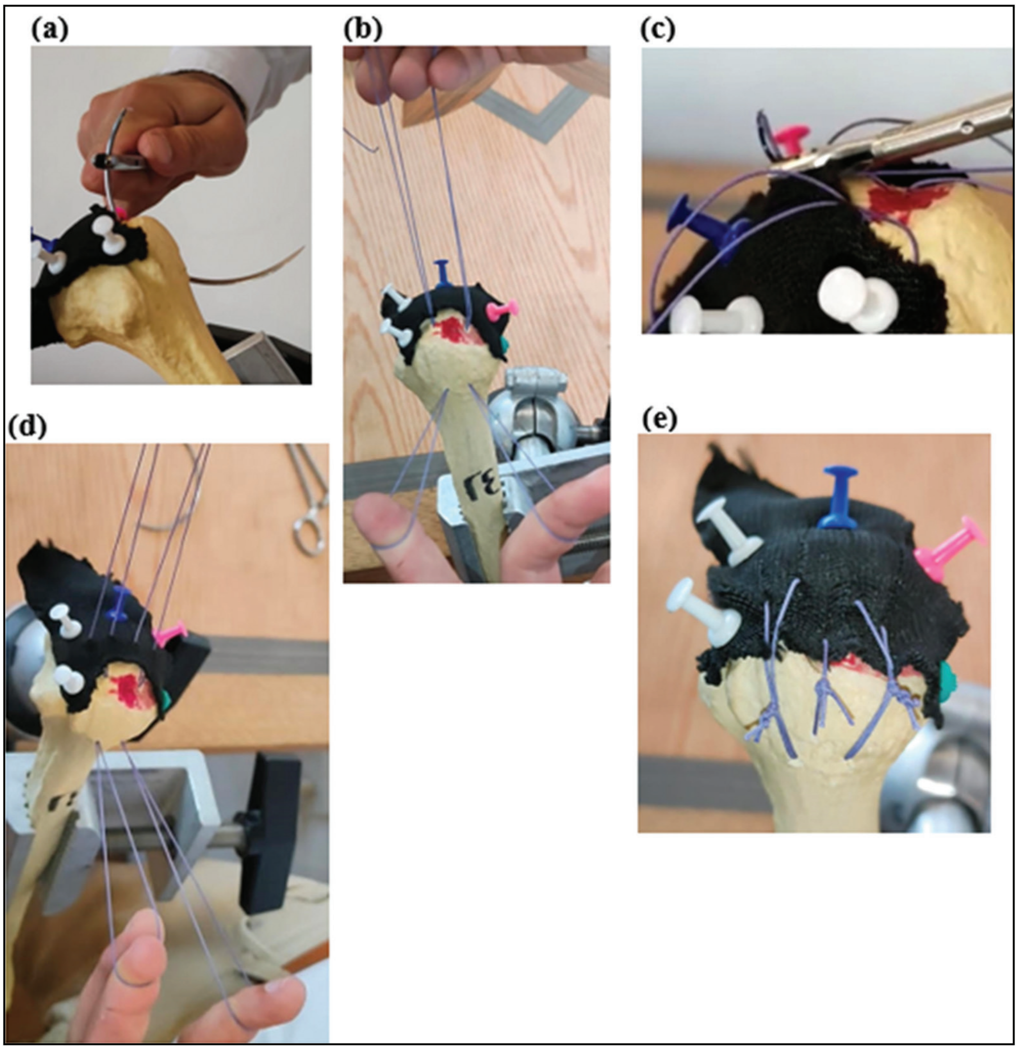
The mean pain severity score (VAS) improved from 8.61 preoperative to 1.73 at 24 months follow-up (FU),

Figure 4



Arthroscopic views show (a) supraspinatus tear after debridement, (b) sutures within the tunnels before passing through the cuff, and (c) final view after repair.

Figure 5



Demonstration of the technique on a model (a) passing of the needle through the humeral head, (b) two loops of high-strength sutures passed through two tunnels, (c) passing of medial limb of the suture loop through the tendon by a suture passer, (d) after passing all medial limbs of loops through the torn cuff tendon, and (e) final repair with racking hitch knots.

while the mean CS score of the affected shoulders improved from 41.29 preoperative to 88.72 at 24 months FU. The SSV mean improved from 42.85% preoperative to 92.15% at 24 months FU (Table 3).

Two patients had postoperative stiffness at 3 months FU. Shoulder stiffness was defined by Chung *et al.* [28] as passive forward flexion of less than 120°, passive external rotation with the arm at the side of less than

Table 3 Preoperative and postoperative outcomes of pain, constant shoulder score, and shoulder subjective value of the patients included in the study

	Preoperative		3 months FU		6 months FU		12 months FU		24 months FU	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
VAS	8.61	0.94	4.52	1.33	2.28	1.28	1.86	0.26	1.73	0.78
CS score	41.29	9.57	60.42	10.43	83.97	10.27	85.68	3.15	88.72	3.03
SSV	42.85	12.67	72.26	11.79	83.92	10.12	90.56	6.72	92.15	5.92

CS, constant shoulder; FU, follow-up; SSV, shoulder subjective value; VAS, visual analog scale.

30°, and passive internal rotation at the back lower than the third lumbar vertebra.

These patients were sent for sonographic-guided shoulder injections with pain management and continued physiotherapy and were improved at the 1-year FU.

Two other patients had traumatic retears (one after 6 months and the other after 8 months of the primary arthroscopic repair). They underwent arthroscopic transosseous revision of rotator cuff repair. Both improved 6 months after the revision surgery.

Discussion

Some authors consider transosseous repair superior to suture anchors in rotator cuff repair based on biological and biomechanical factors. The absence of hardware in the tuberosity area represents a significant advantage. It has been demonstrated that the transosseous approach provides a large footprint coverage and proper pressure distribution with no unwanted stress spikes that may affect the tendon tissue, thereby preserving the integrity of the tissue [18].

Vascularity inside the tissues is believed to play a crucial role in healing. Therefore, bone tunnels through the cuff's footprint add value to the biological healing process by increasing blood flow to the repaired cuff tendon during healing [29].

In elderly patients with poor bone quality, the anchored rotator cuff repair may be complicated by anchor pullout. This complication could be avoided by the cautious use of transosseous techniques. In addition, an increasing prevalence of simple cysts in the greater tuberosity was reported. There is a possibility that these cysts may weaken a large portion of the rotator cuff footprint. This may compromise the suture anchor fixation of the rotator cuff. Transosseous repair method has an advantage for those patients.

Although our rotator cuff repair technique using the giant needle may not seem to be a novel technique, it was first described in 2002 as a technical note. Since then, there have been no sufficient clinical studies that used the giant needle technique for rotator cuff repair. The modification to the original technique was that we created the bone tunnel first and then passed the sutures in a second step. By this, we guarantee that the sutures were passed through a healthy part of the tendon. Also, this would improve the reduction as the sutures would be at a more medial position when compared with passing the needle itself through both the tendon and the bone in one step. Furthermore, the use of a racking hitch knot provided a strong construct having double the thickness of the suture and having two points of fixation through the tendon. This would decrease the stress on the suture–tendon junction to nearly half the stress.

Damage to the axillary nerve is a concern in the transosseous rotator repair. The 45–60° entry would help the needle to exit through the corticocancellous bone and protect the axillary nerve [30,31]. No case of postoperative axillary nerve affection was recorded in this study.

One of the main advantages of this study is that it provides a robust and cost-effective technique to repair RCTs similar to double-row suture anchors. Due to the high cost of implants (anchors and sutures) with an additional row of fixation, several studies indicate that double-row repair is not cost-effective. Rotator cuff repair using the giant needle resulted in lower costs than rotator cuff repair using a double-row of suture anchors [32].

The giant needle cost during the study period was 2500 Egyptian Pounds (EGP) (80.91 USD), while the cost of each suture (MaxBraid; Biomet) was 1000 EGP (32.36 $). For example, in a small RCT, we used one needle with one suture, so the total cost for the repair would be 3500 EGP (about 114 USD). In contrast, for minor RCT repair by two anchors, one Jugger Knot All-Suture anchor costs 7000 EGP, and one Quattro Link knotless anchor (Biomet) costs 9000 EGP, so the total cost for TOE repair would be 16000 EGP (about 518 USD). Each needle can be used for five or six cases, reducing additional hardware costs.

In the literature, we can find many studies that recorded considerable results of transosseous rotator repair. In 2016, Flanagin *et al.* [33] found in their research on 109 shoulders of 107 patients (mean age 56.3 years and mean FU of 38 months) who underwent transosseous arthroscopic rotator repair by the device of Arthrotunneler that the SSV of patients improved to 93.7%. The recorded complications were four cases of failure and one case of postoperative infection.

The prospective study of Black *et al.* [15] on 31 patients concluded an improvement in SSV from a mean of 35–84% after a mean FU of 26 months. Regarding the complications of this study, there were three cases of retears "one traumatic and two atraumatic" and two instances of intraoperative suture cutout from the bone.

Verdano and colleagues found in their study of 34 patients with a mean age of 63.24 years that the CS score of the affected shoulders improved from 24.5 to 83.2 at 6 months and 86.9 at 12 months, with no cases of retears at the 6-month MRI FU. The study recorded two cases of postoperative stiffness that improved with prolonged rehabilitation [17]. These results support our findings that showed significant improvements in VAS, CS, and SSV.

The literature has demonstrated that both transosseous and TOE techniques produce equivalent clinical results, and clinical studies have confirmed this hypothesis. Toussaint *et al.* [34] performed TOE rotator cuff repair on 154 patients and found that the CS improved from 44.42 to 80.47. In that study, 17 patients had postoperative stiffness, and 22 patients were diagnosed as failed repair based on postoperative MRI or CT arthrogram at the 15-month FU.

In 2020, Firat and colleagues performed a prospective comparative study between transosseous and TOE anchor techniques in arthroscopic repair of full-thickness RCT. The VAS improved from 8.1 to 3.15 in the transosseous group and from 8.2 to 3.18 in the TOE group. The CS enhanced from 31.59 to 88.56 in the transosseous group and from 33.48 to 87.23 in the TOE group after an average FU of 32.95 months. MRI identified the retears at the final FU. They found two patients with Sugaya type 4 and one with Sugaya type 5 in the transosseous group, while four patients with Sugaya type 4 and four with Sugaya type 5 were found in the TOE group. The study concluded that both techniques have the same considerable improvements in shoulder functions [35].

Also, Binder and colleagues concluded from their 2022 comparative study of transosseous and TOE anchor methods to repair RCTs that the CS was improved from 50 to 88 in the transosseous group versus from 48 to 87 in the TOE group. The SSV was improved from 47 to 95% in the transosseous group versus from 47 to 95% in the TOE group at 2-year FU. There was no significant difference in the postoperative tendon integrity according to the Sugaya classification [36].

The clinical and functional results of our study are in line with those of previous studies, which discuss the results of various techniques of transosseous and TOE repair, which have low complication rates and are much more cost-effective than suture anchor repair.

The widely used tunnel devices create vertical and horizontal tunnels with a right angle between the limbs, which increases the friction and stress on the sutures at that point, which may lead to cutting the sutures at a sharp angle [37].

There are some limitations relevant to this study. This study analyzed a consecutive group of patients with a very heterogeneous distribution of RCTs with different tear sizes, configurations, and types (traumatic vs. degenerative). Further studies need to be performed to evaluate this technique's long-term clinical and radiographic outcomes and compare it to the TOE anchor repair.

Conclusion

We provided a valuable, safe, and cost-effective technique for rotator cuff repair that did not use any hardware implant and had significant functional improvement. This technique is an excellent alternative to double-row and TOE anchor repair in elderly patients, especially with porotic bone. The procedure is not technically complicated and does not require a long learning curve. Further studies should be performed to compare transosseous and anchored rotator cuff repair in terms of functional and radiological outcomes.

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Conflicts of interest

There are no conflicts of interest.

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