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TECHNICAL NOTE • SHOULDER - ARTRHOSCOPY

Arthroscopic transosseous rotator cuff repair: the eight-shape technique

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Abstract All-arthroscopic anchorless transosseous suture techniques combine the advantages of the open transosseous repair with the benefits of arthroscopic technique. However, all the techniques described until now are very complex, difficult to reproduce and associated with an increased surgical time. The authors developed a novel all-arthroscopic anchorless transosseous suture technique easy to perform and to reproduce. This procedure maximizes the tendon-footprint contact area obtaining both medial and lateral fixation without using any device, employing only 1 suture tape so to avoiding the risk of suture twist. The preparation of two transosseous tunnels is very easily and safely performed thanks to a dedicated instrument. The procedure is described in details. Moreover, the preliminary favorable results after a minimum follow-up of 12 months are reported.

Keywords Rotator cuff · Tendon · Tear · Repair · Transosseous technique · Arthroscopy

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Introduction

For many years, open repair with transosseous (TO) sutures was considered the gold standard treatment for full-thickness rotator cuff tears (RCT). The advent of arthroscopy has revolutionized rotator cuff surgery, and nowadays, arthroscopic rotator cuff repair is becoming the new gold standard as it is less invasive and preserves the deltoid muscle [1, 2]. However, despite the significant improvement of fixation devices (the trend spans from screwed to beaten up to the latest all suture anchors with a continuous material evolution—from titanium, resorbable, peek and UHMWPE) and surgical techniques (single row, double row, suture bridge) that occurred in the last years, non-healing or re-tear rate after arthroscopic rotator cuff repair is still high and it varies between 39 and 94% depending on the number of tendons involved, the patient's age and the tear size [3, 4]. Although there is no general consensus as to the causes of non-healing, taking into account that biological factors are likely to play a major role, a potential limitation of the arthroscopic technique has been related to the use of suture anchors, particularly when used in a single-row configuration, which is not able to completely reproduce the bone–tendon footprint [5, 6].

Nevertheless, no final evidence of better clinical outcomes has been demonstrated between single- and double-row repairs [7, 8] and re-tear after a double-row repair may lead to a medial failure whose management is complicated [9].

Furthermore, the use of anchors has been associated with several complications including anchor pullout in case of poor bone quality and greater tuberosity bone osteolysis [10]. In addition to that, suture anchors are expensive, particularly if used in a double-row or suture-bridge configuration and may have limited efficacy in cases of revision where multiple anchors have previously been implanted into the tuberosity footprint or in the presence of poor bone quality [11, 12]. In an attempt to overcome these limitations, all-arthroscopic anchorless TO suture repairs of the rotator cuff have recently been developed [9, 11–13] Several studies demonstrated that TO tunnels give excellent hold and that TO repairs are associated with a higher load to failure and yield less interference motion when compared to suture anchors [14, 15]. All-arthroscopic anchorless TO suture techniques combine the advantages of the open TO repair with the benefits of arthroscopic technique. However, all the techniques described until now are very complex, difficult to reproduce and associated with an increased surgical time. The authors developed a novel all-arthroscopic anchorless TO suture technique easy to perform and to reproduce. This procedure maximizes the tendon-footprint contact area obtaining both medial and lateral fixation without using any device. In the current technical note, the procedure is described in details and the preliminary results after a minimum follow-up of 12 months are reported.

Materials and methods

Between January 2014 and April 2015, 12 patients (8 males and 4 females, mean age 61.4 years ± 4) with a partial or full-thickness RCT underwent arthroscopic TO repair by the first author (CC) using the technique below described. Inclusion criteria were: partial or full-thickness RCT on the preoperative magnetic resonance imaging (MRI), no previous shoulder surgery, no previous shoulder injections, no previous shoulder infection. Patients with glenohumeral instability, arthritis and stiffness were excluded from the study. Nine patients presented a full-thickness RCT, while 3 patients had a partial articular-side lesion. Of the patients with a full-thickness RCT, 4 had a small lesion (C1 according to Snyder's classification [16], while 5 had a moderate/large lesion (C2–C3). All patients were followed up after a minimum of 12 months clinically by evaluation of the UCLA score and the visual analog scale for pain (VAS; 0 = no pain, 10 = maximum pain). The paired t test was used to determine whether there was a significant difference between preoperative and postoperative UCLA and VAS scores. A *P* value of less than 0.05 was considered to be statistically significant.

Surgical technique

The procedure can be performed depending on anesthesiologist preference under general anesthesia or interscalene cervical plexus block or combined, and either in beach-chair or in lateral decubitus position according to surgeon request.

The authors suggest to use a 3-portal surgical technique: standard posterior (for the scope), lateral and antero-superior (working) portals. Once the reparability of the RCT is assessed is advisable firstly to treat possible associated pathology (long head of the biceps tenotomy/tenodesis, subscapularis repair).

After tendon and bone preparation for suture (respectively, cutting and refreshing the torn tendinous edge and wide surface decortication of the footprint providing maximum seal bone), it is possible to prepare the two TO tunnels required for this technique. A dedicated instrument was developed with the aim to simplify and accelerate the operative procedure avoiding pitfalls and damages to soft tissues.

Once located the lateral cortical entry point (approximatively at about 15–20 mm distally to the greater tuberosity), a 2-mm entrance hole is prepared anteriorly. The device, named Taylor Stitcher® (NCS Lab s.r.l.—Medical Devices Factory, Italy) (Fig. 1a), permits to perform the TO tunnel through the handle screwing that controls the advancement of a Superelastic Transosseus Needle® (STN). Thanks to its multiradius shape, led by the position limiter, the Taylor Stitcher® performs TO tunnels in the footprint area. Tunnels are 3 mm in diameter and present a smooth curved morphology. The shuttle wire is then passed in one single step with the STN (having an eyelet close to the tip) through the TO tunnel so that the suture wires can be dragged into it.

In case of *moderate/large full-thickness RCT* (C2–C3 Snyder classification), after the shuttle wire is passed through the TO tunnel, it is retrieved through the anterior portal and then passed through the medial portion of the tendon with different devices according to surgeon preference. The same procedure is repeated to prepare another TO tunnel posteriorly, leaving a minimum bone bridge of approximatively 10 mm between the 2 TO tunnels in AP direction (Fig. 1b). The two shuttle wires that have passed through the anterior and posterior TO tunnels and through the anterior and posterior aspects of the medial portion of the tendon are available and retrieved through the anterior portal (Fig. 2a). Each shuttle wire is then used to pass one extremity of a smooth suture tape (FiberTape, Arthrex, USA) through the tendon and through the TO tunnel so that one extremity is passed through the anterior aspect of the medial portion of the tendon and the anterior TO tunnel and the other one is passed through the posterior aspect of the medial portion of the tendon and the posterior TO tunnel (like a reverse "U") (Fig. 2b). Both extremities of the tape are then retrieved from the lateral cortical entry points of the tunnels through the lateral portal. Before knot tying, the pressure effect of the mattress suture onto the footprint with closure of RCT can be proved by pulling the suture

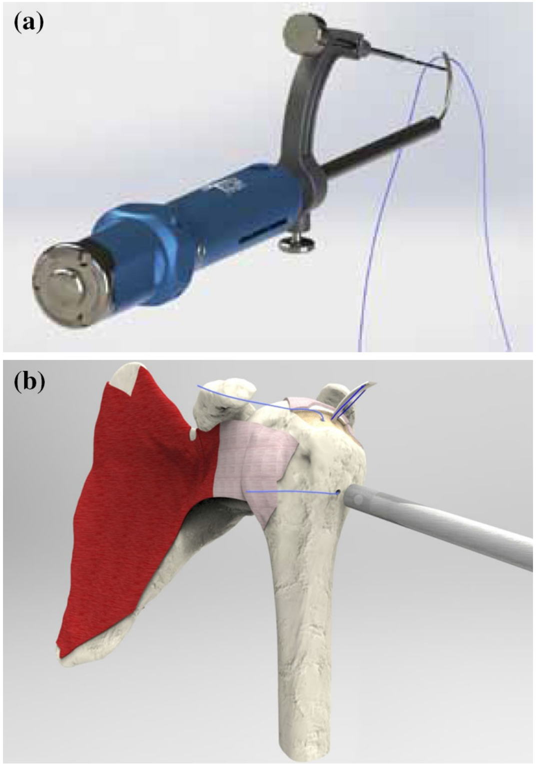

Fig. 1 **a** The Taylor Stitcher® permits to perform the TO tunnel through the handle screwing that controls the advancement of a Superelastic Transosseus Needle®. The shuttle wire is then passed in one single step with the STN (having an eyelet close to the tip) through the TO tunnel so that the suture wires can be dragged into it. **b** Once located the lateral cortical entry point (approximatively at about 15–20 mm distally to the greater tuberosity), a 2-mm entrance hole is prepared. Thanks to its multiradius shape, led by the position limiter, the Taylor Stitcher® performs TO tunnels in the footprint area. Tunnels are 3 mm in diameter and present a smooth curved morphology. The same procedure is repeated to prepare another TO tunnel posteriorly, leaving a minimum bone bridge of approximatively 10 mm between the 2 TO tunnels in AP direction

ends. The medial mattress suture is then completed performing an arthroscopic knot on the lateral cortex of the great tuberosity (Fig. 3). Sliding knots should be avoided because of the potential tissue damage resulting from the sawing motion of these knots. After tying the knot, the two extremities of the suture instead of being cut are then used to perform an additional passage through the lateral portion of the tendon in order to obtain a double-row-like configuration (eight shape). Using the device that best works for the operating surgeon, the extremities are passed through the lateral portion of the tendon slightly anterior and posterior to the medial suture (Fig. 4a). The figure of eight is completed performing a second arthroscopic knot on the tendon so to obtain a trapezoidal double mattress suture configuration. The extremities of the suture are then cut (Fig. 4b). Surgery ends with subacromial decompression if necessary.

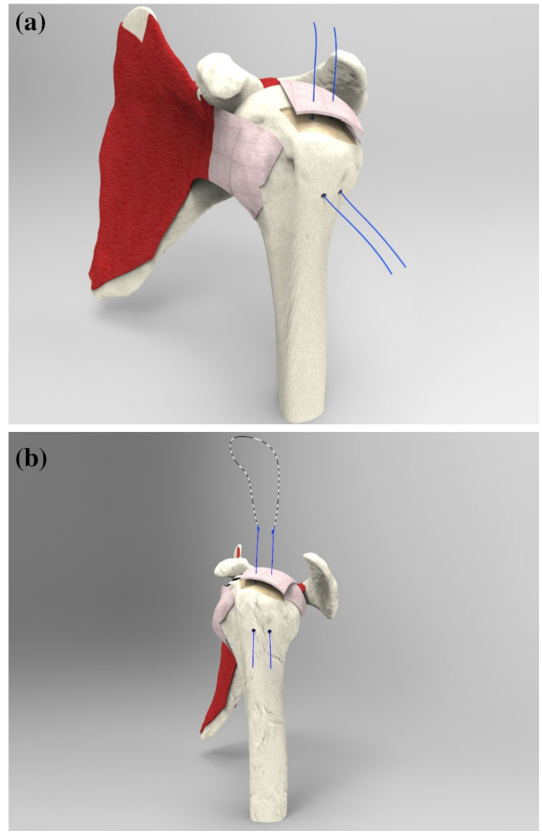

Fig. 2 **a** The two shuttle wires that have passed through the anterior and posterior TO tunnels and through the anterior and posterior aspects of the medial portion of the tendon are available and retrieved through the anterior portal. **b** Each shuttle wire is then used to pass one extremity of a smooth suture tape through the tendon and through the TO tunnel so that one extremity is passed through the anterior aspect of the medial portion of the tendon and the anterior TO tunnel and the other one is passed through the posterior aspect of the medial portion of the tendon and the posterior TO tunnel (like a reverse "U")

Fig. 3 Both extremities of the tape are then retrieved from the lateral cortical entry points of the tunnels through the lateral portal. The medial mattress suture is then completed performing an arthroscopic knot tied on the lateral cortex of the great tuberosity

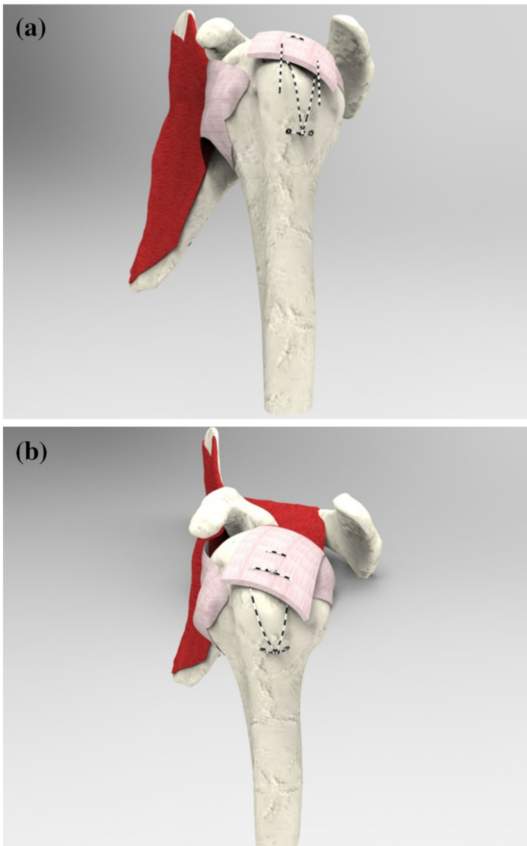

Fig. 4 **a** After tying the knot, the two extremities of the suture instead of being cut are then used to perform an additional passage through the lateral portion of the tendon in order to obtain a double-row-like configuration (eight shape). The extremities are passed through the lateral portion of the tendon slightly anterior and posterior to the medial suture. **b** The figure of eight is completed performing a second arthroscopic knot on the tendon so to obtain a trapezoidal double mattress suture configuration

In case of *small full-thickness RCT* (C1 Snyder classification), the shuttle wire is directly passed with the STN through the TO tunnel and through the medial portion of the tendon in only 1 single step (transtendon technique). The procedure then continues as previously described.

In case of *partial RCT*, the shuttle wire is passed using the same transtendon technique. However, only one single transosseous mattress suture is performed on the lateral cortex of the great tuberosity. After tying the knot, the two extremities of the suture are cut without performing the additional passage through the tendon necessary to complete the eight-shape configuration.

Preliminary results

No intraoperative or postoperative complications were reported. The mean UCLA score significantly improved from 14.6 preoperatively to 32.2 points 12 months after surgery ($P < 0.01$), while the VAS score significantly improved from 8.3 to 2.1 ($P < 0.01$). No difference in clinical outcome was found between patients with partial-thickness and patients with full-thickness RCT and between patients with small and patients with moderate/large full-thickness RCT.

Discussion

Arthroscopic suture-anchor repair is the most widely used technique for treating RCT. However, in elderly patients anchor fixation can be a concern because of the poor bone quality of the greater tuberosity [13]. Moreover, other anchor-related shortcomings, such as difficulty with revision surgery because of the presence of anchors in the greater tuberosity, anchor dislocation and knot impingement, call into question the use of suture anchors in RCT repair [9]. Consequently, in the last few years several arthroscopic anchorless TO techniques have been described with the objective of avoiding the potential weaknesses of anchor fixation and also to provide significant cost savings for a procedure that has become quite expensive, particularly with the use of multiple suture anchors in various configurations [9, 11–13].

However, all the anchorless TO techniques previously described are complex to reproduce and standardize as they involve many surgical steps, the need of fixation devices and cannulas to manage a high number of suture wires so that particular care must be taken to ensure that the sutures have no twists and are not wrapped around one another, which is very time-consuming.

In addition to the significant prolongation of the surgical time, complications related to the instrumentation used (such as needle breakage) were also reported [6].

These techniques seem to be challenging for the majority of arthroscopic surgeons, and because of that they are also called “high demanding” techniques.

The eight-shape technique maximizes the biomechanical advantage of double-row repair using medial and lateral fixation to compress the rotator cuff over its natural footprint without the need for suture anchors or any fixation device. It is economic and easy to perform and to reproduce as it requires few surgical passages and only 1 tape suture that is used to obtain a trapezoidal double-row-like configuration. Moreover, while the other techniques can be used almost exclusively for large RCT, our technique can be performed for all types of RCT.

One of the major problems previously described with the TO technique has been suture cut through the bone tunnel wall or suture abrasion against the bone [17]. This is generally due to a substantial sharp angulated shape of the bone tunnels. With the eight-shape technique, bone tunnels present a curved trajectory without any angulation that allows an uniform contact between suture and bone. In addition, the particular configuration of our suture allows to share the load on the tendon and thus reduces the local stress at the bone interface.

The choice of the suture plays a key role in determining the strength of fixation, particularly in TO suture [17]. Although polyblend tape has comparable biomechanical performance when compared to the polyblend classic suture, it seems to provide a significant increase in tendon-to-bone contact while offering a significantly lower and more equally distributed level of pressure [18]. The lower, more uniformly distributed level of compression may potentially reduce vascular restriction at the level of the repaired tendon and thus promote tendon healing [19].

The current technique is also convenient in the management of partial-thickness RCT allowing to perform a TO transtendon repair without touching the original intact side of the tendon. To our knowledge, there is only another arthroscopic TO transtendon technique for partial RCT described by Tauber et al. [20]. In that technique, a curved, sharp-cut, cannulated needle is introduced at the anterolateral edge of the acromion. As admitted by the authors, the learning curve of this technique is demanding, due to the requirement of experienced handling of the curved needle [20]. Moreover, buckling and breaking of the curved needle during entry into the greater tuberosity as well as fracture of the tip of the greater tuberosity were reported [20].

In our technique, the use of the Taylor Stitcher eliminates all these possible complications. The entry point is on the lateral cortex of the humerus, avoiding any conflicts with the acromion.

In addition, the TO tunnels are created in a smooth and gradual manner avoiding any risk of fracture.

In conclusion, the eight-shape technique presents several advantages over the published techniques. As it does not require any fixation device or cannula, and only 1 suture tape is used avoiding the risk of suture twist, the operating time is decreased. Furthermore, the preparation of the two TO tunnels, generally the most complex part of every TO technique, is very easily and safely performed thanks to the Taylor Stitcher. All of these features allow the eight-shape technique to be more cost-effective [10] and easily reproducible by any arthroscopic surgeon compared with the current published TO techniques [21].

Compliance with ethical standards

Conflict of interest Claudio Chillemi declares that he has no conflict of interest. Matteo Mantovani designed and manufactured the Taylor Stitcher® + Superelastic Transosseus Needle®. Marcello Osimani declares that he has no conflict of interest. Alessandro Castagna declares that he has no conflict of interest.

Ethical approval 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.

Informed consent Informed consent was obtained from all individual participants included in the study.

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