Knee Surg Sports Traumatol Arthrosc (2012) 20:1031–1035
DOI 10.1007/s00167-011-1725-4

SHOULDER

Arthroscopic transosseous (anchorless) rotator cuff repair

Raffaele Garofalo · Alessandro Castagna · Mario Borroni · Sumant G. Krishnan

Received: 23 May 2011 / Accepted: 11 October 2011 / Published online: 20 October 2011

Abstract The traditional open transosseous rotator cuff repair gives excellent results for the fixation of tendon to bone and has represented the gold standard for rotator cuff surgery with excellent long-term results. In the last few years, different arthroscopic techniques using suture anchors have been developed to increase the tendon–bone contact area in an attempt to reconstitute a more anatomic configuration of the rotator cuff footprint while providing a better environment for tendon healing. However, the anchor-based techniques have still not replicated the traditional open transosseous repair. A surgical technique that allows surgeons to perform a standardized arthroscopic transosseous (anchor free) repair of rotator cuff tears using a new disposable device is described. With this system, it is possible to perform a transosseous technique in a reproducible fashion. This novel technique combines the clinical advantages of minimally invasive arthroscopic surgery and the biomechanical advantages of open transosseous procedures. *Level of evidence* V.

R. Garofalo
Shoulder Service Hospital F. Miulli,
Acquaviva delle fonti, BA, Italy

R. Garofalo (✉)
Via Padova 13, 70029 Santeramo in Colle, BA, Italy
e-mail: raffaelegarofalo@gmail.com

A. Castagna · M. Borroni
Shoulder Unit IRCCS Humanitas Institute, Milan, Italy

S. G. Krishnan
Shoulder and Elbow Service, The Carrel Clinic,
Dallas, TX, USA

Keywords Anchorless · Arthroscopic rotator cuff repair · Rotator cuff tear · Transosseous · Shoulder

Introduction

The integrity of rotator cuff repair has been shown to correlate with clinical outcomes, particularly return of strength [3, 14, 27]. Repair of the torn rotator cuff tendon can be performed by a variety of methods including open, mini-open, and arthroscopic techniques. Arthroscopic rotator cuff repair is becoming the gold standard because it is a less invasive technique and spares the deltoid muscle [20]. Despite the improvement in surgical techniques and postoperative protection of the repaired tendon, imaging techniques at follow-up show a high percentage of re-tear or nonhealing of tendons [3, 13]. Although some very important biological aspects related to rotator cuff repair should be better clarified, a potential technical limitation of the arthroscopic technique has been related to the use of suture anchors—particularly when used in a single-row fashion, which only partially is able to reproduce the bone–tendon footprint [1]. Furthermore, the use of anchors has been associated with different complications, such as anchor pull-out and greater tuberosity bone osteolysis [2]. Consequently, as arthroscopic rotator cuff repair techniques continue to evolve, the best all-arthroscopic method has not been established and open transosseous rotator cuff repair techniques still remain the gold standard for tendon healing [21]. Recent biomechanical studies demonstrate that arthroscopic techniques with anchors may mimic open repair, but as of today no replication of the open transosseous technique has been performed in an all-arthroscopic fashion [10]. In this paper, we describe a novel and reproducible technique that allows surgeons to replicate

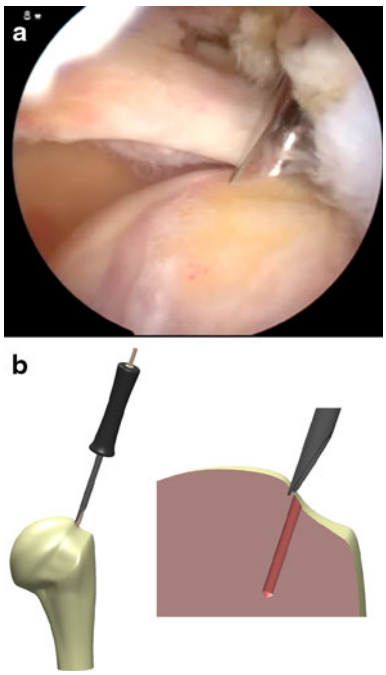

Fig. 1 **a** Arthroscopic view of a right shoulder. The scope is in the posterolateral viewing portal. The specific drill guide is inserted through the anterior superior portal to create a 2.9-mm medial tunnel immediately adjacent to the articular surface. **b** Schematic drawing of the step described in **a**

open transosseous rotator cuff repair in an all-arthroscopic fashion.

Technical note

The procedure is performed with the patient under general endotracheal anesthesia combined with an anterior interscalene cervical plexus block. The patient can be placed in a modified beach-chair position or in a lateral decubitus depending on surgeon preference. For optimal suture management, the authors suggest to use a 4 portal surgical technique: standard posterior and anterior superior portals, an anterolateral portal in line with the anterior edge of the supraspinatus tendon, and a posterolateral portal. Once the reparability of the rotator cuff is assessed, with the scope on the posterior or in the posterolateral portal, a specific drill guide is inserted through the anterior superior portal to create a 2.9-mm medial tunnel immediately adjacent to the articular surface (Fig. 1). At this point, through the anterolateral portal, we gently introduce a device that allows the creation of an intersecting tunnel (ArthroTunneler, Tornier, Edina, MN, USA) (Fig. 2). Once the position is satisfactory, the lateral intersecting 2.5-mm tunnel is drilled. The position of the lateral tunnel is approximately 1.5 cm below the superior tip of the greater tuberosity. At this

Fig. 2 The scope is in the posterolateral viewing portal, and the device that allows the creation of an intersecting tunnel (ArthroTunneler, Tornier, Edina, MN, USA) is introduced through the anterolateral portal

point, a loaded suture inserter is introduced through the hole of the ArthtroTunneler device. The loop of the ArthroTunneler is moved into the retrieval position, and the suture inserter is removed leaving the suture passed in a transosseous fashion through the greater tuberosity (Fig. 3). The suture is retrieved by the device through the medial tunnel completing the transosseous suture passage. This suture is used as a shuttle to pass 2 or 3 definitive sutures through the tunnel (Fig. 4). All transosseous sutures are first placed in the bone and are then passed through the cuff with different devices according to surgeon preference (Figs. 5, 6). Depending on the tear size, one, two, three, or even four tunnels can be created to repair the tear; furthermore, different kinds of suture pattern can be created based on surgeon preference (Fig. 7).

Discussion

Tendon fixation to bone is one of the most critical aspects for rotator cuff repair, and maximizing tendon healing is the primary goal of rotator cuff repair surgery. With advances in arthroscopic surgery, different techniques have been developed to increase the tendon–bone contact area, reconstituting a more anatomic configuration of the rotator cuff footprint and providing a better environment for tendon healing [3, 16–18]. For this purpose, several techniques of double-row suture anchor repair have been proposed [5, 9, 12, 24, 25]. Park et al., in particular, have found that a transosseous-equivalent (TOE) repair using suture bridges can improve pressurized contact area and overall pressure at a repaired rotator cuff insertion [18]. The suture tension for any true transosseous technique provides a more direct tendon-to-bone compression vector. In contrast, the sutures for the suture anchor technique provide a circumferential tension around the tendon but relatively little compression between tendon and bone [18].

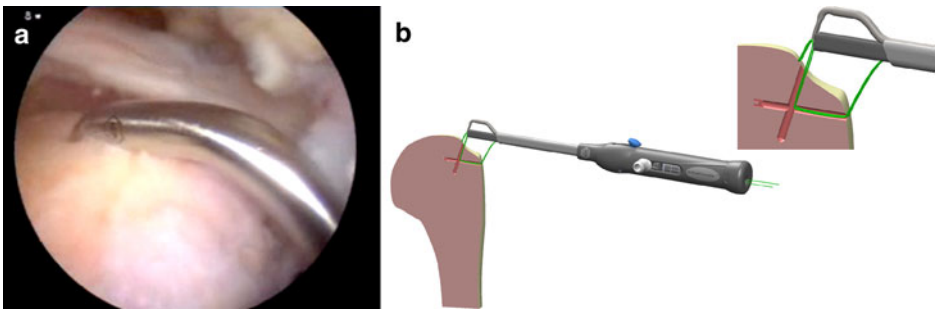

Fig. 3 **a** Arthroscopic view of a right shoulder. The scope is in the posterolateral viewing portal. The arthrotunneler device introduced through the anterolateral portal, the tip of the arthrotunneler inside the previous hole and the arm, is against the upper part of the greater tuberosity. The position of the lateral tunnel is approximately 1.5 cm below the superior tip of the greater tuberosity. **b** A loaded suture inserter is introduced through the hole of the ArthtroTunneler device. The loop of the ArthroTunneler is moved into the retrieval position, and the suture inserter is removed leaving the suture passed in a transosseous fashion through the greater tuberosity. A transosseous suture passage is created

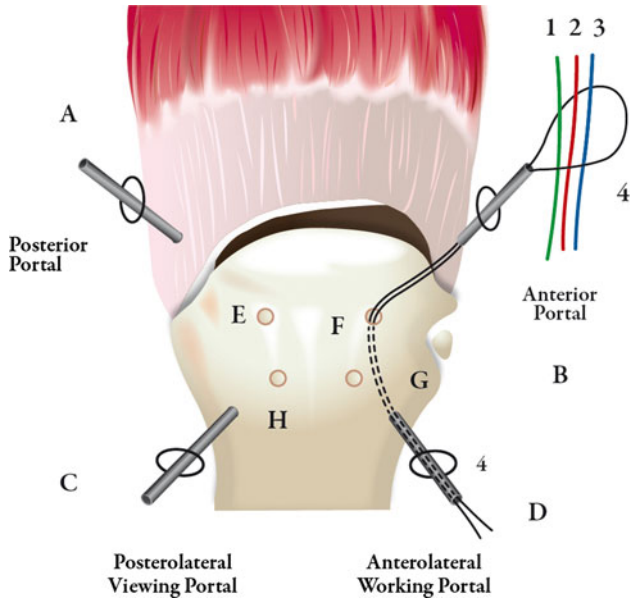

Fig. 4 Schematic drawing of a right shoulder showing as the suture loop (n. *4*) is retrieved through the anterior portal and used to pass 2 or 3 definitive sutures through the anterior tunnel (*F G*)

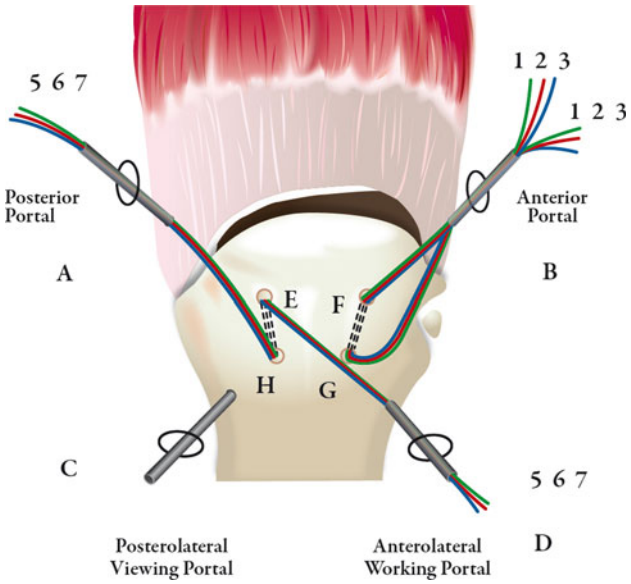

Fig. 5 Schematic drawing of a right shoulder showing one possibility of suture management with two tunnels (anterior *F*/*G* and posterior *E*/*H*) and 6 sutures (*1*, *2*, *3*, *5*, *6*, *7*) before to start the cuff repair

The TOE technique, however, requires many anchors, and recent comparative studies show that clinical outcomes are similar to single-row anchor repair [19]. Furthermore, Cho reported a significantly higher incidence of medial failures in transosseous equivalent repair techniques compared to single-row repair [6]. This catastrophic failure close to the musculotendinous junction of the rotator cuff leads to very difficult revision reconstruction.

The traditional open transosseous repair gives excellent results for the fixation of tendon to bone and has represented the gold standard for rotator cuff repair with excellent long-term results [22]. Recently, arthroscopic anchorless transosseous techniques have been introduced to combine the minimal invasiveness of the arthroscopic procedures with the biomechanical advantages of the open procedures. One technique uses an anterior cruciate ligament tibial drill guide to create the holes in the greater tuberosity; the sutures are then passed in the created holes and through the rotator cuff using cannulated needles or suture passers [15, 23]. Fleega introduce the technique of a giant needle in which the needles and sutures pass through the tendon and bone in one single step [7]. In this technique, the author uses a needle with a sharp triangular section that potentially might cut through the tendon. Other authors also proposed a similar technique using a hollow needle instead of a sharp needle (TransOsteoNeedle;Arthrex FL) [8, 26]. Recently, Frick et al. proposed a technique of arthroscopic transosseous cuff repair using an arthroscopic bone needle with the aim to modify and improve the method of suture passage [11]. All of these techniques,

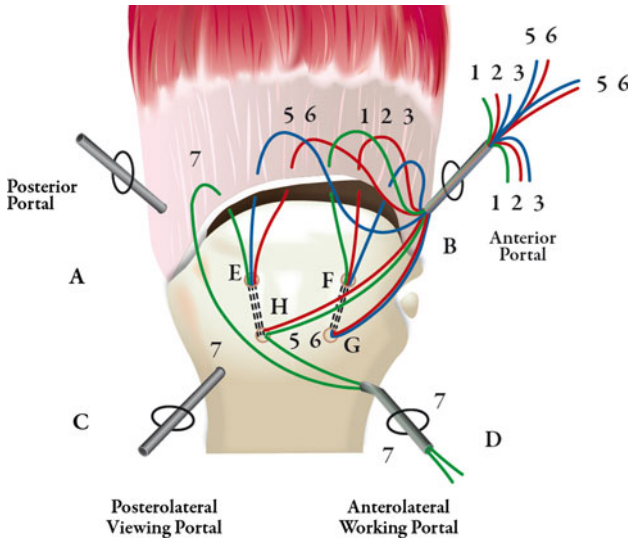

Fig. 6 Schematic drawing of a right shoulder showing one possibility of suture management once all sutures are passed through the torn tendon. Note as we have all suture exiting through the anterior portal and then we start to knot from posterior to anterior

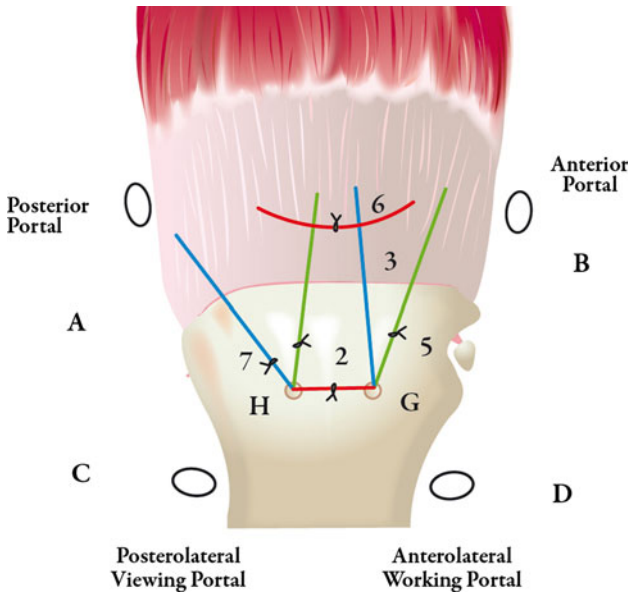

Fig. 7 Schematic drawing of one possible pattern of cuff suturing using the transosseous repair. In this case, a mattress suture combined with 2 simple sutures is showed. This represents a very tight repair. However, different suture configurations (more simple and more complex) can be done

however, are difficult to reproduce and standardize. Furthermore, they can have complications related to needle breakage, and the axillary nerve can be also at risk because the exit point of the needle or drill is variable and related to the angle of insertion used by the surgeon.

In this paper, a novel surgical technique that allows surgeons to perform an arthroscopic transosseous (anchor free) repair of rotator cuff tears is reported. With the Arthrotunneler device (Tornier, Edina, MN, USA), it is possible to perform a transosseous technique in a standardized and reproducible fashion, without neurovascular or other risk. In particular, the lateral tunnel is drilled approximately 1.5 cm below the superior tip of the greater tuberosity. This is a very important aspect, because the strength of the fixation of a RCR with a transosseous technique can be increased placing the lateral tunnel more than 10 mm distal to the tip of the greater tuberosity [4]. Clinical and biomechanical evaluation of this exciting technique continues, and this represents a potentially advantageous option for surgeons managing rotator cuff pathology.

References

1. Apreleva M, Ozbaydar M, Fitzgibbons PG, Warner JJ (2002) Rotator cuff tears: the effect of the reconstruction method on three-dimensional repair site area. Arthroscopy 18(5):519–526
2. Benson EC, MacDermid JC, Drosdowech DS, Athwal GS (2010) The incidence of early metallic suture anchor pull-out after arthroscopic rotator cuff repair. Arthroscopy 26(3):310–315
3. Boileau P, Brassart N, Watkinson DJ, Charles M, Hatzidakis AM, Krishnan SG (2005) Arthroscopic repair of full-thikness tears of the supraspinatus: does the tendon really heal? J Bone Joint Surg Am 87(6):1229–1240
4. Caldwell GL, Warner JP, Miller MD, Boardman D, Towers J, Debski R (1997) Strength of fixation with transosseous sutures in rotator cuff repair. J Bone Joint Surg Am 79(7):1064–1068
5. Charousset C, Grimberg J, Duranthon LD, Bellaiche L, Petrover D (2007) Can a double-row anchorage technique improve tendon healing in arthroscopic rotator cuff repair? A prospective, non-randomized, comparative study of double row anchorage techniques with computed tomographic arthrography tendon healing assessment. Am J Sports Med 35(8):1247–1253
6. Cho NS, Yi JW, Lee BG, Rhee YG (2010) Retear patterns after arthroscopic rotator cuff repair: single row versus suture bridge technique. Am J Sports Med 38(4):664–671
7. Fleega BA (2002) Arthroscopic transhumeral rotator cuff repair: giant needle technique. Arthroscopy 18(2):218–223
8. Fox MP, Auffarth A, Tauber M, Hartmann A, Resch H (2008) A novel transosseous button technique for rotator cuff repair. Arthroscopy 24(9):1074–1077
9. Franceschi F, Ruzzini L, Longo UG et al (2007) Equivalent clinical results of arthroscopic single row and double row suture anchor repair for rotator cuff tears: a randomized controlled trial. Am J Sports Med 35(8):1254–1260
10. Frank JB, ElAttrache NS, Dines JS, Blackburn A, Crues J, Tibone JE (2008) Repair site integrity after arthroscopic transosseous-equivalent suture-bridge rotator cuff repair. Am J Sports Med 36(8):1496–1503
11. Frick H, Haag M, Volz M, Stehle J (2010) Arthroscopic bone needle: a new, safe, and cost-effective technique for rotator cuff repair. Tech Should Surg 11:107–112
12. Galatz LM, Griggs S, Cameron BD, Iannotti JP (2001) Prospective longitudinal analysis of postoperative shoulder function:

a ten year follow-up study of full-thickness rotator cuff tears. J Bone Joint Surg Am 83-A(7):1052–1056
13. Galatz LM, Ball CM, Teefey SA, Middleton WD, Yamaguchi K (2004) The outcome and repair integrity of completely arthroscopically repaired large and massive rotator cuff tears. J Bone Joint Surg Am 86A(2):219–224
14. Jost B, Pfirmann CW, Gerber C, Switzerland Z (2000) Clinical outcome after structural failure of the rotator cuff repairs. J Bone Joint Surg Am 82(3):304–314
15. Kim KC, Rhee KJ, Shin HD, Kim YM (2008) Arthroscopic transosseous rotator cuff repair. Orthopedics 31(4):327–330
16. Lo IK, Burkhart SS (2003) Double row arthroscopic rotator cuff repair: re-establishing the footprint of the rotator cuff. Arthroscopy 19(9):1035–1042
17. Park MC, Cadet ER, Levine WN, Bigliani LU, Ahmad CS (2005) Tendon-to-bone pressure distributions at a repaired rotator cuff footprint using transosseous suture and suture anchor fixation techniques. Am J Sports Med Aug 33(8):1154–1159
18. Park MC, ElAttrache NS, Tibone JE, Ahmad CS, Jun BJ, Lee TQ (2007) Part I: footprint contact characteristics for a transosseous-equivalent rotator cuff repair technique compared with a double-row repair technique. J Shoulder Elbow Surg 16(4):461–468
19. Pennington WT, Gibbons DJ, Bartz BA et al (2010) Comparative analysis of single row versus double row repair of rotator tears. Arthroscopy 26(11):1419–1426
20. Post M, Silver R, Singh M (1983) Rotator cuff tear. Diagnosis and treatment. Clin Orthop Relat Res 173:78–91
21. Ramsey ML, Getz CL, Parsons BO (2009) What's new in shoulder and elbow surgery. J Bone Joint Surg Am 92(4): 1047–1061
22. Rossouw DJ, McElroy BJ, Amis AA, Emery RJ (1997) A Biomechanical evaluation of suture anchors in repair of the rotator cuff. J Bone Joint Surg Br 79(3):458–461
23. Shea KP, Jennings JE (1998) Arthroscopic rotator cuff repair using a transhumeral approach to fixation. Arthroscopy 14(1):118–122
24. Sugaya H, Maeda K, Matsuki K, Mooriishi J (2005) Functional and structural outcome after arhroscopic full thickness rotator cuff repair: single row versus dual row fixation. Arthroscopy 21(11):1307–1316
25. Tashjian RZ, Hollins AM, Kim HM et al (2010) Factors affecting healing rates after arthroscopic double row rotator cuff repair. Am J Sports Med 38(12):2435–2442
26. Tauber M, Koller H, Resch H (2008) Transosseous arthroscopic repair of partial articular-surface supraspinatus tendon tears. Knee Surg Sports Traumatol Arthrosc 16(6):608–613
27. Zumstein MA, Jost B, Hempel J, Hodler J, Gerber C (2008) The clinical and structural long-term results of open repair of massive tears of the rotator cuff. J Bone Joint Surg A 90(11):2423–2431