

Arthroscopic Rotator Cuff Repair (Double Row Repair): Current Evidence

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ABSTRACT

BACKGROUND: Surgical techniques for rotator cuff tears have improved from single row repair (SR) to double row repair (DR) including transosseous equivalent repair as new surgical devices or suture anchors were developed. Many biomechanical evidence favors DR with respect to footprint contact area and pressure and compression for cuff tendons. Some surgeons reported better clinical outcomes of DR compared to SR, whereas some described no difference of clinical outcomes between SR and DR. The purpose of this article was to review the current evidence regarding outcomes of DR comparing to SR and clarify whether better clinical or radiological outcomes can be obtained by performing DR.

METHODS: We conducted a systematic review of clinical studies published for last 5 years which compared SR to DR. A systematic

review of the literature was performed to identify all publications in the English literature. The databases MEDLINE and Google Scholar were searched. Also, we reviewed the latest systematic review and meta-analysis published between 2012 and 2018.

RESULTS: Four clinical articles with evidence Levels I or II published in last 5 years were identified. Two of them documented superiority of DR over SR. Four systematic review and meta-analysis published between 2012 and 2018 were identified. Among them, two showed that DR provides better clinical outcomes and a lower re-tear rate compared with SR but its superiority is seen in the limited situation (only large tears or UCLA score).

CONCLUSION: Although some reports with higher evidence Levels showed DR provides better clinical outcomes, it may be too early to conclude which repair technique is better because of lack of enough evidence.

Key words: Shoulder joint; Rotator cuff; Arthroscopy; Suture techniques

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INTRODUCTION

Arthroscopic rotator cuff repair has become popularity over the past two decades. Surgical techniques for rotator cuff tears have improved from single row repair (SR) to double row repair (DR) including transosseous equivalent repair as new surgical devices or suture anchors were developed. These days DR is widely performed as the arthroscopic cuff repair. To achieve successful healing and avoid re-tear after surgery, restoration of the footprint and bone-tendon interface are important for biological healing. From the viewpoint of the shoulder biomechanics, there are some points to improve the early stages of healing: initial fixation and contact pressure and area between the cuff tendon and the footprint. Many biomechanical studies^[1-6] have already demonstrated that DR recreates the native

Table 1 Four clinical articles comparing single row repair to double row repair with high levels of evidence.

Authors	Published year	Evidence level	Number of the subjects	Clinical outcomes	Radiological assessment	Tear size	DR techniques	Others
Gartsman <i>et al.</i> ^[14]	2013	I	90	-	Ultrasound; SR < DR	< 2.5 cm	Transosseous equivalent	
Barber <i>et al.</i> ^[15]	2016	I	40	SR = DR	MRI; SR = DR	< 3 cm	Transosseous equivalent	PRP augmentation
Franceschi <i>et al.</i> ^[16]	2016	I	58	-	MRA; SR < DR	Excluded massive tears	Conventional	Accelerated rehabilitation program
Nicholas <i>et al.</i> ^[19]	2016	II	49	SR = DR	-	All size	Transosseous equivalent	

SR: single row repair; DR, double row repair; MRA: Magnetic Resonance arthrography; PRP: platelet-rich plasma fibrin membrane.

Table 2 Systematic review and meta-analysis published between 2012 and 2018.

Authors	Published	Number of articles	Investigated articles	Clinical results
McElvany <i>et al.</i> ^[20]	2012	108	1980-2012	-
Roth <i>et al.</i> ^[21]	2014	10(7 level I studies and 3 level 2 studies)	2007-2013	SR = DR
Ying <i>et al.</i> ^[22]	2015	11(7 level I studies and 4 level 2 studies)	2007-2012	SR < DR; in large tears
Sobhy <i>et al.</i> ^[23]	2018	7 level I studies	2005-2016	SR < DR; UCLA only

SR: single row repair; DR: double row repair

footprint more and is able to tolerate a significantly greater load to failure and decreased gap formation. Thus, biomechanically, superiority of DR over SR was already demonstrated in the literatures. However, clinically, does DR result in better clinical outcomes? Many clinical outcomes of DR have been reported. Some surgeons^[7-9] reported better clinical outcomes of DR compared to SR, whereas some^[10-13] described no difference of clinical outcomes between SR and DR. The purpose of this article was to review the current evidence regarding outcomes of DR. Especially, we focused on most recent articles (published in the last five years) comparing SR to DR with high levels of evidence and herein introduce the latest systematic review and meta-analysis.

METHODS

We conducted a systematic review of clinical studies published in the last 5 years (between June 2013 and June 2018) which compared SR to DR. A systematic review of the literature was performed to identify all publications in the English literature. The databases MEDLINE and Google Scholar were searched: 'rotator cuff' AND 'clinical' AND/OR 'double row' AND 'dual row' AND 'arthroscopic'. Among the articles comparing SR to DR, we focused on most recent articles with high levels of evidence (Level I or II). Also, we reviewed the latest systematic review and meta-analysis published between 2012 and 2018.

RESULTS

Four clinical articles with evidence Levels I or II published between June 2013 and June 2018 which compared SR to DR were found: three articles with evidence Level I and one with evidence Level II (Table 1). In 2013, Gartsman *et al.*^[14] performed a Level-I study of 90 patients to compare the structural outcomes of SR and DR (transosseous equivalent). Thirty of 40 patients (75%) with SR demonstrated a healed rotator cuff repair compared to 40/43 (93%) patients with DR. They concluded that DR resulted in a significantly higher tendon healing rate when compared to SR. However, clinical scores were not evaluated in this study. In 2016, a Level-I study of 40 patients diagnosed with full-thickness tears was performed by Barber^[15]. There was no MRI difference in re-tear rate at 12 months postopera-

tively between SR and transosseous equivalent DR. No difference could be demonstrated between these two repairs on clinical outcome scores. Franceschi *et al.*^[16] performed a Level-I study of 58 patients undergoing early accelerated mobilization to investigate whether conventional DR provides better clinical outcomes and a lower re-tear rate compared with SR. MR arthrography showed a significantly lower re-tear rate for DR (8%) than for SR (24%). In contrast, there was no significant difference at 2-year follow-up in terms of the rate of stiffness in SR and DR. A Level-II study by Nicholas *et al.*^[17] also indicated that clinical outcomes were not different between SR and transosseous equivalent DR, with generally excellent outcomes for both repairs.

Four systematic review and meta-analysis published between 2012 and 2018 were identified (Table 2). Systematic review and meta-analysis by McElvany^[18] showed that the number of published articles increased dramatically in the last decade. However, there is little evidence that the results of rotator cuff repair are improving. This comprehensive analysis of the published evidence regarding the radiological and clinical outcomes includes data on over 8000 rotator cuff repairs. The mean re-tear rate was 26.6% at a mean of 24 months after surgery. Re-tears were associated with more fatty infiltration, larger tear size, advanced age, and conventional DR. Review report by Roth^[19] indicated that Level I clinical outcome studies have failed to document a difference of clinical outcomes between SR and DR. They concluded that DR has not yet resulted in an improvement in clinical outcomes. Especially, in massive tears, there is insufficient evidence to make a recommendation (SR or DR), although transosseous equivalent DR is recommended in tears no greater than 3 cm. Ying *et al.*^[20] systematically reviewed reports published between 2007 and 2012 that compared the outcomes of SR and DR. They found that DR have a higher rate of tendon healing, lower rate of re-tear and greater muscle strength than SR. In their subgroup analysis, they found no statistically significant difference between SR and DR in tears no greater than 3 cm. However, there was a statistically significant difference between the two groups for larger tears. They reported that no definite conclusion could be drawn about differences in overall outcomes of SR and DR. Most recently, Sobhy *et al.*^[21] performed a systematic review and meta-analysis of clinical studies published between 2005 and 2016. They concluded that within the domain of Level I mid-term and short-term studies, DR showed significant better UCLA score only. This may correlate with the significant lower partial-thickness re-tear rates of DR. On the other hand, long-term level III studies showed a direct correlation of both functional outcomes and cuff structural integrity, with superiority of DR over SR.

DISCUSSIONS

In the articles published between 2013 and 2018, only four clinical articles with evidence Levels I or II comparing SR to DR were found. The tear size of the subjects of each study varied. In Gartsman's

study^[14], only full-thickness supraspinatus tears less than 25 mm in anteroposterior length were included. In Barber 's study^[15], subjects were only patients diagnosed with tears no greater than 3 cm in anteroposterior length. In Nicholas study^[17], large and massive tears were included although they did not compare the clinical outcomes of only massive tears. McElvany *et al*^[18] suggest that re-tears after surgery are more frequent for larger tears: odds ratio 4.06 (large to massive tears compared with small to medium tears). To clarify the relationship between the clinical results and tear size, we need more evidence comparing SR to DR to demonstrate the radiological and clinical outcomes in both small to medium and large to massive tears. Among for clinical articles with evidence Level L or II, two articles demonstrated that DR provides better clinical outcomes and a lower re-tear rate compared with SR, whereas two indicated no difference between SR and DR. In these two articles, subjects were only patients diagnosed with tears no greater than 3 cm, and large to massive tears were excluded from their studies. On the other hand, large to massive tears were included in the articles showing no difference between SR and DR. From these results, we are able to state that DR is superior to SR in small to medium tears but superiority of DR over SR is not yet demonstrated in large to massive tears. However, it may be too early to conclude which repair is better because of the following reasons. First, only limited number of articles with high levels of evidence investigated the difference of two repairs. One article compared only the radiological healing by ultrasound and did not investigate clinical outcomes (Table 1). In the other article^[15], all repairs were augmented with platelet-rich plasma fibrin membrane. Also, in one article^[16], accelerated rehabilitation program was chosen. Further clinical and radiological studies comparing SR to DR should be directed to study the variables effect (tear size, repair technique, augmentation, rehabilitation protocol, etc).

Four systematic review and meta-analysis published between 2012 and 2018 were identified. Two of them demonstrated the clinical superiority of DR over SR, although the superiority of DR was seen in only large tears in one study^[20] and DR showed better UCLA score only in another study^[21]. One of four systematic review and meta-analysis showed no significant difference between SR and DR. Thus, it is hard to say that better clinical results can be obtained by DR because of the lack of enough evidence. Even though the clinical superiority of DR over SR was demonstrated in some articles, its superiority was seen in the limited situation such as in only large tears or UCLA score. Furthermore, some articles which were reviewed in these systematic review and meta-analysis were published more than 10 years ago. Considering that surgical techniques for rotator cuff tears have improved for last ten years, we need further clinical studies in which recent transosseous equivalent DR technique is performed.

Kim *et al*^[22] compared the re-tear pattern of SR and transosseous equivalent DR. They found that in the SR group, 15 shoulders (71%) had a type 1 (unhealed tendons) re-tear, whereas 13 shoulders (59%) had a type 2 (medially ruptured tendons with a healed footprint) re-tear in the transosseous equivalent DR group. This study indicated that transosseous equivalent DR had a different re-tear pattern compared with that of SR. Our recent study^[23] measuring the strain by ultrasound elastography demonstrated that the rotator cuff tendon became stiffer after arthroscopic rotator cuff repair, especially transosseous equivalent DR. Results showed that the superficial layer of the supraspinatus tendon was stiffer after transosseous equivalent DR than the contralateral side at the final follow up (mean, 14 months). In addition, our finite-element analysis^[24] revealed that a high-stress concentration was observed around the insertion sites of the medial row threads. Another biomechanical study^[25] using cadaveric shoul-

ders which measured the strain after transosseous equivalent DR also demonstrated the similar trend. Strain of the infraspinatus tendon from ten cadaveric shoulders were measured by the micro strain sensor. Strain significantly reduced at footprint of the tendon in the repaired tendon compared with the intact tendon for all loads. At tendon where the medial sutures were passed, the strain increased for all loads when compared with the intact tendon. The strain of the tendon repaired with transosseous equivalent DR was significantly smaller than that of the intact tendon at the footprint and significantly greater at the medial row suture level. Based on these results, we recommend that surgeons should pay attention to the quality of the greater tuberosity or cuff tendon, especially at the medial row area when applying the transosseous equivalent technique. In large to massive tears, tendon quality is often very poor due to degenerative change and the tendon stump is retracted and thin. Of course, we need the initial strong fixation to avoid pull-out failure after surgery. However, in large to massive tears with poor tendon quality, the strong fixation may cause re-tear medial to the repair site for the above-mentioned reasons. This might be one of limitations of transosseous equivalent DR in large to massive tears.

In addition to improvement of clinical outcomes, we need to consider operative costs. It is clear that DR utilize more anchors when comparing similar tears treated with SR. A transition from SR to DR would therefore be expected to increase operative costs to the healthcare system. Operative cost itself is a necessary consideration in selection of treatment options. Bisson *et al*^[26] calculated the costs to the US healthcare system of transition from SR to DR and they reported that conversion from SR to DR would result in considerable increases in healthcare expenditures. They also calculated the decrease in revision surgeries for re-tear that DR would need to accomplish in order to render the transition costneutral. Since the large decreases in revision surgery rates necessary to justify DR purely on a cost basis may not be realistic or even possible, the use of these methods should be supported by evidence of improved structural healing rates and quality-adjusted life years in comparison with SR methods.

Despite the lack of evidence regarding the clinical superiority of DR over SR, in reality many surgeons have already begun to perform DR, especially transosseous equivalent repair these days. The rationale behind this trend involves the improved tendon-footprint compression and greater initial fixation. Indeed, many biomechanical studies¹⁻⁶ have clarified that DR was superior to SR in terms of contact area or pressure between the rotator cuff tendon and the footprint, and the initial pull-out strength. Using this DR technique, we are able to expect the strong biomechanical fixation. However, there is one question. Would the greater initial fixation strength result in better clinical outcomes? Unfortunately, there are no evidences clarifying it in the literatures. It is still unclear that better clinical outcomes are obtained by the greater initial fixation strength. Clinically, many surgeons have performed transosseous equivalent DR believing these biomechanical advantages these days. Thus, there is a gap between the results obtained in biomechanical studies and the ones in clinical reports. Of course, it would be beneficial for surgeons to obtain basic knowledge about the shoulder biomechanics and to know the biomechanical effects on the shoulder or advantages and disadvantages of surgical procedures. However, regarding the clinical outcomes, the superiority of DR is not sufficiently clarified. There is still a gap between the results obtained in biomechanical studies and the ones in clinical reports. We need more evidence to fill in such a gap.

DR is roughly divided into two: conventional and transosseous equivalent DRs. In this article, these two repairs were not separated when comparing to SR. DR varies by surgeon, especially there are

many technical variations of transosseous-equivalent DR which is used in the most recent articles reporting the clinical outcomes of DR. Medial knots are tied or not. Also, there is a variation between anchors: double- or triple loaded suture anchors or suture anchor with sutures or suture tapes. Simple comparison of SR to DR including conventional and transosseous equivalent repairs was done in this article. Surgical techniques for rotator cuff tears have improved recently as new surgical devices or suture anchors were developed. There is a possibility that the clinical outcomes of new techniques of transosseous equivalent DR will improve more. In the future, we need to compare the clinical outcome of each DR technique.

In conclusion, only four clinical articles with evidence Levels I or II published in the last 5 years were identified. Two of them documented superiority of DR over SR. Among four systematic review and meta-analysis published since 2012, two showed that DR provides better clinical outcomes and a lower re-tear rate compared with SR but its superiority is seen in the limited situation (only large tears or UCLA score). Although some reports with higher evidence Levels showed DR provides better clinical outcomes, it may be too early to conclude which repair technique is better.

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