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A comparison of simple and complex single-row versus transosseous-equivalent double-row repair techniques for full-thickness rotator cuff tears: a systematic review and meta-analysis

Nikhil Ponugoti, MBBS, DNB Ortho, MRCS[a,*], Aashish Raghu, MBBS, MS Ortho, MRCS[b], Henry B. Colaco, MSc, FRCS(Tr&Orth) MFSTEd[c], Henry Magill, MBBS, MRes, MRCS[d]

[a]*Orthopaedic Registrar, Hampshire Hospital NHS Foundation Trust, Basingstoke, Hampshire, UK*
[b]*Orthopaedic Registrar, East & North Hertfordshire NHS Trust, Stevenage, Hertfordshire, UK*
[c]*Consultant Orthopaedic Surgeon, Hampshire Hospital NHS Foundation Trust, Winchester, Hampshire, UK*
[d]*Orthopaedic Registrar, Chelsea and Westminster Hospital, London, UK*

A R T I C L E I N F O

Keywords:
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Arthroscopy
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Single-row repair
Double-row repair

Level of evidence: Level III; Meta-analysis

Background: Rotator cuff injuries have traditionally been managed by either single-row or double-row arthroscopic repair techniques. Complex single-row techniques have recently been proposed as a biomechanically stronger alternative treatment option. However, no rigorous meta-analysis has evaluated the effectiveness of complex single-row against double-row repair. This meta-analysis aims to evaluate clinical outcomes in patients with full-thickness rotator cuff injuries treated with both simple and complex single-row, as well as transosseous-equivalent (TOE) double-row procedures.
Methods: An up-to-date literature search was performed using the predefined search strategy. All studies that met the inclusion criteria were assessed for methodological quality and included in the meta-analysis. Pain, functional scores, range of motion, and retear rate were all considered in the study.
Conclusion: The results of our meta-analysis suggest that there is no significant difference between complex single-row and TOE double-row procedures in any of the observed outcomes. At this point in time, the available comparative data between simple single-row and TOE double-row repair techniques are limited. Further high-quality studies are required to assess the clinical outcomes and cost-effectiveness of these different techniques.

Arthroscopic repair of rotator cuff tears is an established method of treatment that holds considerable advantages over open approaches in terms of the morbidity and risk of surgical infections.[2]

The success of the rotator cuff repair largely relies on secure restoration of the tendon footprint to ensure adequate bone-tendon healing, usually via suture anchors.[7] To achieve secure restoration, there are multiple single-row and double-row repair techniques described in literature. Numerous studies have demonstrated that a double-row repair offers a more complete restoration of the tendon footprint than single-row techniques.[7,21,33,38,40,42] However, previous meta-analyses have suggested similar outcomes between each repair methodology.[5,7,28,30,32] In addition, numerous systematic reviews and meta-analyses that directly compare traditional single-row and double-row techniques demonstrate no evidence of superiority of one technique over the other.[5,7,21,32] The variability in observed outcomes is due to heterogeneity of techniques used that are broadly classified as ‘single-row’ and ‘double-row’ repairs.[4,16]

Various ‘complex’ single-row techniques have been compared over the years; these include the use of a Mason-Allen stitch, triple-loaded suture anchors, and massive cuff-tear stitch techniques. These methods have been proven to be biomechanically superior to traditional ‘single-row’ techniques such as the double-loaded simple repair and horizontal mattress techniques.[4,6] Similarly, the transosseous-equivalent (TOE) technique, also known as a suture bridge, has been proposed as a novel gold standard double-row technique. In the TOE technique, the free suture limbs of medial row anchors are fastened laterally with anchors to provide improved tendon-bone contact.[17] TOE techniques have been demonstrated to be a biomechanically superior alternative to conventional double-row technique.[31]

Institutional review board approval was not required for this systematic review.

*Corresponding author: Nikhil Ponugoti, MBBS, DNB Ortho, MRCS, Registrar Office, Basingstoke and North Hampshire Hospital, Basingstoke, Hampshire, RG24 9NA, United Kingdom.
E-mail address: drnikhilponugoti@gmail.com (N. Ponugoti).

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For the purpose of this study, we have classified single-row repair techniques as either simple single-row repair (sSR) or complex single-row repair (cSR) and compared these methods against TOE double-row repair (TOE DR) repair techniques.

Methods

Literature search

The qualitative analysis was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses[22] and the Cochrane Handbook for Systematic Review of Intervention.[12] We have searched databases, namely MEDLINE, Embase, and Google Scholar from inception till November 2020 using search terms "Single-row (ti;ab) OR Double-row (ti;ab) AND Rotator cuff (MeSH).

Searching other resources

A further search was performed for any other previously published, planned, and incomplete studies by identifying references in ClinicalTrials.gov (http://clinicaltrials.gov/) and the World Health Organization International Clinical Trials Registry (http://apps.who.int/trialsearch/).

Study selection

Two authors (NP and HM) independently screened the titles and abstracts for relevant studies. When a disparity was encountered, a third reviewer (AR) was made available for final opinion. Randomized controlled trials or comparative observational studies comparing simple single-row, complex single-row, and TOE double-row techniques were considered.

Inclusion criteria

1. Full-thickness tears treated with sSR, cSR, and TOE DR.
2. Level I, II, and III studies comparing sSR vs. TOE DR and cSR vs. TOE DR.
3. Human research.
4. English language.
5. Skeletally mature patients (older than 18 years).

Exclusion criteria

1. Partial thickness tears.
2. Case reports, abstracts, and reviews.
3. Studies with languages other than English.
4. Classic double-row repair.

Outcome measures

The primary outcome measures of interest for this review were as follows:

1. Pain score.
2. American Shoulder and Elbow Surgeons (ASES) score.
3. Constant score.
4. University of California at Los Angeles Shoulder (UCLA) score.
5. Range of motion—forward flexion and external rotation.
6. Retear rate.

Data extraction

Data were extracted separately by two reviewers (NP and AR). The basic demographics recorded for each study were first author, country of origin, year of publication, study design, level of evidence, type of interventions, sample size, mean age, follow-up in months, tear size, outcomes, and tear characteristics. Any disagreements were resolved through discussion between the two reviewers, and in the case of conflict, a third reviewer (AR) was consulted (Table I).

Data synthesis and statistical analysis

The mean difference was used to analyze continuous variables, and the risk difference was used to analyze all dichotomous variables. Review Manager© 5.3 was used for all data syntheses and subsequent analyses. $P < .05$ was considered statistically significant with confidence intervals set to 95%. A 'random effects model' was applied if significant heterogeneity existed between the studies compared. Results for each parameter have been displayed in a forest plot. A chi-square test was used to analyze heterogeneity between the studies, and heterogeneity size was formally determined with I^2 (where 0%-25% indicates low heterogeneity, 25%-75% indicates moderate heterogeneity, and >75% suggests high heterogeneity).

Methodological quality assessment

Two co-authors (NP and AR) independently appraised the quality and the associated risk of bias of all the randomised controlled trials (RCTs) in accordance with Cochrane Handbook for Systematic Reviews and Interventions.[12] To assess the quality of randomized controlled trials, the following parameters were evaluated: (1) randomization, (2) concealment of allocation, (3) blinding of participants in the study, (4) blinding of outcome assessment, (5) incomplete outcome data, (6) selective outcome reporting, and (7) other bias. All nonrandomized studies were formally assessed for quality as per the Newcastle-Ottawa scale.[37] This scale uses a star system from 0-9, where six or more is considered as a high-quality study.

Results

Literature search results

The initial search of the MEDLINE, Embase, and Google Scholar databases resulted in 1303 articles. Seven hundred ninety-four titles and abstracts of the articles were reviewed after excluding duplicates, and among them, 18 articles were deemed eligible for screening. Out of 18 articles, 4 studies were excluded, as 2 studies were based on partial tears and 2 studies were review articles which did not meet the inclusion criteria. Finally, 14 cohort studies were included in the meta-analysis for qualitative and quantitative assessment. The Preferred Reporting Items for Systematic Reviews and Meta-analyses flowchart is shown in Fig. 1.

Quality assessment

Randomized controlled trials were assessed based on the risk of bias classification. A risk of bias graph and risk of bias summary suggest that studies included were of good quality (Fig. 2 and 3). All nonrandomized studies were assessed for quality using the Newcastle Ottawa score with a subjective score out of 9. All the included studies are of good quality which had 2 or 3 stars in the selection domain, 1 or 2 in the comparability domain, and 2 or 3 in the outcome and exposure domain. All scores are displayed in Table II.

Characteristics of studies included

A total of 14 studies were included in the meta-analysis (Table I). All included studies were published between 2010 and 2020. Six

Table I
Characteristics of included studies.

Study	Country	Year	Study design	Level of evidence	Intervention	Sample size (SR/DR)	Age in years (SR/DR)	Follow-up (months)	Outcomes	Tear size (cm)	Tear characteristics
Aydin et al[1]	Turkey	2010	RCT	II	sSR vs. TOE DR	34/34	59/57	36 (24-40)	Constant score	<1, (1-3)	FT
Hantes et al[10]	Greece	2018	Prospective study	II	sSR vs. TOE DR	61/84	49.4/59.2	46	UCLA, Constant score, retear rate	1-3, 3-5	FT
Ide et al[14]	Japan	2015	Retrospective study	III	sSR vs. TOE DR	25/36	64/62	81/34	UCLA, JOA, pain, function, ROM	(1-3), (3-5)	FT
Imam et al[15]	United Kingdom	2020	RCT	I	sSR vs. TOE DR	40/40	61.6/60.0	36	VAS, Constant score, UCLA, OSS	1-3, >3	FT
Kim et al [19]	Korea	2013	Retrospective study	III	sSR vs. TOE DR	17/31	56.94/58.77	26.6	UCLA Constant score, ASES, retear rate	(3-5)	FT
Kim et al [19]	Korea	2013	Retrospective study	III	sSR vs. TOE DR	16/32	62.67/72.21	26.6	UCLA Constant score, ASES, retear rate	(3-5)	FT
Nicholas et al[23]	USA	2016	RCT	II	sSR vs. TOE DR	20/16	62 ± 7	26.4 ± 19.2	Penn, ASES, SST, ROM	(1-3), (3-5), (>5)	FT
Wade et al[35]	India	2017	RCT	II	sSR vs. TOE DR	28/28	55.39/57.18	6	UCLA, ASES, retear rate	NR	FT
Yamakado et al [39]	Japan	2019	RCT	I	sSR vs. TOE DR	38/37	65.8/65.4	28.1	UCLA, pain, retear	(1-3)	FT
Yoon et al[41]	Korea	2019	Retrospective study	III	sSR vs. TOE DR	31/25	58.1/56	24	ASES, UCLA, pain, SSV, retear, ROM	NR	FT
Barber et al[3]	USA	2016	RCT	I	cSR vs. TOE DR	20/20	57/55	28/27	Constant, ASES, Rowe, SST, Sane	<1, (1-3)	FT
Gerhardt et al[9]	Germany	2012	Prospective study	III	cSR vs. TOE DR	20/20	61.5 ± 7.4/61.2	16.8 ± 4.6/ 23.4 ± 2.9	Constant score, WORC, SSV, retear rate	NR	FT
Jeong et al[17]	Korea	2018	Retrospective study	III	cSR vs. TOE DR	190/225	58.99 ± 9.13/ 59.76 ± 8.18	53.2 ± 20.72/ 31.9 ± 11.36	Pain VAS, function VAS, Constant, ASES, SST	<1, (1-3), (3-5)	FT
Plachel et al[29]	Germany	2020	Retrospective study	III	cSR vs. TOE DR	16/11	60 ± 6/62 ± 8	156 ± 12/ 144 ± 12	Constant score, WORC, SSV, SST, ASES, ROM, retear rate	(1-3)	FT
Tashjian et al[34]	USA	2018	Retrospective study	III	cSR vs. TOE DR	18/21	65/61	12	VAS, SST, ASES	(1-3)	FT

ASES, American Shoulder and Elbow Surgeons; *cSR*, complex single-row repair; *ROM*, range of motion; *sSR*, simple single-row repair; *TOE DR*, transosseous-equivalent double-row repair; *SR*, single-row repair; *DR*, double-row repair; *cm*, centimeters; *RCT*, randomised controlled trials; *UCLA*, University College of Los Angeles Shoulder score; *FT*, full-thickness tear; *JOA*, Japanese Orthopaedic Association Score; *ROM*, range of motion; *VAS*, visual analogue scale; *OSS*, Oxford Shoulder Score; *SST*, Simple Shoulder Test score; *SSV*, Subjective Shoulder Value score; *WORC*, Western Ontario Rotator Cuff index.

RCTs, 2 prospective cohort studies, and 6 retrospective cohort studies were included. A total of 1231 rotator cuff tear cases were included in the study, of which 571 were treated with single-row repair and 660 had TOE double-row repair. The follow-up time of the involved studies ranged from 6 to 156 months. The mean follow-up time of all studies was 34.6 months. The study by Kim et al[19] has classified RCTs into group 1 (remnant tendon length <10 mm) and group 2 (remnant tendon length >10 mm); we have continued the same classification in this meta-analysis and subcategorized the data in each forest plot as Kim et al Gp1 and Kim et al Gp2, respectively. Types of cSR in the included studies are highlighted in Table III.

When comparing time to surgery from initial presentation, only a few studies have mentioned a time period of unsuccessful conservative management leading to surgery, that is 3 studies have suggested 3 months of nonoperative management[10,39,41] and 1 study suggests 6 months of nonoperative management.[15]

Outcomes

Pain score

For sSR vs. TOE DR, pain scores were reported in 2 RCTs and 1 observational study which comprised 211 subjects. No statistically significant difference exists between the groups.

For cSR vs. TOE DR, pain scores were reported in 2 observational studies which included 454 subjects. There was no statistically significant difference between the groups (Fig. 4).

ASES score

For sSR vs. TOE DR, ASES scores were reported in 1 RCT and 3 observational studies which comprised 226 subjects. A statistically significant difference ($P = .01$) exists between the groups favoring TOE DR.

For cSR vs. TOE DR, ASES scores were reported in 1 RCT and 3 observational studies which included a total of 521 subjects. There was no statistically significant difference between the groups (Fig. 5).

Constant score

For sSR vs. TOE DR, Constant scores were reported in 2 RCTs and 2 observational studies, which comprised 371 subjects. There was no statistically significant difference between the groups.

For cSR vs. TOE DR, Constant scores were reported in 1 RCT and 3 observational studies, which included 522 subjects. There was no statistically significant difference between the groups (Fig. 6).

UCLA score

For sSR vs. TOE DR, UCLA scores were reported in 2 RCTs and 4 observational studies, which comprised 406 subjects. There was no statistically significant difference between the groups (Fig. 7).

Range of motion

For sSR vs. TOE DR, forward elevation values were reported in 2 RCTs and 2 observational studies, which comprised 228 subjects. There was no statistically significant difference between the groups.

For cSR vs. TOE DR, the forward elevation value was reported in only 1 observational study. There was no statistically significant difference between the groups (Fig. 8).

For sSR vs. TOE DR, external rotation values were reported in 2 RCTs and 2 observational studies, which comprised 228 subjects. There was no statistically significant difference between the

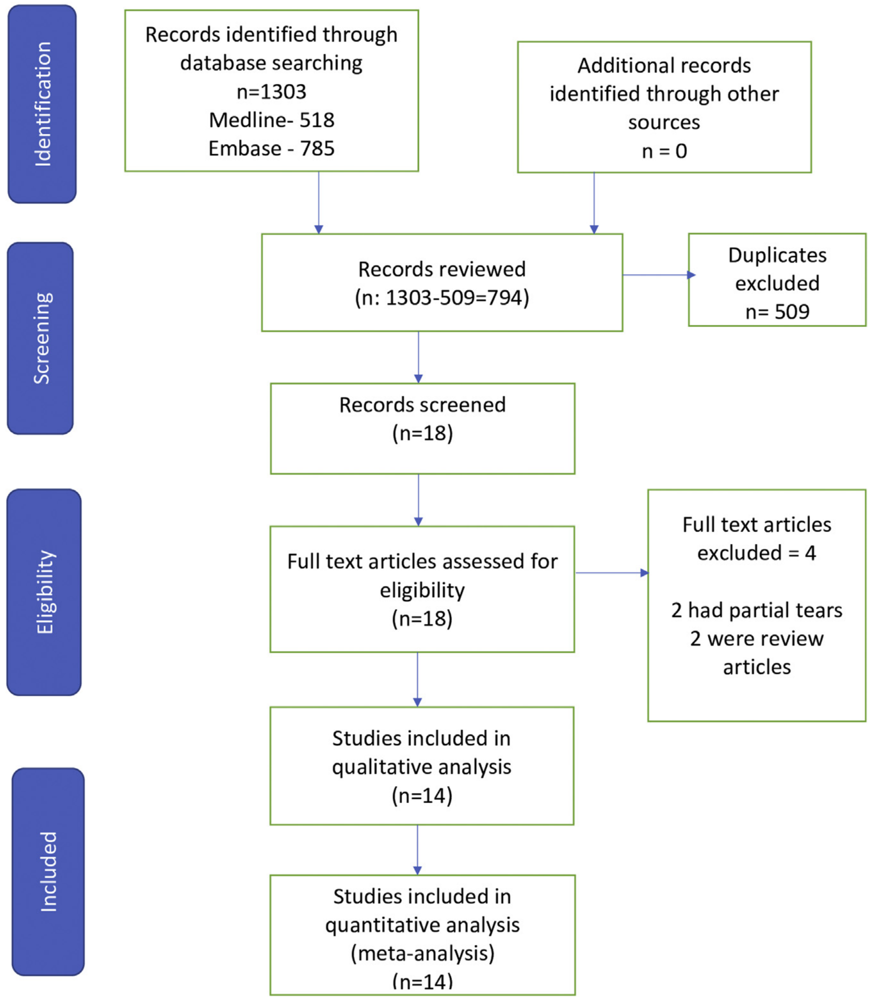

Figure 1 PRISMA flow chart of data extraction.

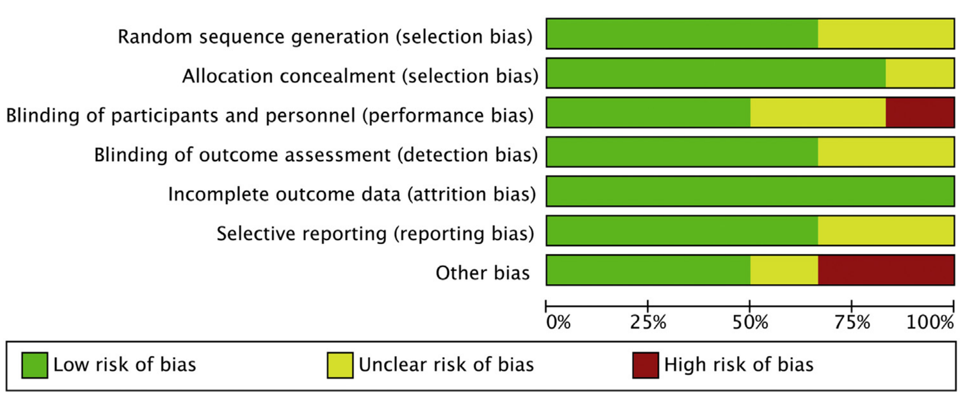

Figure 2 Risk of bias graph: review authors' judgments about each risk of bias item presented as percentages across all included studies.

groups. External rotation range of motion was not compared among complex single-row studies (Fig. 9).

Retear rate

For sSR vs. TOE DR, retear rates were reported in 2 RCTs and 3 observational studies, which comprised 410 subjects and showed a lower retear rate in the TOE DR group.

For cSR vs. TOE DR, retear rates were reported in 1 RCT and 3 observational studies, which comprised 522 subjects. There was no statistically significant difference between the groups (Fig. 10).

Sensitivity analysis

A sensitivity analysis was performed on all statistically significant comparisons where both fixed- and random-effects models were applied; the ASES score and retear rate for sSR vs. TOE DR forest plots were significant in a fixed-effects model, but were not

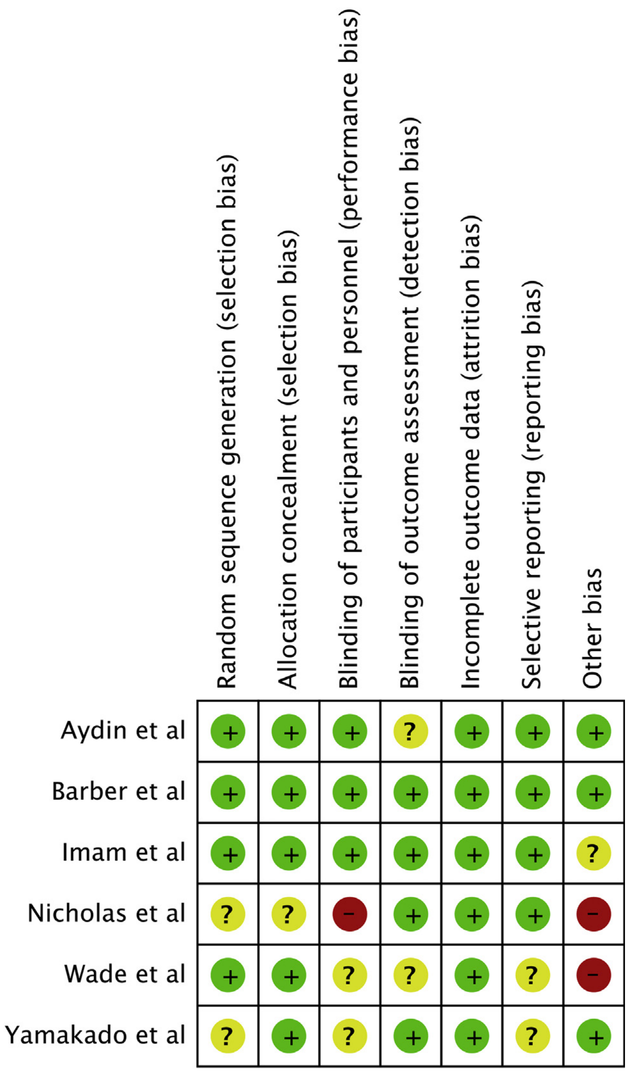

Figure 3 Risk of bias summary: review authors' judgments about each risk of bias item for each included study.

Table II
Newcastle-Ottawa score for qualitative assessment of nonrandomized studies.

Study	Selection	Comparability	Outcome	Total score
Gerhardt et al[9]	2	2	3	7
Hantes et al[10]	3	2	3	8
Ide et al[14]	3	1	2	6
Jeong et al[17]	3	2	2	7
Kim et al[19]	3	2	2	7
Plachel et al[29]	2	2	3	7
Tashjian et al[34]	3	2	3	8
Yoon et al[41]	3	2	2	7

Table III
Type of cSR in included studies.

Study	Type of cSR (vs. TOE DR)
Tashjian et al[34]	Triple-loaded anchors
Plachel et al[29]	Modified Mason-Allen stitch SR
Gerhardt et al[9]	Modified Mason-Allen stitch SR
Barber et al[3]	Triple-loaded anchors
Jeong et al[17]	Nonmodified Mason-Allen stitch SR

cSR, complex single-row repair; *TOE DR*, transosseous-equivalent double-row repair.

significant when a random-effects model was applied; the rest of the outcome comparisons did not alter with either model.

Discussion

A successful rotator cuff repair relies on suture security, tendon-to-bone contact, and biomechanical stability.[13,38] Biomechanical studies have suggested that double-row repairs are associated with improved footprint contact, reduced gap formation, and increased load-to-failure.[13,20,36,38] However, preceding meta-analyses that assess clinical outcomes have suggested similar outcomes between repair methodologies broadly categorized as single-row and double-row.[5,21,32]

Recent literature suggests that more complex single-row techniques offer a biomechanical advantage over traditional single-row techniques.[6,28] An extensive review by Bishop et al in 2017 reviewed and summarized data collected from comparative studies between various SR techniques. The review summarized that more complex repair techniques with more passes through the tendon (Mason-Allen, rip-stop, etc.) demonstrated the strongest repair among SR configurations and that double-loaded simple and horizontal mattress repairs were biomechanically inferior.[4] Similarly, data from Park et al suggest that more complex repair techniques were associated with improved clinical, radiographic, and biomechanical outcomes when compared with simple stitch methodologies.[26] These complex single-row techniques therefore warrant individual comparison against TOE DR techniques.

Biomechanical studies have demonstrated that the TOE repair better recreates the footprint and has larger load-to-failure when compared with the classic DR construct.[11,25,27,38] This type of DR repair is a more advanced, modified suture-bridge technique as described by Park et al.[24] Numerous clinical studies, with long-term follow-up, demonstrate increased function and cuff integrity with the TOE DR when compared with single-row technique; en masse[10,18,26] variable conclusions observed are likely due to the broad classification of techniques used rather than individual subtypes.[5,21,42] Our meta-analysis compares the outcomes of sSR and cSR against TOE DR repair.

The included literature in this study exhibits no significant difference between the TOE DR methods when compared with the complex single-row method. Similarly, most of included studies in this meta-analysis demonstrate equivalence of the TOE DR when compared with the simple single-row method. Although our study suggests possibly improved ASES scores and lower retear rates with TOE DR when compared with sSR, because of differing results with fixed- and random-effects models, the differences in ASES scores and retear rates between simple single-row and TOE techniques may not be significant or clinically meaningful. Hence, there is a need for more high-quality studies specifically comparing these treatment options.

We have highlighted a number of statistically significant findings. However, we appreciate that the data heterogeneity remains high in these outcome domains ($I^2 = 70\%$) despite efforts to subcategorize the data sets. It is likely that the increased heterogeneity is due to the wide variety of pathological subtypes, tear sizes, and differing techniques within each of our defined categories. In addition, the data are limited with regard to the recorded chronicity of the injuries. A small number of the included studies have stated that the patient cohort had failed nonoperative treatment for at least 3[10,39,41] or 6 months.[15] Importantly, no standard postoperative rehabilitation or follow-up protocol exists in the included studies. Furthermore, the latest cSR methods lack extensive outcome data given their innovative nature. In addition, most of older literature that may include these techniques has failed to individually classify them.

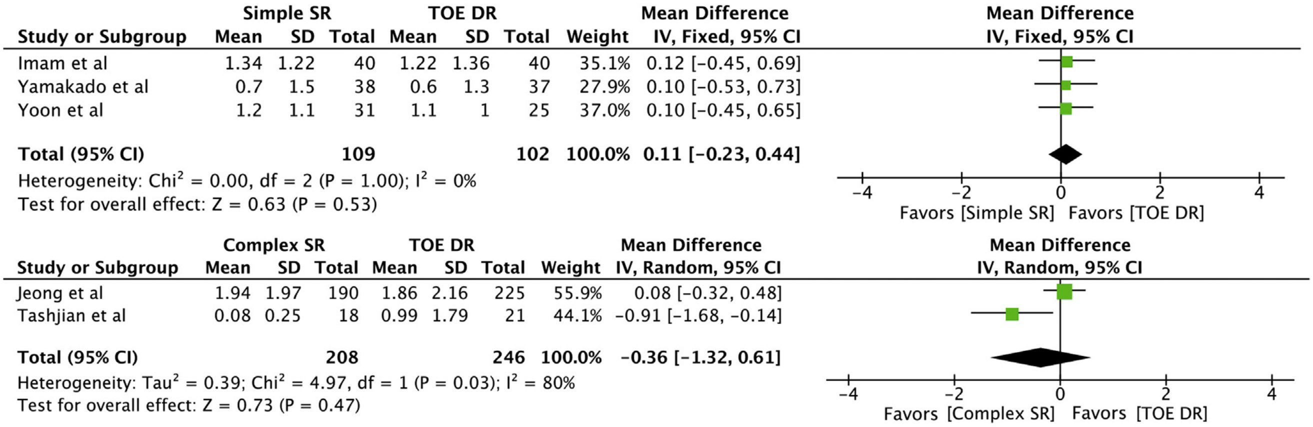

Figure 4 Forest plots of the comparison of pain scores between the sSR vs. TOE DR and cSR vs. TOE DR approaches. *cSR*, complex single-row repair; *CI*, confidence interval; *IV*, independent variable; *M-H*, Mantel-Haenszel; *sSR*, simple single-row repair; *SD*, standard deviation; *TOE DR*, transosseous-equivalent double-row repair.

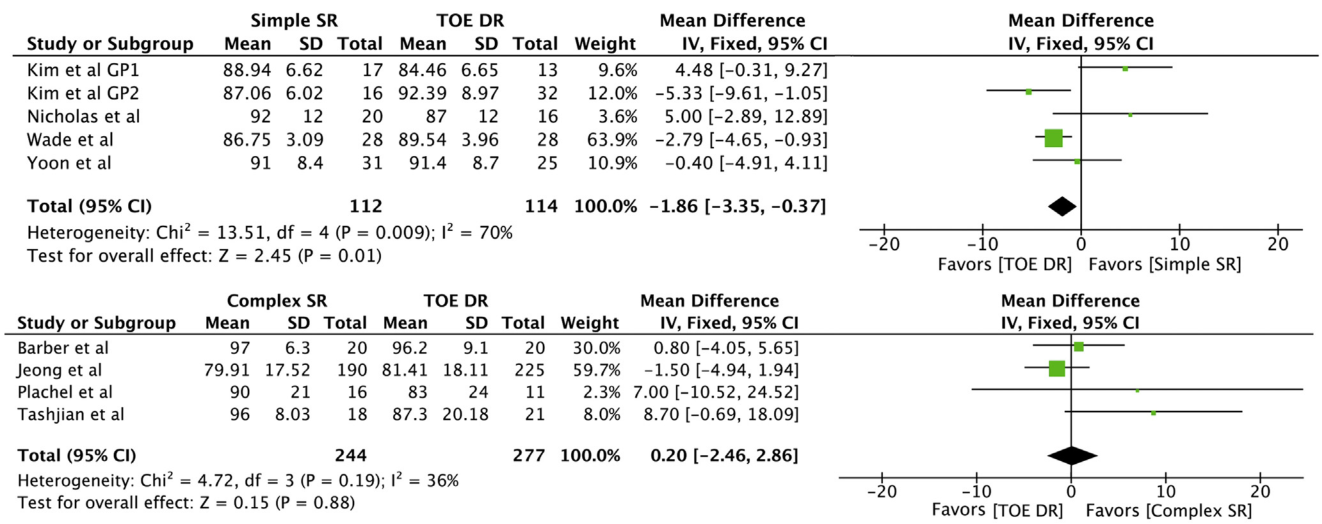

Figure 5 Forest plots of the comparison of ASES scores between the sSR vs. TOE DR and cSR vs. TOE DR approaches. *ASES*, American Shoulder and Elbow Surgeons; *CI*, confidence interval; *cSR*, complex single-row repair; *IV*, independent variable; *M-H*, Mantel-Haenszel; *sSR*, simple single-row repair; *SD*, standard deviation; *TOE DR*, transosseous-equivalent double-row repair.

This study would therefore suggest possible advantage of TOE DR and cSR techniques over the traditional sSR techniques. However, we appreciate the limitations highlighted and that there are important factors to consider such as biological factors affecting tendon healing, time to surgery, and overall health care costs including implant costs and operating time, which may differ between these techniques. The data were limited in terms of these outcomes and were beyond the scope of this study. The largest factor determining the choice of technique may ultimately be dependent on the surgeon's training and experience.[8]

Conclusion

The results of this meta-analysis suggest that there is no significant difference between complex single-row and TOE double-row methods in any of the observed outcomes. Similarly, most of included studies demonstrate equivalence of the TOE DR when compared with the simple single-row method. However, the study suggests that there are improved ASES functional scores and lower retear rates with TOE DR when compared with sSR.

The available data in the literature suggest possible superiority of TOE double-row repair and cSR techniques for the treatment of full-thickness rotator cuff tears. At this point in time, the available comparative data between TOE double-row repair and sSR techniques are limited to give any robust conclusions. Further high-quality studies are therefore required to assess the clinical outcomes and cost-effectiveness of these different techniques to draw more meaningful conclusions.

Disclaimers:

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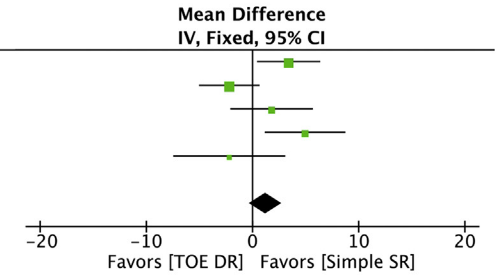
Conflicts of interest: The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements) or nonfinancial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript.

Study or Subgroup	Simple SR Mean	Simple SR SD	Simple SR Total	TOE DR Mean	TOE DR SD	TOE DR Total	Weight	Mean Difference IV, Fixed, 95% CI
Aydin et al	82.2	6	34	78.8	6.5	34	27.7%	3.40 [0.43, 6.37]
Hantes et al	81	9.32	61	83.19	7.61	84	30.2%	−2.19 [−5.04, 0.66]
Imam et al	79.4	8.3	40	77.6	9.4	40	16.2%	1.80 [−2.09, 5.69]
Kim et al GP1	83.18	5.73	17	78.23	4.85	13	17.1%	4.95 [1.16, 8.74]
Kim et al GP2	81	9.32	16	83.19	7.61	32	8.8%	−2.19 [−7.46, 3.08]
Total (95% CI)			**168**			**203**	**100.0%**	**1.22 [−0.34, 2.79]**

Heterogeneity: $Chi^2 = 12.98$, df = 4 (P = 0.01); $I^2 = 69\%$
Test for overall effect: Z = 1.53 (P = 0.13)



Study or Subgroup	Complex SR Mean	Complex SR SD	Complex SR Total	TOE DR Mean	TOE DR SD	TOE DR Total	Weight	Mean Difference IV, Fixed, 95% CI
Barber et al	88.3	9.5	20	93	7	20	20.3%	−4.70 [−9.87, 0.47]
Gerhardt et al	82.2	8.1	20	77	8.6	20	20.3%	5.20 [0.02, 10.38]
Jeong et al	76.39	15.88	190	75	16.09	225	57.0%	1.39 [−1.70, 4.48]
Plachel et al	85	19	16	80	20	11	2.4%	5.00 [−10.05, 20.05]
Total (95% CI)			**246**			**276**	**100.0%**	**1.01 [−1.32, 3.34]**

Heterogeneity: $Chi^2 = 7.53$, df = 3 (P = 0.06); $I^2 = 60\%$
Test for overall effect: Z = 0.85 (P = 0.39)

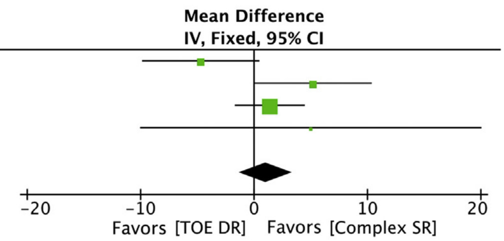


Figure 6 Forest plots of the comparison of Constant scores between the sSR vs. TOE DR and cSR vs. TOE DR approaches. *CI*, confidence interval; *cSR*, complex single-row repair; *IV*, independent variable; *M-H*, Mantel-Haenszel; *sSR*, simple single-row repair; *SD*, standard deviation; *TOE DR*, transosseous-equivalent double-row repair.

Study or Subgroup	Simple SR Mean	Simple SR SD	Simple SR Total	TOE DR Mean	TOE DR SD	TOE DR Total	Weight	Mean Difference IV, Random, 95% CI
Ide et al	30.8	3.5	25	31.8	3.4	36	13.7%	−1.00 [−2.77, 0.77]
Imam et al	31	2.3	40	31.3	2.2	40	17.6%	−0.30 [−1.29, 0.69]
Kim et al GP1	30.65	1.73	17	27.23	4.07	13	10.9%	3.42 [1.06, 5.78]
Kim et al GP2	27.38	4.99	16	32.25	2.2	32	10.1%	−4.87 [−7.43, −2.31]
Wade et al	30.14	1.58	28	31.5	1.77	28	18.1%	−1.36 [−2.24, −0.48]
Yamakado et al	33	3.1	38	33.4	3.3	37	15.3%	−0.40 [−1.85, 1.05]
Yoon et al	31.9	3.5	31	32.1	2.8	25	14.3%	−0.20 [−1.85, 1.45]
Total (95% CI)			**195**			**211**	**100.0%**	**−0.64 [−1.79, 0.50]**

Heterogeneity: $Tau^2 = 1.69$; $Chi^2 = 25.30$, df = 6 (P = 0.0003); $I^2 = 76\%$
Test for overall effect: Z = 1.10 (P = 0.27)

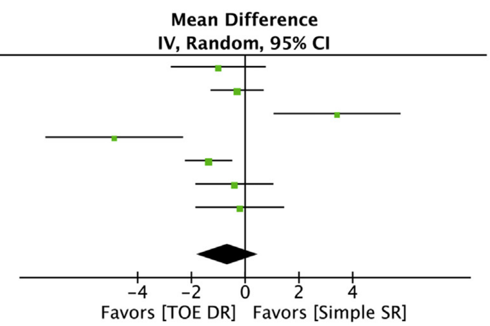
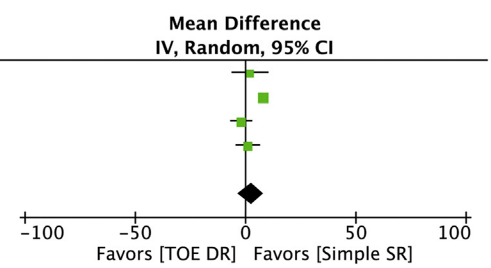


Figure 7 Forest plots of the comparison of UCLA scores between the sSR vs. TOE DR. *CI*, confidence interval; *IV*, independent variable; *M-H*, Mantel-Haenszel; *sSR*, simple single-row repair; *SD*, standard deviation; *TOE DR*, transosseous-equivalent double-row repair.

Study or Subgroup	Simple SR Mean	Simple SR SD	Simple SR Total	TOE DR Mean	TOE DR SD	TOE DR Total	Weight	Mean Difference IV, Random, 95% CI
Ide et al	161	16	25	159	17	36	19.0%	2.00 [−6.38, 10.38]
Nicholas et al	170	3	20	162	3	16	30.8%	8.00 [6.03, 9.97]
Yamakado et al	159	12	38	161	10	37	25.7%	−2.00 [−6.99, 2.99]
Yoon et al	149	10	31	148	11	25	24.5%	1.00 [−4.57, 6.57]
Total (95% CI)			**114**			**114**	**100.0%**	**2.57 [−3.17, 8.31]**

Heterogeneity: $Tau^2 = 26.88$; $Chi^2 = 17.78$, df = 3 (P = 0.0005); $I^2 = 83\%$
Test for overall effect: Z = 0.88 (P = 0.38)



Study or Subgroup	Complex SR Mean	Complex SR SD	Complex SR Total	TOE DR Mean	TOE DR SD	TOE DR Total	Weight	Mean Difference IV, Fixed, 95% CI
Tashjian et al	168	5	18	160	29	21	100.0%	8.00 [−4.62, 20.62]
Total (95% CI)			**18**			**21**	**100.0%**	**8.00 [−4.62, 20.62]**

Heterogeneity: Not applicable
Test for overall effect: Z = 1.24 (P = 0.21)

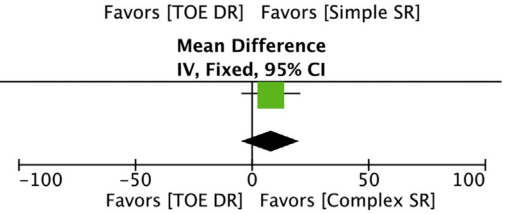


Figure 8 Forest plots of the comparison of forward elevation ROM between the sSR vs. TOE DR and cSR vs. TOE DR approaches. *CI*, confidence interval; *cSR*, complex single-row repair; *IV*, independent variable; *M-H*, Mantel-Haenszel; *sSR*, simple single-row repair; *SD*, standard deviation; *TOE DR*, transosseous-equivalent double-row repair; *ROM*, range of motion.

Study or Subgroup	Simple SR Mean	SD	Total	TOE DR Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Ide et al	46	13	25	47	14	36	26.8%	−1.00 [−7.85, 5.85]
Nicholas et al	67	10	20	59	10	16	29.1%	8.00 [1.43, 14.57]
Yamakado et al	52	15	38	49	16	37	25.5%	3.00 [−4.02, 10.02]
Yoon et al	52	15	31	49	16	25	18.7%	3.00 [−5.20, 11.20]
Total (95% CI)			**114**			**114**	**100.0%**	**3.38 [−0.16, 6.93]**

Heterogeneity: Chi² = 3.49, df = 3 (P = 0.32); I² = 14%
Test for overall effect: Z = 1.87 (P = 0.06)

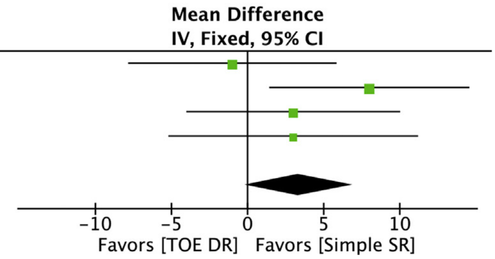


Figure 9 Forest plots of the comparison of external rotation ROM between the sSR vs. TOE DR approaches. *CI*, confidence interval; *IV*, independent variable; *M-H*, Mantel-Haenszel; *sSR*, simple single-row repair; *SD*, standard deviation; *TOE DR*, transosseous-equivalent double-row repair; *ROM*, range of motion.

Study or Subgroup	Simple SR Events	Total	TOE DR Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Hantes et al	13	61	5	84	18.5%	4.28 [1.44, 12.75]
Kim et al GP1	1	17	6	13	35.8%	0.07 [0.01, 0.72]
Kim et al GP2	3	16	2	32	6.1%	3.46 [0.52, 23.23]
Wade et al	11	28	2	28	6.8%	8.41 [1.65, 42.76]
Yamakado et al	1	38	3	37	16.6%	0.31 [0.03, 3.09]
Yoon et al	4	31	3	25	16.2%	1.09 [0.22, 5.38]
Total (95% CI)		**191**		**219**	**100.0%**	**1.83 [1.03, 3.23]**
Total events	33		21			

Heterogeneity: Chi² = 16.42, df = 5 (P = 0.006); I² = 70%
Test for overall effect: Z = 2.07 (P = 0.04)

Study or Subgroup	Complex SR Events	Total	TOE DR Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Barber et al	3	20	3	20	12.4%	1.00 [0.18, 5.67]
Gerhardt et al	6	20	5	20	17.1%	1.29 [0.32, 5.17]
Jeong et al	17	190	11	225	44.8%	1.91 [0.87, 4.19]
Plachel et al	3	16	1	11	4.7%	2.31 [0.21, 25.66]
Tashjian et al	4	18	6	21	21.0%	0.71 [0.17, 3.08]
Total (95% CI)		**264**		**297**	**100.0%**	**1.46 [0.83, 2.55]**
Total events	33		26			

Heterogeneity: Chi² = 1.73, df = 4 (P = 0.79); I² = 0%
Test for overall effect: Z = 1.32 (P = 0.19)

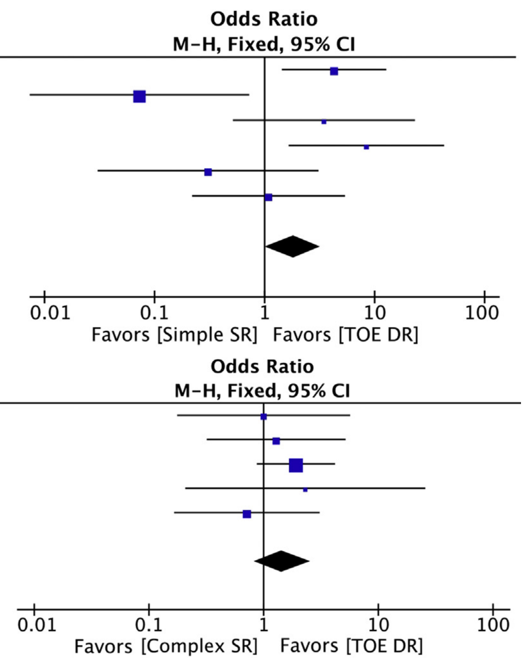


Figure 10 Forest plots of the comparison of retear rate between the sSR vs. TOE DR and cSR vs. TOE DR approaches. *CI*, confidence interval; *cSR*, complex single-row repair; *IV*, independent variable; *M-H*, Mantel-Haenszel; *sSR*, simple single-row repair; *TOE DR*, transosseous-equivalent double-row repair; *ROM*, range of motion.

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