Transtendinous Repair of Partial Articular Sided Supraspinatus Tears is Associated With Higher Rates of Stiffness and Significantly Inferior Early Functional Scores Than Tear Completion and Repair: A Systematic Review

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Abstract

Introduction

Transtendon repair (TTR) and tear completion and repair (TCR) are common repair techniques for partial thickness rotator cuff tears (PTRCTs). Previous systematic reviews have not demonstrated any advantage of either but have not specifically addressed early recovery.

Aim

To compare the outcomes of these two techniques in treating PTRCTs with respect to post-operative stiffness, delay in functional recovery and re-tear rates.

Material and Methods

A systematic review of the Medline and EMBASE database was performed in accordance with the PRISMA guidelines. Both cases series and comparative studies reporting functional outcomes, post-operative stiffness or re-tear rate after either TTR or TCR for PTRCTs were included.

Results

The search strategy identified 21 studies (n=797); 4 comparative studies (n=214), 15 TTR (n=511) and 2 TCR case series (n=72). All four comparative studies included were randomised controlled trials. One RCT reported early outcomes and demonstrated significantly slower recovery in the TTR group at 3 months (ASES p=0.037, Constant score p=0.019 and pain p=0.001). Similarly, data from the case series suggested that the rate of post-operative stiffness was higher in the TTR group. All comparative studies demonstrated

no significant difference at final follow up in terms of pain, range of motion or functional score.

Discussion

The results of this systematic review suggest that transtendinous repairs are associated with more pain and worse function during the first 3 months. This suggests that tear completion and repair should be the preferred option as comparative studies do not demonstrate any long term advantage of transtendinous repair.

Type of study: Systematic review

Level of Proof: Level II evidence

Keywords

Rotator cuff tear

Tear completion

Transtendinous repair

Partial rotator cuff tear

Stiffness

Introduction

Partial thickness rotator cuff tears (PTRCTs) were first described by Codman [1] and later classified by Ellman according to the depth and location of the tear. [2] PTRCTs may occur on the articular side, within the tendon, or on the bursal side, with articular-sided tears being 2–3 times more common than bursal-sided tears [3, 4]. Possible pathogenesis of tears includes intrinsic degeneration, extrinsic impingement and trauma [5]. Partial tears are shown to have a variable rate of progression with 28-40% eventually becoming full thickness tears [6-8].

While many patients with cuff tears that involve under 50% of the tendon improve clinically with non-operative treatment modalities, surgical repair may be indicated if tears exceed 50% or in those who have failed non-operative treatment [9, 10]. Weber et al. reported that arthroscopic debridement and acromioplasty alone was associated with a higher reoperation rate than observed in those that underwent repair when the tear extended to over 50% [10]. Similarly, Ellman reported a high (25%) reoperation rate in patients treated with only debridement and acromioplasty [2]. This has led to a trend in repairing lesions that extend to more than 50% of the tendon thickness [2, 10-12]. Two common treatments are the transtendon repair technique and formal repair after completion of PTRCTs.

The theoretical advantages of transtendinous repair are maintenance of the intact part of the tendon and improved biomechanical properties (less gapping and higher mean ultimate failure strength) [13-16]. However, there is concern that the tendon can become overtensioned [15, 16], as repair of the articular side may cause bunching of the bursal layer of the cuff resulting in unbalanced tendon tension and residual discomfort. [17] The alternative technique is to convert the PTRCT to a full thickness tear before repair and this has the potential advantages of better access to the tendon footprint for preparation of the bony bed and removal of degenerative tissue [10, 18]. However, the procedure involves removal of structurally sound bursal sided tendon and may potentially lead to a higher re-tear rate [19]. Although previous reviews and meta-analysis have demonstrated that both techniques can provide similar improvement in shoulder function [20, 21], the risk of post-operative stiffness and delay in functional recovery have not been thoroughly evaluated. The aim of this study was to compare the two surgical techniques for treating articular-sided PTRCTs, with respect to the association with these adverse early outcomes and also an evaluation of the re-tear rate at long term follow-up.

Methods

A systematic review of the literature was conducted in accordance with the PRISMA guidelines [22] using the online databases Medline and EMBASE. The review was registered on the PROSPERO database on 25th March 2017 (Reference CRD42017060207). The searches were performed independently by two authors on the 18th of March 2017 and repeated on the 25th of April 2017 to ensure accuracy. The Medline search strategy is illustrated in Table 1.

Only studies that were published in English were included. Both cases series and comparative studies reporting outcomes after either transtendinous repair (TTR) or tear completion and repair (TCR) of PTRCTs were included. Studies reporting outcomes of patients with partial subscapularis or infraspinatus tears were excluded. Only arthroscopic repairs were included but any surgical technique was acceptable. The study must have reported the American Shoulder & Elbow Shoulder Surgeons Evaluation Form (ASES) or the Constant Score, and/or the incidence of post-operative stiffness and/or re-tear rate. In addition, only primary research was considered for review with any abstracts, comments, review articles and technique articles excluded.

Data from comparative studies and case series were presented together as a narrative synthesis of each individual outcome measure. The studies were appraised independently by two authors using the tool developed by the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) Working Group [23]. In addition, the robustness of study methodology was appraised using the Methodological index for non-randomized studies (MINORS) [24].

Results

The search strategy identified 21 studies eligible for inclusion; 4 comparative studies [19,25-27], 15 TTR case series [14, 17, 18, 28-39] and, 2 TCR case series. [40, 41]. A flow chart of the search strategy is shown in Figure 1. The total number of participants in all studies was 797. 214 participants were included in the comparative studies with sample sizes ranging from 32 to 74 [19, 25-27]. The TTR case series included 511 patients and the TCR case series 72. Concise details of the included studies are given in Table 2 to 5.

Functional Outcomes

Three comparative studies reported functional scores; the Constant score in all three and the ASES in two studies. All demonstrated statistically significant improvement in functional outcomes with both surgical techniques as demonstrated in Table 2. However, there was no difference between the groups at final follow up [19, 25, 26]. Only one comparative study reported functional outcomes in the early post-operative period, demonstrating a significantly slower recovery in the TTR group at 3 months [19]. After 3 months the ASES had improved significantly more in the TCR group (49.2 to 64.6) compared to the TTR group (50.8 to 54.9), (p=0.037). Similarly the Constant Score (p=0.019) had significantly improved more in the TCR group (59.0 to 70.8) compared to the TTR group (54.8 to 57.9). Early recovery was not reported in the other three comparative studies. The evidence reviewed relating to functional outcomes was of moderate quality (see Table 6).

In the TTR case series a variety of functional outcome measures were used with the most common being the ASES in 6 studies and the Constant score in 3 studies. All case series reviewed reported improvement in functional outcomes after TTR as shown in Table 3. The ASES was reported in both TCR case series which demonstrated statistically significant improvement as demonstrated in Table 4. However, the studies lacked information on early functional recovery with outcomes reported at final follow up only; mean range of follow up was 12 to 62 months in the TTR case series and 24 to 38 months in the TCR case series.

Pain

Two comparative studies reported improvements in pain using the VAS score (see Table 2); Shin et al. demonstrated a rise of 4.1 in the TTR group and 4.2 in the TCR group whilst Castagna et al. a rise of 3.4 and 3.6 respectively [19, 25]. Only Shin et al. reported early pain relief where pre-operative pain had worsened in the TTR group from 5.5 to 5.9 and reduced from 5.3 to 2.8 in the TCR group (p=0.001) [19]. However, these authors report that from six months onwards there was no statistical difference between the groups [19]. Nine TTR and one TCR case series reported pain with improvements ranging from 3.8 to 6.7 after TTR and being 5.7 after TCR [17, 18, 28, 31-33, 36-38, 40] (see Tables 3 and 4).

Re-tear

The re-tear rate was reported in three comparative studies and four TTR case series, these results are demonstrated in Table 5. In the comparative studies, the re-tear rate ranged from 0% to 5.9% in the TTR group and from 0% to 8.3% in TCR group [19, 26, 27]. None of the comparative studies demonstrated any statistically significant difference between the groups at final follow up (mean range 19 to 38 months) [19, 26, 27]. The incidence of re-tear in TTR case series ranged from 0 to 12% but this outcome was not reported in the TCR case series. The use of the GRADE tool highlights that this should be considered very low quality evidence (see Table 6).

Post-operative stiffness

Two comparative studies reported the incidence of post-operative stiffness. Franceschi et al. reported a rate of 9.3% in the TTR group and 10.7% in the TCR group during the first six months following surgery suggesting. All cases in the TTR group resolved but two thirds of cases in the TCR group required arthroscopic capsular release [26]. Shin et al. reported a slightly higher rate of post-operative stiffness after TTR 12.5% versus 8.3% after TCR [19]. The GRADE tool suggested that the evidence reviewed on this topic was deemed to be of very low quality (see Table 6).

Five studies reported the rate of post-operative stiffness in the TTR case series (n=244) with the rate ranging from 0 to 18%. Vinanti et al. performed the largest TTR case series and suggest that 18% of their patients had stiffness at 3 months although all had improved by 6 months (n=100) [37]. Both TCR case series reported the incidence of post-operative stiffness ranging from 0 to 2.8%.

Discussion

The results of this review demonstrate that early functional recovery and pain relief after TCR is superior when compared to TTR (ASES p=0.037, Constant Score p=0.019 and pain p=0.001). These findings originate from a good quality RCT conducted by Shin et al. that provided level 1 evidence [19] and are further supported by case series which report a higher rate of post-operative stiffness after TTR. Shin et al. [19] suggest that inferior early outcomes in the TTR groups could be due to a mismatch in tension between the articular and bursal layers in the initial period after repair and that completion allows for repair with correct tensioning of the rotator cuff [19]. This has led to some authors describing surgical techniques to minimise this discrepancy in tension but these initial reports consist of small series without comparative groups [29, 33].

Although all three comparative studies reporting functional outcomes at final follow up demonstrated significant improvements with both TTR and TCR, none demonstrated any difference in outcome between the techniques at final follow up [19, 25, 26], this supports the findings of a previous meta-analysis [21]. Furthermore, no significant differences in re-tear rate were reported. The case series similarly demonstrated the ability of both TTR and TCR to provide good pain relief and functional improvement after treatment of PTRCTs at final follow up. It is therefore suggested that if there is no difference between the procedures at long term follow up, that early functional recovery and the rate of post-operative stiffness should be important clinical considerations. If TCR can provide significantly better early functional scores and less post-operative stiffness, then it should be considered as the preferred approach particularly when it has not been shown to be disadvantageous with respect to re-tear rates at long term follow-up. However, only one comparative study reported the early recovery of patients undergoing repair for PTRCTs and this highlights that early outcomes following these procedures have thus far been neglected in the literature. This review suggests that further research is required to validate the work of Shin et al that has demonstrated improved early functional recovery and pain relief in the TCR group when compared to TTR [19].

Although the risk of stiffness after TTR is a concern, its incidence was reported in only two RCTs and seven case series. Shin et al. demonstrated a trend to a higher incidence after TTR (12.5% versus 8.3%) [19], whereas Franceschi et al. reported similar rates of stiffness (TTR 9.3% versus TCR 10.7%) [26]. In addition, the case series suggest a higher rate of stiffness in the TTR group (range 0 to 18% compared to 0 to 2.8% after TCR). Shin et al. suggested that any potential increase in stiffness after TTR could also be a result of a mismatch in tension between the articular and bursal layers in the initial period restricting motion [19]. The risk of post-operative stiffness after either TTR or TCR was higher than the previously reported 3.3% for repair of full thickness rotator cuff tears [42]. This higher risk of stiffness after repair of partial tears has previously been described, Huberty et al. retrospectively studied 489 patients showing that 4.9% had post-operative stiffness but those with PTRCTs had a higher risk at 15% [43]. The results of this systematic review would support the view that partial tendon tears are at higher risk of stiffness post-operatively regardless of the surgical technique used to repair them.

Re-tear rate is another important outcome that was reported in three RCTs and four TTR case series. The three comparative studies utilised post-operative MRI scans to identify those with re-tears and but did not show consensus between studies [19, 26, 27]. Shin et al. reported more re-tears in the TCR group (8.3% vs 0%) [19], Franceschi demonstrated similar re-tear rates (TTR 3.1% vs TCR 3.6%) [26] and Kim et al. demonstrated a higher re-tear rate in the TCR group (5.9% versus 0%) [27]. The three TTR case series reporting re-tear ranged from 0% to 12%, whereas values for re-tear were not available from the TCR case series.

Previously authors have raised concern over the risk of an increased re-tear rate after TCR due to the risk of poor tendon healing after the intact rotator cuff has been completely taken down [35] but the reviewed studies have not demonstrated any increased rate of re-tear in the TCR group. The reported re-tear values after both TTR and TCR patients compare favourably against the incidence of re-tears after repair of full thickness rotator cuff tears (17% to 46%) [44, 45]. A previous meta-analysis suggests that both TCR and TTR have a relatively high rate of healing and that partial thickness tears intrinsically have good healing potential when compared to large full thickness tears [20]. This may explain the low rate of re-tears reported after repair of partial tears reported in this review.

Limitations

The main limitations of this SR were the failure of the comparative series to report early functional recovery in two studies [25, 26] and rate of stiffness in another two studies [25, 27]. The heterogeneity between studies with respect to the population, the functional outcome measures reported and reporting of early functional recovery precluded pooling of data and meta-analysis. The studies failed to uniformly report additional details of the tear including tendon quality, presence of delamination and the degree of retraction of the deep layer which are all factors that can independently impact on patient outcomes. The availability of only small samples sizes in the comparative studies risks underpowering of the studies and may result in failure of these studies to demonstrate any significant difference even if present. In addition, the discrepancy between the number of TTR case series (n = 15) and TCR case series (n= 2) restricted comparison of the groups.

Table 6 illustrates the GRADE assessment of comparative studies and reported that the quality of this evidence ranged from moderate to low quality. The case series provided only level IV evidence and hence had significant limitations that must be taken into account when interpreting the results. Tables 7 and 8 illustrate the appraisal of the studies according to the MINORS criteria and demonstrated that the scores ranged from 3 to 7 against the 12 criteria. This demonstrated significant weaknesses in these studies with common limitations being the loss of patients to follow up, risk of outcome bias and lack of a comparative group.

Despite these limitations the review highlights that TTR is associated with a higher incidence of post-operative stiffness, higher pain scores and slower functional recovery than tear completion and repair. This warrants further study but also suggests that in the absence of higher quality evidence, and a lack of significant difference in long term outcomes in previous systematic review comparing the two techniques, that TCR should be considered for surgical management of PTRCTs.

Conclusion

The results of this systematic review suggest that transtendinous repairs are associated with more pain and worse function during the first 3 months after surgery. This suggests that tear completion and repair should be the preferred option as comparative studies do not demonstrate any advantage of transtendinous repair at long term follow-up.

Conflict of Interest and Source of Funding

Professor A Saithna is a consultant for Arthrex.

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References

1. Codman E. The shoulder: rupture of the supraspinatus tendon and other lesions in or about the subacromial bursal. 1934 RE Kreiger. ISBN: 0898747317.
2. Ellman H. Diagnosis and treatment of incomplete rotator cuff tears. Clin Orthop Relat Res 1990; 254:64–74.
3. Fukuda H. The management of partial-thickness tears of the rotator cuff. J Bone Joint Surg Br 2003; 85:3–11.
4. Lehman RC, Perry CR. Arthroscopic surgery for partial rotator cuff tears. Arthroscopy 2003; 19: E81–84.
5. Tang KL, Habermeyer P, Li QH, Lichtenberg S, Yang L. Etiology, classification and clinical evaluation of partial-thickness tears of rotator cuff. Chin J Traumol 2003; 6(5);309-317.
6. Kim YS, Kim SE, Bae SH, Lee HJ, Jee WH, Park CK. Tear progression of symptomatic full-thickness and partial-thickness rotator cuff tears as measured by repeated MRI. Knee Surg Sports Traumatol Arthrosc 2017; 25(7):2073-2080.
7. Mall NA, Kim HM, Keener JD, Steger-May K, Teefey SA. Symptomatic progression of asymptomatic rotator cuff tears: a prospective study of clinical and sonographic variables. J Bone Joint Surg Am 2010; 92(16):2623-2633.
8. Yamanaka K, Matsumoto T. The joint side tear of the rotator cuff. A follow up study by arthrography. Clin Orthop Relat Res 1994; 304:68-73.
9. Arce G, Bak K, Bain G, Clavo E, Ejnisman B, Di Giacomo G, Gutierrez V, Guttman D, Itoi E, Kibler B, Ludvigsen T, Mazzocca A, de Castro Pochini A, Savoie F, Sugaya H, Uribe J, Vergara F, Willems J, Yoo YS, McNeil JW, Provencher MT. Management

of disorders of the rotator cuff: proceedings of the ISAKOS upper extremity committee consensus meeting. Arthroscopy 2013; 29(11):1840–1850.

10. Weber SC. Arthroscopic debridement and acromioplasty versus mini-open repair in the treatment of significant partial thickness rotator cuff tears. Arthroscopy 1999; 15(2):126–131.
11. Mazzocca AD, Rincon LM, O'Connor RW, Obopilwe E, Andersen M, Geaney L, Arciero RA. Intraarticular partial-thickness rotator cuff tears: analysis of injured and repaired strain behaviour. Am J Sports Med 2008; 36(1):110–116.
12. Strauss EJ, Salata MJ, Kercher J, Barker JU, McGill K, Bach BR, Romeo AA, Verma NN. Multimedia article. The arthroscopic management of partial-thickness rotator cuff tears: a systematic review of the literature. Arthroscopy 2011; 27(4): 568–580.
13. Brockmeier SF, Dodson CC, Gamradt SC, Coleman SH, Altchek DW. Arthroscopic intratendinous repair of the delaminated partial-thickness rotator cuff tear in overhead athletes. Arthroscopy 2008; 24:961-965.
14. Lo IK, Burkart SS. Transtendon arthroscopic repair of partial-thickness articular surface tears of the rotator cuff. Arthroscopy 2004; 20(2):214-220.
15. Peters KS, Lam PH, Murrell GA. Repair of partial-thickness rotator cuff tears: a biomechanical analysis of footprint contact pressure and strength in an ovine model. Arthroscopy 2010; 26(7):877–884.
16. Woods TC, Carroll MJ, Nelson AA, More KD, Berdusco R, Sohmer S, Boorman RS, Lo IKY. Transtendon rotator-cuff repair of partial-thickness articular surface tears can lead to medial rotator-cuff failure. Open Access Journal of Sports Medicine 2014; 5:151–157.

17. Castagna A, Deller Rose G, Conti M, Snyder SJ, Borroni M, Garofalo R. Predictive factors of subtle residual shoulder symptoms after transtendinous arthroscopic cuff repair. A clinical study. Am J Sports Med 2009; 37(1):103-108.

18. Kamath G, Galatz LM, Keener JD, Teefey S, Middleton W, Yamaguchi K. Tendon integrity and functional outcome after arthroscopic repair of high grade partial-thickness supraspinatus tears. J Bone Joint Surg Am 2009; 91:1055-1062.

19. Shin SJ. A comparison of 2 repair techniques for partial-thickness articular-sided rotator cuff tears. Arthroscopy 2012; 28: 25-33.

20. Ono Y, Woodmass, Lo IK. Arthroscopic repair of articular surface partial thickness rotator cuff tears: Transtendon technique versus repair after completion of the tear – a meta-analysis. Adv Orthop 2016.

21. Sun L, Zhang Q, Ge H, Sun Y, Cheng B. Which is the best repair of articular-sided rotator cuff tears: a meta-analysis. J Orthop Surg 2015; 10:84.

22. Moher D, Liberati A, Tetzlaff J, Altman DG. The PRISMA Group. Preferred reporting items for systematic reviews and meta-analysis: the PRISMA statement. BMJ 2009; 339:25-35.

23. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello, Schunermann J. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008; 336:924.

24. Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (MINORS): Development and validation of a new instrument. Anz J Surg 2003; 73:712-76.

25. Castagna A, Borroni M, Garofalo R, Cesari E, Padua R, Conti M, Gumina S. Deep partial rotator cuff tear: transtendon repair or tear completion and repair? A randomized clinical trial. Knee Surg Sports Traumatol Arthrosc 2015; 23:460-463.

26. Franceschi F, Papalia R, Del Buono A, Vasta S, Costa V, Maffulli N, Denaro V. Articular-sided rotator cuff teas: which is the best repair? A three-year prospective randomised controlled trial. Int Orthop 2013; 37:1487-1493.

27. Kim YS, Lee HJ, Bae SH, Jin H, Song HS. Outcome comparison between in situ repair versus tear completion repair for partial thickness rotator cuff tears. Arthroscopy 2015; 31(11):2191-2198.

28. Duralde XA, McClelland WB. The clinical results of arthroscopic transtendinous repair of grade III partial articular-sided supraspinatus tendon. Arthroscopy 2012; 28(2):160-168.

29. Fukuta S, Amari R, Tsutsui T. Double arthroscopic transtendon repair of partial-thickness articular surface tears of the rotator cuff: a surgical technique. Journal of Orthopaedic Surgery 2015; 23(3):395-397.

30. Ide J, Maeda S, Takagi K. Arthroscopic transtendon repair of partial-thickness articular-side tears of the rotator cuff. Anatomical and clinical study. Am J Sports Med 2005; 33(11):1672-1679.

31. Kim KC, Shin HD, Cha SM, Park JY. Repair integrity and functional outcome after arthroscopic conversion to a full-thickness rotator cuff tear. Articular versus Bursal side partial tears. Am J Sports Med 2013; 42(2):451-456.

32. Ranalletta M, Rossia LA, Bertona AB, Atala NA, Tanoira I, Maignon G, Bongiovanni SL. Arthroscopic transtendon repair of partial-thickness articular-side rotator cuff tears. Arthroscopy 2016; 32(8):1523-1528.

33. Shin SJ, Jeong JH, Jeon YS, Kim RG. Preservation of bursal-sided tendon in partial-thickness articular sided rotator cuff tears: a novel arthroscopic transtendon anatomic repair technique. Arch Orthop Trauma Surg 2016; 136:1701–1708.

34. Spencer EE. Partial-thickness articular surface rotator cuff tears. An all-inside repair technique. Clin Orthop Relat Res 2010; 468:1514-1520.

35. Stuart KD, Karzel RP, Ganjianpour M, Synder SJ. Long-term outcome for arthroscopic repair of partial articular-sided supraspinatus tendon avulsion. Arthroscopy 2013; 29(5):818-823.

36. Tauber M, Koller H, Resch H. Transosseous arthroscopic repair of partial articular-surface supraspinatus tendon tears. Knee Surg Sports Traumatol Arthrosc 2008; 16:608-613.

37. Vinanti GB, Rossato A, Scrimieri D. Arthroscopic transtendon repair of partial articular-sided supraspinatus tendon avulsion. Knee Surg sports Traumatol Arthrosc 2017; 25(7):2151-2156.

38. Waibl B, Buess E. Partial-thickness articular surface supraspinatus tears: a new transtendon technique. Arthroscopy 2005; 21(3):376-381.

39. Wang Y, Lu L, Lu Z, Xiao L, Kang Y, Wang Z. Arthroscopic transtendinous repair of articular-sided pasta injury. Int J Clin Exp Med 2015; 8(1):101-107.

40. Deutsch A. Arthroscopic repair of partial-thickness tears of the rotator cuff. J Should Elbow Surg 2007; 16:193-201.

41. Porat S, Nottage WM, Fouse MN. Repair of partial thickness rotator cuff tears: a retrospective review with minimum two-year follow up. J Shoulder Elbow Surg 2008; 17:729-731.

42. Denard PJ, Ladermann A, Burkhart SS. Prevention and management of stiffness after arthroscopic rotator cuff repair: systematic review and implications for rotator cuff healing. Arthroscopy 2011; 27(6):842-848.

43. Huberty DP, Schoolfield JD, Brady PC, Vadala AP, Arrigoni P, Burkhart SS. Incidence and treatment of postoperative stiffness following arthroscopic rotator cuff repair. Arthroscopy 2009; 25(8):880-890.

44. Carr A, Cooper C, Campbell MK, Rees J, Moser J, Beard DJ, Fitzpatrick R, Gray A, Dawson J, Murphy J, Bruhn H, Cooper D, Ramsay C. Effectiveness of open and arthroscopic rotator cuff repair (UKUFF): a randomised controlled trial. Bone Joint J 2017; 99-B(1):107-115.

45. Le BT, Wu XL, Lam PH, Murrell GA. Factors predicting rotator cuff retears: an analysis of 1000 consecutive rotator cuff repairs. Am J Sports Med 2014; 42(5):1134-1142.

Figure 1: Flow diagram of review process

Table 1: Search strategy for Medline

Table 2 – Summary of the comparative studies included

Table 3 – Summary of the transtendinous repair (TTR) case series

Table 4 – Summary of the tear completion and repair (TCR) case series

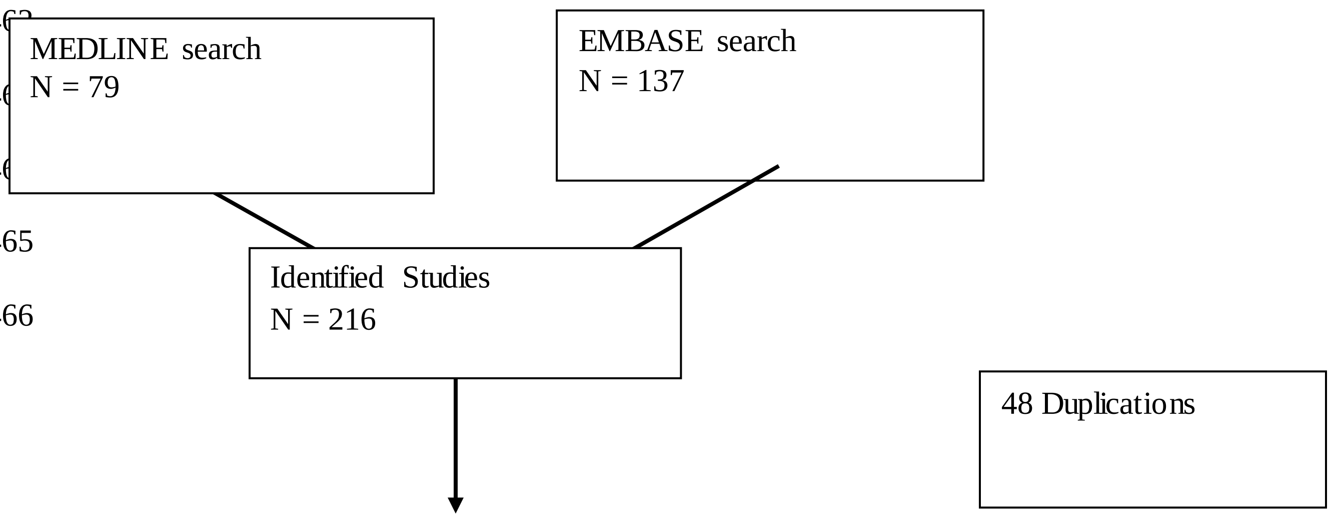
Table 5 – Summary of the re-tear rates after TTR and TCR

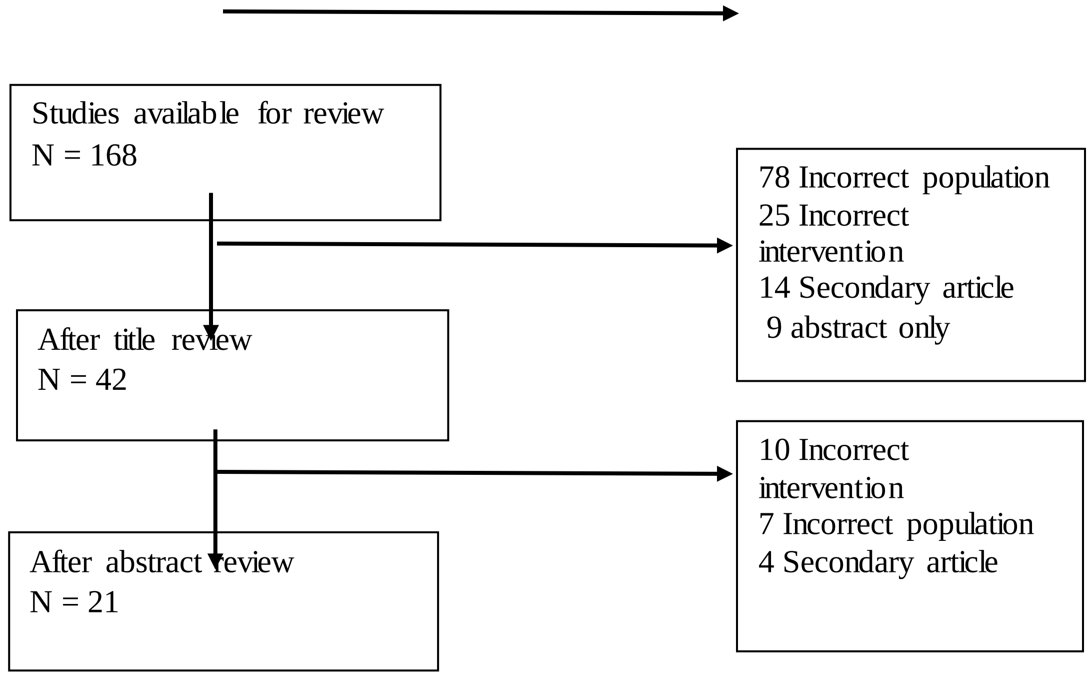
Table 6: GRADE assessment of outcome measures of interest

Table 7: Methodological items for non-randomized studies (MINORS) Scores for transtendinous repair case series

Table 8: Methodological items for non-randomized studies (MINORS) Score for tear completion and repair case series

Figure 1: Flow diagram of review process




Studies available for review
N = 168
78 Incorrect population
25 Incorrect intervention
14 Secondary article
9 abstract only
After title review
N = 42
10 Incorrect intervention
7 Incorrect population
4 Secondary article
After abstract review
N = 21