Biceps Autograft Augmentation for Rotator Cuff Repair

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Published in:
Arthroscopy

DOI:
10.1016/j.arthro.2017.10.044

Publication date:
2018

Systematic Review

Biceps Autograft Augmentation for Rotator Cuff Repair: A Systematic Review

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Purpose: To improve surgical outcomes in patients with massive cuff defects, different techniques and augmentations are proposed. The biceps tendon is easily available as an autograft. Our aim was to conduct a qualitative systematic review of various methods and surgical techniques that use a biceps autograft (BAG) for rotator cuff repair. Functional outcomes are also reported. We hypothesized that by using a BAG to treat massive rotator cuff tears, a more anatomic and biomechanical reconstruction could be achieved compared with other techniques. **Methods:** A qualitative systematic review was conducted (MEDLINE and Embase databases) to inventory surgical techniques for use of a BAG for rotator cuff repair. The following search terms were used for MEDLINE: biceps AND (augment* OR autograft* OR transplantation* OR (cuff AND graft*) OR biceps-incorporat*). Studies were included if the following criteria were fulfilled: description of surgical technique, only human subjects, functional outcomes noted, all study designs except technical notes, and no restrictions on study date. The quality of the studies was assessed in a standardized manner using a tool based on the Cochrane handbook. **Results:** We identified 981 studies; among these, 8 case series met the inclusion criteria. We identified 6 studies as high quality and 2 as medium quality. Different techniques for harvest and augmentation were used. Some studies left the proximal or distal portion intact, whereas others used it as a free graft. The clinical results of these studies showed significantly improved function, pain relief, and range of motion at follow-up, although this was not compared with a control group. The constructs were intact on magnetic resonance imaging in most patients (82%) within 2 years. **Conclusions:** It can be concluded that use of a BAG is an option for augmentation in massive rotator cuff tears, although no definitive recommendations can be given. This is based on Level IV medium- and high-quality studies. **Level of Evidence:** Level IV, systematic review of Level IV studies.

See commentary on page 1306

Massive cuff tears can be challenging to repair because of retraction, fatty infiltration, and defect size. In comparative studies, the mean outcomes of patient groups after rotator cuff repair were similar to those of patient groups in which conservative treatment was maintained.[1,2] Given that successful healing rates from 27% to 74% have been reported, the incidence of retears or incomplete healing is high.[3] Better outcomes are associated with successful restoration of the rotator cuff integrity compared with failed or incomplete healing of cuff repairs.[1]

Several techniques have been proposed to improve the outcome of cuff repairs, such as the use of anchors, in a single or double row; bone morphogenetic proteins (BMPs); platelet-rich plasma (PRP); scaffolds; and muscle transfers. All have shown inconsistent results.[4-9] Autografts can be used to replace or reinforce ruptured tendons. A method to treat rotator cuff deficiency is the use of the intra-articular portion of the biceps tendon for rotator cuff repair. This biceps autograft (BAG) technique has several advantages: It is available in most patients; because it is an autograft, there are no immune reactions; it is relatively easy to harvest during the same (arthroscopic) procedure; and it is rich in tenocytes and fibroblasts.[10]

Our aim was to conduct a qualitative systematic review of various methods and surgical techniques that use a BAG for rotator cuff repair. Functional outcomes are also reported. We hypothesized that by using a BAG to treat massive rotator cuff tears, a more anatomic and

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The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received April 30, 2017; accepted October 21, 2017.

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0749-8063/17593/$36.00

https://doi.org/10.1016/j.arthro.2017.10.044

biomechanical reconstruction could be achieved compared with other techniques.

Methods

Literature Search

We conducted a systematic search of the literature by using the online databases MEDLINE and Embase according to Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines.[11] For this study, we developed a systematic review protocol that was added to the PROSPERO database (No. 51299).

Study Selection

The following search terms were used for MEDLINE: biceps AND (augment* OR autograft* OR transplantation* OR (cuff AND graft*) OR biceps-incorporat*). For Embase, other search terms were used because different instructions are needed to achieve an optimal result: biceps* AND (augment* OR autograft* OR transplantation* OR (cuff* AND graft*) OR biceps NEAR/5 incorporat*). All publications had to meet the following general inclusion criteria for selection: publications about the use of a BAG for rotator cuff repair; description of surgical technique; only human subjects included (cadavers allowed); functional outcomes noted but not required; all study designs except technical notes; no restrictions on study date; and languages restricted to English, German, and Dutch because the authors are familiar with these languages.

Nonblinded standardized literature appraisal was conducted independently by 2 reviewers (E.J.D.V. and R.L.D.). All duplicates were removed after the literature searches. The abstracts and titles were scanned, and any disagreements between reviewers were resolved by consensus. The reference lists of all selected publications were manually checked to retrieve relevant publications that had not been found in the primary search. The reviewers independently checked the full texts of the remaining articles for eligibility.

Quality Assessment

A tool based on the Cochrane Collaboration handbook and further developed by the McMaster University School of Rehabilitation Science was used to assess reporting quality.[12,13] The quality assessment consists of 16 questions distributed into 9 categories that give an impression of the risk of bias: citation, study purpose, literature, design, sample, outcomes, intervention, results, and conclusions and implications. This method is considered appropriate to assess randomized controlled trials, cohort studies, single-case designs, before-and-after designs, case-control studies, cross-sectional studies, and case studies. Each quality item is answered yes, no, or "not applicable". Each item is also provided with supplementary information to substantiate the choices made.[14] In this study the citation and design categories were removed from the list because they are only descriptive and are already displayed in the characteristics, leaving 14 questions (Table 1). Two authors (E.J.D.V. and R.L.D.) independently assessed the included studies. In a consensus meeting any differences were resolved by discussion and settled by a third reviewer (M.S.). The maximum score obtainable was 14. An arbitrary grading score was created: Studies were regarded to be of high quality when the sum score was 8 or higher, regardless of study type.[23] Studies with a score between 5 and 7 were regarded to be of medium quality, and scores of 4 or lower identified low-quality studies.

Table 1. Quality Assessment Questions

Category	Question	Rating*
Study purpose	1. Was the purpose clearly stated?	+, −
Literature	2. Was the relevant background reviewed?	+, −
Sample	3. Was the sample described in detail?	+, −
	4. Was the sample size justified?	+, −, NA
Outcomes	5. Were the outcome measures reliable?	+, −, NA
	6. Were the outcome measures valid?	+, −, NA
Intervention	7. Was the intervention described in detail?	+, −, NA
	8. Was contamination avoided?	+, −, NA
	9. Was co-intervention avoided?	+, −, NA
Results	10. Were the results reported in terms of statistical significance?	+, −, NA
	11. Were the analysis methods appropriate?	+, −, NA
	12. Was clinical importance reported?	+, −
	13. Were dropouts reported?	+, −
Conclusions	14. Were conclusions appropriate, given study methods and results?	+, −

NA, not applicable.
*Variables were rated as positive or yes (plus sign), negative or no (minus sign), or NA.

Data Analysis

A general study analysis form was used to extract data. The surgical technique was analyzed by focusing on 2 aspects: the method of proximal harvest of the graft and the method of distal harvest and/or method of fixation. Descriptive data such as patient characteristics and functional outcome scores were displayed with means and, when possible, their standard deviations. The overall agreement in the quality assessment between the 2 reviewers was calculated with a weighted Cohen κ coefficient.

Results

Study Selection

The search strategy identified 981 potentially eligible citations (398 in MEDLINE and 583 in Embase). After removal of duplicates, a total of 588 titles were screened for eligibility (as detailed in the flowchart shown in Fig 1). After screening, 48 abstracts were analyzed; of these, 19 seemed suitable, and their full texts were reviewed for

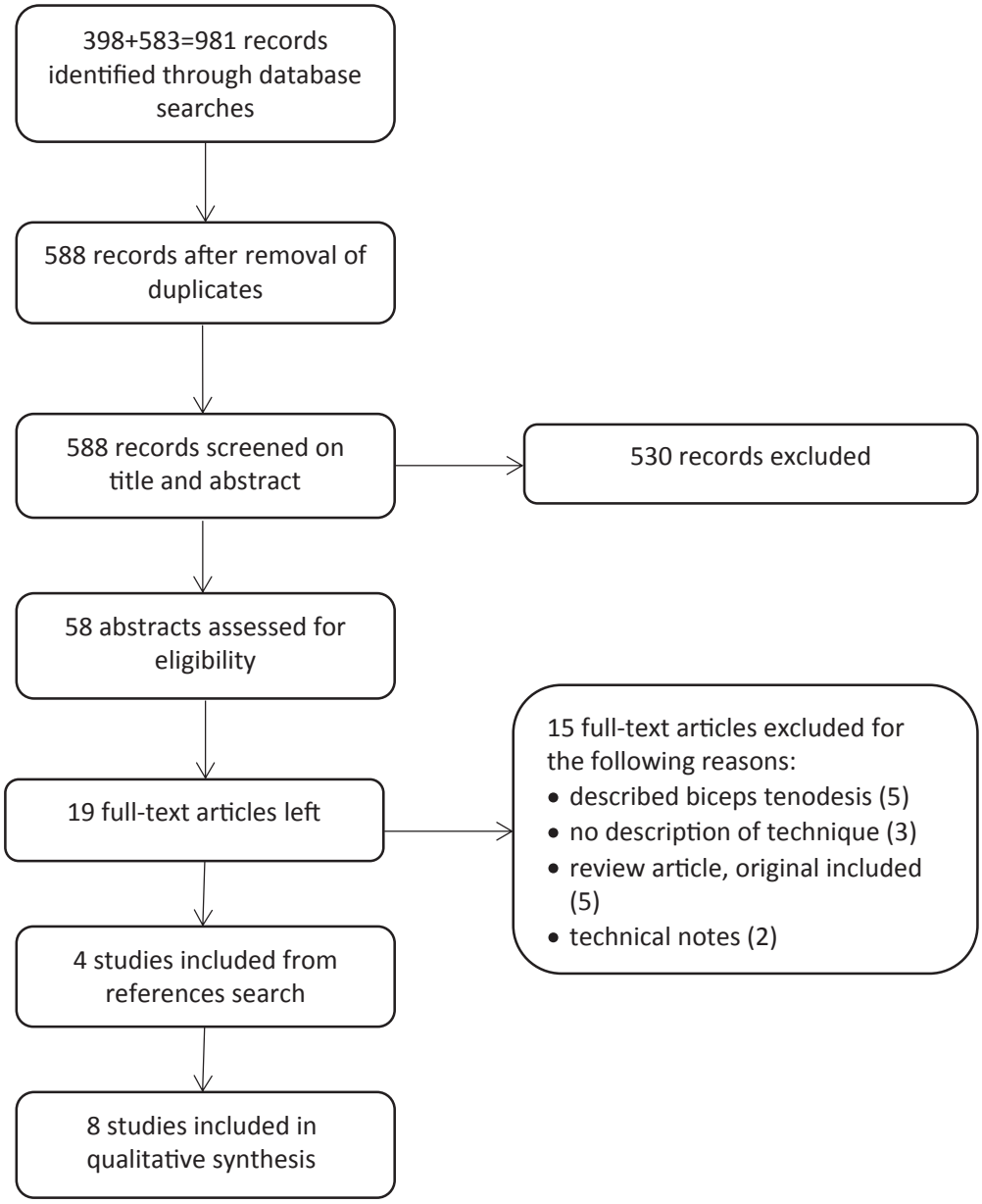

Fig 1. Flowchart of data selection.

eligibility. Two studies used a BAG technique but had technical notes, so they were excluded.[24,25] Eventually, 8 studies met all the criteria and were included.[15-22] Because of incomplete data, no meta-analysis could be conducted. When the search was repeated on June 23, 2016, no additional publications of interest were found.

Methodologic Quality

All 8 studies were case series. Two studies had partial overlap of the patient population but were reviewed separately.[19,20] The overlap accounted for a maximum of 16 patients treated arthroscopically in the study of Rhee et al.,[19] who were also part of a group of 37 arthroscopically treated patients in the study of Cho et al.[20] The overall agreement between the 2 reviewers for the 14 items applied to the 8 publications was considered fair (weighted Cohen κ coefficient, 0.346 ± 0.058 [standard error]). Disagreements arose mainly for items 8, 9, 10, 11, and 14. All of these were resolved after the consensus meeting. The percentages of the maximum attainable score ranged from 38% to 86%. A total of 6 studies were considered high quality,[17-22] and 2 studies were categorized as medium quality.[15,16] The outcome of the methodologic quality assessment of the studies is presented in Table 2.

Study Characteristics

Table 3 shows the characteristics of the studies. The total number of patients was 170, with the mean age ranging from 55 to 64 years. The first study to describe a surgical technique using the biceps tendon for rotator cuff repair was published in 1974.[16] The largest case series consisted of 37 patients.[20] In half of the studies,

Table 2. Quality Assessment

Study	Item 1 (Study Purpose)	Item 2 (Literature)	Item 3 (Sample)	Item 4 (Sample)	Item 5 (Outcomes)	Item 6 (Outcomes)	Item 7 (Intervention)	Item 8 (Intervention)	Item 9 (Intervention)	Item 10 (Results)	Item 11 (Results)	Item 12 (Results)	Item 13 (Results)	Item 14 (Conclusions)	Total Score	%
Neviaser,[15] 1971	+	−	+	−	−	−	+	NA	+	NA	−	+	−	+	6	50
Wolfgang,[16] 1974	−	+	+	−	−	−	+	NA	−	−	−	+	−	+	5	38
Guven et al.,[17] 2001	+	−	+	−	+	+	+	NA	+	−	−	+	−	+	8	62
Pavlidis et al.,[18] 2003	+	+	+	−	+	+	+	NA	+	−	−	+	−	+	9	69
Rhee et al.,[19] 2008	+	+	+	−	+	+	+	+	+	+	+	+	−	+	12	86
Cho et al.,[20] 2009	+	+	+	−	+	+	+	+	+	+	+	+	−	+	12	86
Sano et al.,[21] 2010	+	+	+	−	+	+	+	NA	+	+	+	+	−	+	11	85
Ji et al.,[22] 2014	+	+	+	−	+	+	+	+	+	+	+	+	−	+	12	86

NOTE. Every question could be answered yes (plus sign) or no (minus sign). Some questions were not applicable and therefore were answered NA; these are excluded in the total score. The rightmost columns depict the total scores and percentages of maximum attainable scores.

NA, not applicable.

Table 3. Studies Included

Study	Design	Level of Evidence	No. of Patients	Mean Age, yr	FU (months), range or mean	Open vs Arthroscopy	Defect Size	Acromioplasty	Biceps Harvest Technique	
									Insertion	Groove
Neviaser,[15] 1971	Case series	IV	10	55	4-30	Open	NN	NN	Tenotomy	Tenodesis*
Wolfgang,[16] 1974	Case series	IV	14	55	9.8	Open	NN	When indicated	Intact	Tenotomy
Guven et al.,[17] 2001	Case series	IV	14	60	40.7	Open	NN	Yes	Intact	Tenodesis*
Pavlidis et al.,[18] 2003	Case series	IV	15	55	23	Open	NN	NN	Tenotomy	Tenodesis*
Rhee et al.,[19] 2008	Case series	IV	31	59	16	Arthroscopy in 16 and open in 15	>5 cm	When indicated	Tenotomy	Intact
Cho et al.,[20] 2009	Case series	IV	37	60	21	Arthroscopy	>5 cm	When indicated	Tenotomy	Intact
Sano et al.,[21] 2010	Case series	IV	14	64	28	Open	>5 cm	Yes	Tenotomy	Tenodesis*
Ji et al.,[22] 2014	Case series	IV	35	62	24	Arthroscopy	>3 cm	Yes	Intact	Intact

FU, follow-up; NN, not noted.
*The biceps tendon was tenotomized at the insertion of the glenoid, and the humeral part of the tendon was fixated.

an open cuff repair was performed; in the other half, the procedure was arthroscopic. All studies mentioned "massive cuff tears," but only 3 defined these by identifying tears of at least 3 or 5 cm.[19,20,22] The mean follow-up period ranged from 9.8 to 40.7 months.

Surgical Techniques

The biceps tendon was used for augmentation in both open and arthroscopic procedures. In 3 studies, the proximal insertion was left intact,[16,17,22] whereas in another 3 studies, the distal portion was left intact.[19,20,22] A tenodesis of the distal portion of the intra-articular part of the biceps tendon was performed in 4 studies,[15,17,18,21] and a free graft (cut at both ends) was used in 3 studies.[15,18,21] The tendon was weaved, was used as an onlay, was fixed in a longitudinal way, was first fixed to the cuff or first to the footprint, and was sometimes described as "attached tension-free." In some studies the tendon was split longitudinally before being used.[17,21] Standard acromioplasty was performed in 3 studies,[15,16,22] and in 2 others, it was performed when indicated.[16,20] There was no mention of any intervention on the acromion in the remaining studies.

Functional Outcome

In 7 of the 8 clinical studies, a functional outcome score was used, albeit without the use of a standard outcome score in any of the studies (Tables 4 and 5). The Constant-Murley score (CMS) was used in 4 studies[17-20]; the University of California, Los Angeles score was used in 3 studies.[19,20,22] The Simple Shoulder Test, American Shoulder and Elbow Surgeons score, and Japanese Orthopaedic Association shoulder score were each used in 1 study. Differences between scores before and after the intervention are presented in Table 4, and all studies using an outcome score showed significant improvement. One study noted an improvement but did not mention the outcome score. When measuring function, 6 studies showed a significant increase in the range of motion (Table 5). In 5 studies, patients reported a significant decrease in pain on a visual analog scale[17,19-22]; in the other 3, it was not noted.[15,16,18]

Radiologic Outcome

A total of 112 magnetic resonance imaging (MRI) scans were performed in 5 studies (Table 6)[18-22]: 68 showed intact graft constructs (61%); 23 showed thinning, granulation tissue, or partial tears (21%); and 21 showed retorn graft constructs (19%). Two studies reported the time between surgery and MRI as ranging from 12 to 51 months.

Discussion

The results of using biceps tendon autografts in reconstruction of rotator cuff tears are comparable with those of studies using artificial grafts such as non–cross-

Table 4. Clinical Outcome Scores

Study	Clinical Score	Before	Range	SD	After	Range	SD
Neviaser,[15] 1971	—	—	—	—	Improved	—	—
Wolfgang,[16] 1974	—	—	—	—	Not noted	—	—
Guven et al.,[17] 2001	CMS	46.7	—	2.526	75.35	—	4.129
Pavlidis et al.,[18] 2003	CMS	—	—	—	82.7	—	—
Rhee et al.,[19] 2008	CMS	48.4	8-70	—	81.8	37-96	—
	UCLA	12.5	6-19	—	31.1	9-35	—
	SST	4.2	1-8	—	10.2	8-12	—
Cho et al.,[20] 2009	CMS	38.5	—	—	82.6	69-95	—
	UCLA	14.1	6-12	—	32.6	22-35	—
Sano et al.,[21] 2010	JOA	54.7	—	9.3	83.1	—	7.5
Ji et al.,[22] 2014	UCLA	18.4	—	4.4	31.3	—	2.5
	SST	6.2	—	2.4	9.0	—	9.6
	ASES	52.4	—	16.7	86.6	—	6.7

ASES, American Shoulder and Elbow Surgeons score; CMS, Constant-Murley score; JOA, Japanese Orthopaedic Association shoulder score; SD, standard deviation; SST, Simple Shoulder Test; UCLA, University of California, Los Angeles score.

linked human dermis scaffolds. Eight case series could be found, and the total number of patients was 170, with the mean age ranging from 55 to 64 years. The summary of the quality-analysis questions ranged from 38% to 86% as a percentage of the maximum attainable score; 6 studies were considered high quality and 2 were medium quality. Each study used a different technique, and both open and arthroscopic procedures were performed. All showed improvement in different functional scores, and the authors of the studies considered this improvement clinically relevant. As for the studies using the CMS, all scores improved by more than 10.4 points, which is considered a threshold for the minimal clinically important difference.[26] For the other outcome scores used, no minimal clinically important difference has been described, so any conclusions should be interpreted with caution. Of the 8 studies, 3 did not mention any effect on pain. In 5 studies follow-up was performed using MRI, showing 81% fully or partially intact cuffs. All proposed techniques are augmentations for supporting the biomechanical forces, and they seem less suitable for tissue bridging—this is in contrast to other graft techniques.

Different techniques have been proposed to improve the results of cuff repairs, such as the use of anchors for better bone fixation, in a single or double row, thereby theoretically offering better fixation and biomechanics. There has also been a focus on the biological processes of tendon healing by promoting intrinsic repair with stimulation of the ingrowth using BMPs, PRP, and other growth factors.[4-6] The use of BMPs in in vivo experiments has shown promising results, although a recent

Table 5. Range of Motion

	Forward Flexion, °		External Rotation , °		Abduction, °		Internal Rotation		
Study	Before	After	Before	After	Before	After	Before	After	Improvement
Neviaser,[15] 1971	—	—	—	—	145	152	—	—	Improved
Wolfgang,[16] 1974	—	—	—	—	—	—	—	—	Not noted
Guven et al.,[17] 2001	47.5	142.8	13.2	51.1	—	—	—	T12	Significant improvement
Pavlidis et al.,[18] 2003	—	—	—	—	—	—	—	—	Not noted
Rhee et al.,[19] 2008	126	162	38	47	134	168	L1	T10	Significant improvement
Cho et al.,[20] 2009	131.6	156.2	36.8	47, 0	140	162	T12	T11	Significant improvement
Sano et al.,[21] 2010	—	—	—	—	—	—	—	—	Significant improvement
Ji et al.,[22] 2014	146.2 ± 19.3	161.8 ± 16.8	37.4 ± 25.1	67.3 ± 21.8	142.8 ± 24.1	162.6 ± 18.3	L1 (buttock-T7)	T12 (buttock-T7)	Significant improvement

NOTE. Data are presented as mean or mean ± standard deviation.

Table 6. MRI Evaluation

Study	Cuff Integrity	Timing of MRI
Neviaser,[15] 1971	—	—
Wolfgang,[16] 1974	—	—
Guven et al.,[17] 2001	—	—
Pavlidis et al.,[18] 2003	10 intact, 4 thinning, 1 retear	Not noted
Rhee et al.,[19] 2008	9 intact, 2 partial retear, 3 retear	Not noted
Cho et al.,[20] 2009	14 intact, 10 retear	Mean, 15 mo
Sano et al.,[21] 2010	13 intact, 10 thinning, 1 retear	Not noted
Ji et al.,[22] 2014	22 intact, 7 partial retear, 6 retear	Range, 12-51 mo

MRI, magnetic resonance imaging.

meta-analysis of the use of PRP after arthroscopic cuff repair showed no benefit.[4-6] Another technique, augmentation with synthetic or acellular human- or animal-based scaffolds, is based on principles of offering biological ingrowth of tenocytes and better biomechanics, although it does not always stimulate cell ingrowth and can be costly. Results are still inconsistent when compared with traditional cuff repair.[7-9] One study consisting of 16 patients with a massive rotator cuff tear size (>5 cm and/or 2 tendons involved) treated with a GraftJacket allograft (Wright Medical Technology, Arlington, TN) showed an improvement from 18.4 to 30.4 in the University of California, Los Angeles score and from 53.8 to 84.0 in the CMS after a mean follow-up period of 27 months.[27] This compares quite nicely with the scores of the different studies in our review (Table 4). In a randomized controlled trial using a GraftJacket allograft, MRI scans were obtained after 1 to 2 years' follow-up, showing 85% intact repairs in the augmented group and 40% in the non-augmented group.[28] It should be noted that with this scaffold, a larger gap can be bridged because it is available with dimensions of up to 4 × 7 cm. Superior capsule reconstruction is another technique for the treatment of massive rotator cuff tears; it emphasizes covering the humeral head.[29] This is in contrast to the technique of using the BAG as a scaffold or bridge for cuff repair.

Series reporting on the use of a non−cross-linked scaffold made of porcine small intestinal submucosa (Restore, DePuy) showed a severe, sterile postoperative inflammatory reaction in 20% to 30% of patients. One of these trials was aborted for this reason.[30] A study by Encalada-Diaz et al.[31] evaluated the use of the synthetic scaffold Biomerix RCR Patch (polycarbonate polyurethane) as an augmentation device in 10 patients and reported a 10% failure rate on MRI. Because the scaffold was used in small- to medium-sized tears in their study, it is not comparable. Use of the BAG has also been described for revision rotator cuff tears, showing good results in 10 patients.[32]

The incidence of rotator cuff tears increases with age. Up to 62% of patients aged 80 years or older show symptomatic or nonsymptomatic tears.[33] Patients with symptomatic rotator cuff tears present with pain, decreased range of motion, and limitations in daily life. After failed conservative therapy, surgical repair is an option.[1] Rotator cuff tears can occur as part of degenerative cuff disease in middle-aged or older patients and as a result of lower tendon quality.[33] In some patients with rotator cuff tears, the biceps tendon is also degenerated; hence not all patients are eligible for the technique. Use of a hamstring autograft (semitendinosus and/or gracilis muscle) can be an option.[34]

This surgical technique of using the biceps tendon as augmentation can be an option for patients with shoulder dysfunction and pain resulting from a massive rotator cuff tear when other surgical repairs do not seem suitable. The technique uses no artificial augmentation, so it is comparatively less costly than other techniques; however, the results can be influenced by the different techniques that are used. Some studies left the proximal or distal portion intact, whereas others used it as a free graft. Several of the studies in this review used the BAG for treatment of massive cuff tears, which are defined as 2- or 3-tendon tears of the cuff that can be challenging to treat.[35] These tears can be retracted and cannot be mobilized to be reconstructed up to the original footprint. A muscle transfer such as latissimus dorsi muscle transfer can be an option, although the results are unpredictable; a more anatomic repair is preferred.[36]

It is recommended that medium- and long-term results be collected in studies with a prospective design. Studies should also be powered sufficiently to assess the relevance of any improvement in clinical results. Patient-reported outcome scores can be of added value in studies such as these, given that the scores in this review are mainly functional. It would also be interesting to have some histologic samples to see if the tenocytes really incorporate or scar tissue remains. Although the studies have varying levels of evidence, the clinical and radiologic results are comparable with the literature on other scaffolds.

Limitations

This study should be interpreted cautiously because rotator cuff tears of different sizes are included and this may influence outcomes. In addition, the biceps tendon is known for being a source of pain; therefore, a biceps tenotomy itself may already lead to pain reduction.[37] Another limitation of this systematic review is the heterogeneity of the study population. Because of the type of study, only a general tool to assess the quality and, consequently, the risk of bias could be used. Publication bias may also be present. Finally, the statements about the BAG are based on case series, that

is, studies without control groups. No recommendations could be provided based on the current evidence.

Conclusions

It can be concluded that use of a BAG is an option for augmentation in massive rotator cuff tears, although no definitive recommendations can be given. This is based on Level IV medium- and high-quality studies.

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