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Surgical outcomes and complications following distal biceps tendon reconstruction: a systematic review and meta-analysis

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Background: Primary repair of chronic distal biceps tendon ruptures may not be possible because of tendon retraction, and there remains no clear consensus on the type of reconstruction technique used. The purpose of this study was to report the clinical outcomes and complication rates following reconstruction of chronic distal biceps tendon ruptures.

Methods: A systematic review was performed following PRISMA guidelines. The following databases were searched: Embase, MEDLINE, and Cochrane Central Register of Controlled Trials. The primary outcomes of interest included range of motion, strength, and functional outcome scores. Secondary outcomes included complication, reoperation, and revision rates. Outcomes and complication rates of each graft type and fixation technique were aggregated and compared with nonparametric Wilcoxon signed rank and rank sum tests. Spearman rank coefficients were calculated for time from injury to surgery on all outcomes.

Results: There were no significant differences found between the graft type or fixation technique for postoperative range of motion, strength, and patient-reported outcomes. Postoperative complications were substantially higher in the autograft group (34%) as compared to the allograft group (14%). The fixation technique used also demonstrated a significantly increased complication rate in the weave group compared with the onlay group (34% and 9%, respectively).

Conclusion: Our results do not reveal any statistically significant differences between groups in the primary outcomes. However, substantially higher complication rates were observed in the autograft and weave cohorts; more than half of the complications related to the use of autograft were associated with donor site morbidity. No specific graft type was identified as superior, although this may be due to the small patient numbers included within this study.

Distal biceps tendon ruptures occur most often in men in their fourth to sixth decades of life and may be more prevalent than once thought.[32] Treatment of acute injuries has been well defined, with evidence supporting primary repair as the gold standard.[32] Chronic, untreated ruptures are associated with pain, muscle cramping, and significant loss of elbow flexion and supination strength and endurance.[6,10,13,22,25,26,29,37] Several studies have demonstrated a decrease in flexion strength and endurance up to 36% and 62%, respectively, and a decrease in supination strength and endurance up to 55% and 86%, respectively.[23] This patient cohort often reports low patient-reported outcome scores, including the Mayo Elbow Performance Score and the Disabilities of the Arm, Shoulder, and Hand (DASH) score.

In the chronic setting, several surgical options have been described in the literature. Primary repair is still possible for some patients[24]; however, in cases of severe tendon retraction, direct repair is not possible. Tenodesis of the distal biceps tendon to the brachialis has proven to reliably decrease pain; however, this method of treatment fails to restore muscle strength or endurance associated with the injury.[15,17,23]

In recent years, reconstruction options have been developed for chronic, irreparable tendon ruptures. Several authors have published on a variety of reconstruction techniques that use a host of tendon graft tissues such as the tibialis anterior, gracilis, semitendinosus, Achilles, flexor carpi radialis, and the lacertus fibrosis.[5,10,11,15,18,20,25,26,37] In addition to the type of graft used,

Institutional Review Board approval was not required for this systematic review.

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several methods have been described for fixation between the graft tissue and native biceps tendon including end-to-end, Pulvertaft weave, and onlay techniques. The results of such reconstruction techniques are promising, with improvement in supination and flexion strength and endurance.[26]

The purpose of this study was to report the clinical outcomes and complication rates after distal biceps tendon reconstruction stratified according to graft source and fixation technique by means of a systematic review. We hypothesized that surgical outcomes would be better in the autograft group and that there would be no difference in outcomes between weave and onlay fixation techniques. Lastly, we hypothesized that surgical outcomes would be lower and complication rates higher as the time interval from injury to surgery increased.

Methods

Search strategy and selection criteria

A systematic review of the literature was performed following the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.[21] The search for studies up until January 2020 was conducted using 4 electronic databases: Embase, MEDLINE, PubMed, and Cochrane Central Register of Controlled Trials. The search terms used included *distal biceps*, *reconstruction*, *allograft*, *autograft*, *outcomes*, and *complications*. Studies were included if they met the following criteria: (1) English language or available for translation; (2) primary reconstruction cases; and (3) reporting of at least 1 primary outcome of interest. When a study included pooled or incomplete data, all authors with available correspondence information were contacted. Consequently, the study was included if the full study data were available and met our inclusion criteria. If a study described a cohort of patients who met the study criteria and other patients who did not, the study was included and only the data for the patients who met our entry criteria were extracted. Studies were excluded if they met the following criteria: (1) primary distal biceps repair studies; (2) revision reconstruction cases; (3) insufficient reconstruction surgery details; (4) pooled or combined data (ie, primary and reconstruction) that could not be stratified; (5) reviews and technique articles without clinical data; and (6) conference abstracts and expert-opinion articles. Studies were initially screened by title and abstract, and if a study appeared to fit the established criteria, the full-text article was obtained for full review. If the abstract of a study was not available, the full article was reviewed. Reference lists of identified articles were also reviewed, and all relevant studies were included. All included studies underwent a final review by 2 investigators (M.L. and J.P.); disagreements during this stage were resolved by a third author (A.J.B.).

Data extraction

Patient demographic characteristics, hand dominance, time from injury to surgery, and duration of follow-up were recorded. Intraoperative data including surgical approach, graft source, and graft fixation technique were documented. The primary outcome data obtained included (1) preoperative and postoperative active range of motion (ROM) including flexion, extension, supination, and pronation; (2) strength; and (3) patient-reported outcome measures including the Mayo Elbow Performance Score, Oxford Elbow Score, DASH, quickDASH (qDASH), and visual analog scale for pain. The secondary outcome data recorded included (1) complications, (2) reoperations/revisions, and (3) radiographic outcomes if available (eg, heterotopic ossification). A complication was defined as any intraoperative or postoperative event that was likely to have a negative influence on the patients' outcome. A reoperation was defined as a return to the operating room for any reason relating to the elbow, whereas revision procedures were defined as a revision reconstruction or repair of a previous reconstruction. All primary and secondary outcome data were stratified according to the graft source used (autograft vs. allograft), as well as by graft fixation technique (weave vs. onlay).

Statistical analysis

Descriptive representation of the data included mean and standard deviation for continuous data and rates for categorical data. Primary and secondary outcome data were compared within groups (graft source; fixation technique). Comparisons of group data were performed with nonparametric Wilcoxon signed rank and rank sum tests whereas exact χ^2 tests were used for categorical data. Spearman rank coefficients were calculated for time from injury to surgery and all primary and secondary outcome measures. $P < .05$ was considered statistically significant. All analyses were performed using SAS, version 9.4 (SAS Institute, Cary, NC, USA) software.

Results

Study selection

The initial database search yielded 168 studies; 72 studies remained after duplicates were removed. Of these, 39 studies were excluded after abstract screening. Thirty-three full-text manuscripts were assessed for eligibility. Twelve articles were excluded after manuscript screening, and 3 were included after reviewing the reference lists of included studies. Overall, 24 studies (157 elbows) met the inclusion and exclusion criteria (Fig. 1). Of these, 16 of the included studies utilized autograft and 8 allograft tissue for tendon reconstruction; 12 used a weave fixation technique, 10 used onlay, 1 study reported on both weave and onlay, and 1 study used an “end-to-end” technique. The single study using an end-to-end technique also used autograft tendon in their study and as such, the results were included for analysis of graft source but were not assessed for the fixation technique

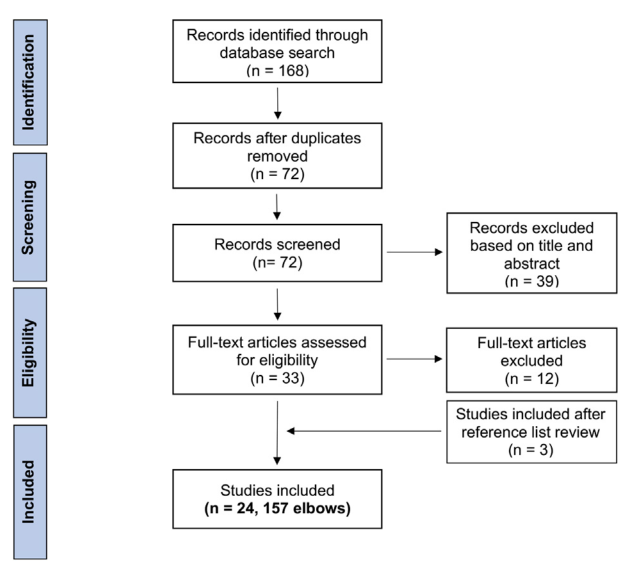

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram presenting the systematic review process used in this study.

Table I
Characteristics of included studies

Reconstruction	Study	Year	Country	Study design	LOE	Elbows, n	Graft source	Age, yr	FU, mo
Autograft (weave)	Hang et al[11]	1996	USA	Case report	IV	1	ST	54	12
	Gentlemen et al[9]	2004	Germany	Case report	IV	1	TFL	39	39
	Hallam et al[10]	2004	AUS	Case series	IV	9	ST	47	—
	Ryhanen et al[28]	2006	Finland	Case series	IV	2	TFL	41	31
	Wiley et al[37]	2006	USA	Retrospective cohort	III	7	ST	49	63
	Vastamaki et al[36]	2008	Finland	Case series	IV	14	Plantaris (7), toe extensors (6), PL (1)	44.8	133.2
	McCarty et al[19]	2008	USA	Case report	IV	1	ST	—	12
	Morrell et al[22]	2012	USA	Case series	IV	12	TFL	42	14.5
	Blond et al[2]	2015	Denmark	Case report	IV	1	ST	47	14
	Ribeiro et al[27]	2018	Brazil	Case series	IV	4	ST	37.8	15
	Frank et al[8]	2019	Canada	Retrospective cohort	III	19	ST	46	45
Autograft (onlay)	Kaplan et al[15]	2002	USA	Case series	IV	3	TFL	40	57.7
	Junior et al[13]	2012	Brazil	Case series	IV	4	ST	51	—
	Blond et al[2]	2015	Denmark	Case report	IV	1	Quadriceps	47	14
	Caputo et al[4]	2016	USA	Case series	IV	12	Lacertus fibrosis	46.2	20
	Storti et al[33]	2017	Brazil	Case report	IV	1	Triceps	51	6
	Tsekes et al[35]	2017	UK	Case report	IV	1	Lacertus fibrosis	33	6
Allograft (weave)	Darlis et al[6]	2006	USA	Case series	IV	7	Achilles	38	29
	Phadnis et al[26]	2016	UK	Case series	IV	21	Achilles	44	15
Allograft (onlay)	Sanchez et al[29]	2002	USA	Case series	IV	4	Achilles	39	28.5
	Patterson et al[25]	2009	USA	Case report	IV	1	Achilles	41	5.5
	Snir et al[30]	2013	USA	Case series	IV	18	Achilles (15), ST (1), gracilis (1), tibialis anterior (1)	46.9	21
	Cross et al[5]	2014	USA	Case series	IV	7	Tibialis anterior	44	16
	Burrus et al[3]	2015	USA	Case report	IV	1	Achilles	45	12
Autograft (end-to-end)	Levy et al[18]	2000	USA	Case series	IV	5	FCR	41	34

LOE, level of evidence; *FU*, follow-up; *ST*, semitendinosis; *TFL*, tensor fascia lata; *PL*, palmaris longus; *FCR*, flexor carpi radialis; *AUS*, Australia; *UK*, United Kingdom; *USA*, United States of America.

analysis given the small number of patients for comparison (n = 5). Overall, 157 elbows were included for analysis of graft source (autograft vs. allograft), and 152 elbows were assessed by graft fixation technique (weave vs. onlay). Twenty-two of the included studies consisted of Level IV evidence (ie, retrospective case series and case reports) and 2 studies were of Level III evidence (ie, retrospective comparative design studies) (Table I).

Study characteristics

The study group included exclusively male patients, with the exception of 20 patients where the authors did not report sex. The mean age at the time of reconstruction surgery was 43.8 years (range, 20-68 years). Of the studies reporting hand dominance, 59% (n = 92) of surgeries were undertaken on the dominant arm. The mean follow-up duration was 29.5 months (range, 1-267 months). The mean time from injury to reconstructive surgery was 21.4 months (range, 1-156 months) (Table I). There were no statistically significant differences for baseline characteristics, including age, sex, hand dominance, follow-up duration, or time between injury to surgery among the treatment groups stratified by graft source or by fixation technique.

Of the 157 elbows, 62.4% (n = 98) underwent reconstruction using autograft (semitendinosus, tensor fascia lata, lacertus fibrosis, quadriceps tendon, flexor carpi radialis), whereas the remaining 37.6% (n = 59) were reconstructed with allograft tissue (Achilles tendon, tibialis anterior, tensor fascia lata, palmaris longus, and semitendinosus). A total of 99 patients (63%) had their graft fixed in a "weave" technique (n = 71, autograft; n = 28, allograft), 53 patients (34%) used an "onlay" technique (n = 22, autograft; n = 31, allograft), and the remaining 5 patients (3%) underwent a direct end-to-end tendon reconstruction using autograft tissue (ie, flexor carpi radialis) (Table I).

Surgical details

All authors describe carefully identifying and protecting the lateral antebrachial cutaneous nerve (LABCN) during the surgical approach and protecting the posterior interosseous nerve with arm position. Similarly, authors of the included studies emphasized performing release of adhesions between the biceps and brachialis muscle and along the subcutaneous surface of the biceps muscle to permit restoration of the excursion of the muscle and maximize tendon length. There was variability between studies regarding the technique used for distal attachment of the graft tissue to the radial tuberosity. There was no agreement between studies in terms of elbow position (ie, degree of elbow flexion), which ranged from 45-90 degrees of flexion during graft tensioning.

Weave technique

Similar to the Pulvertaft weave method, the weave technique dictates that the graft physically passes through the remaining autologous muscle and tendon stump at least twice; different weaving configurations have been described (Fig. 2, *A*). The graft is joined to the patient's residual tendon end if present, and/or the distal muscle belly by corner stitches at each site where the graft passes through the native muscle-tendon tissue. Lastly, the graft is sutured to itself to reinforce the reconstruction (Fig. 2, *B*).

Onlay technique

After the allograft tendon is secured to the radial tuberosity, the elbow is placed in 60°-90° of flexion (dependent on distal excursion of native biceps muscle) and the forearm in supination. While distal tension is placed on the biceps tendon and moderate tension on the graft tissue, a no. 5 nonabsorbable suture is placed through the graft and residual biceps tendon (ie, "key stitch") (Fig. 3, *A*).

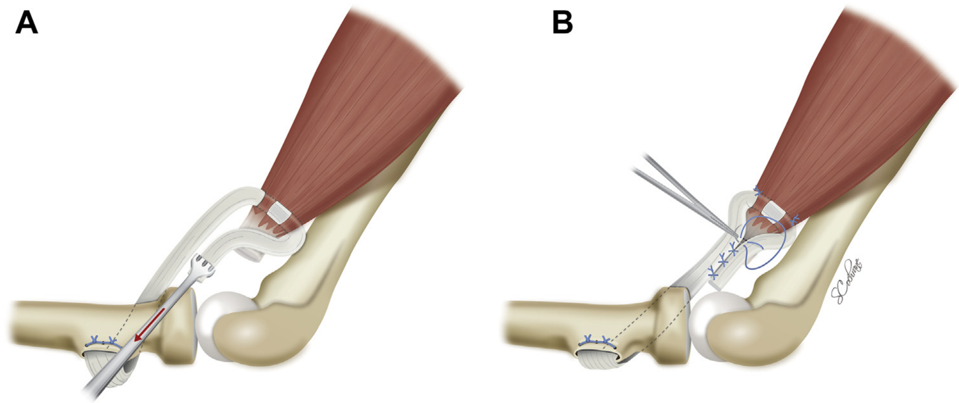

Figure 2 Weave technique. (**A**) The tendon graft is weaved through the residual biceps muscle belly just proximal to the muscle-tendon junction. (**B**) The tendon graft is secured to the residual biceps tendon and the construct is further reinforced by suturing the limbs of the graft to itself and by placement of sutures at the site where the graft passes through the biceps muscle.

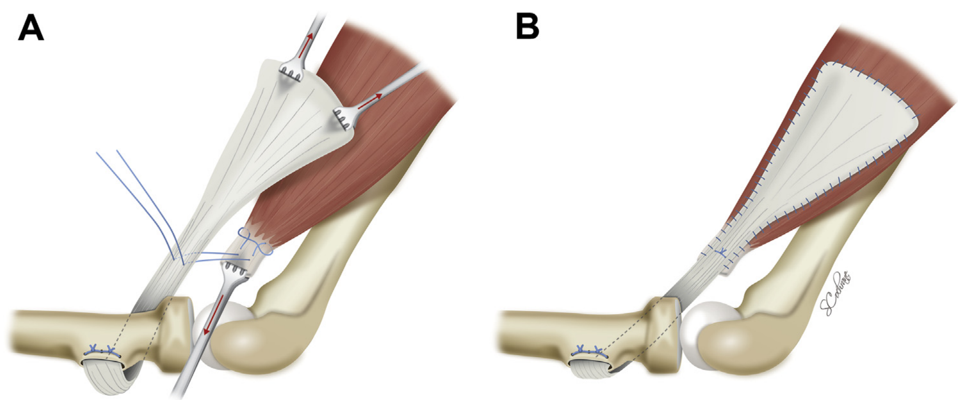

Figure 3 Onlay technique. (**A**) While placing distal tension on the biceps tendon and moderate tension on the graft tissue, a no. 5 nonabsorbable suture is placed through the graft and residual biceps tendon (ie, "key stitch"). (**B**) The proximal part of the graft is then draped over the host biceps muscle and tendon stump and secured with a running locked no. 1 nonabsorbable suture. (Adapted from Sanchez-Sotelo J, Morrey BF, Adams RA, O'Driscoll SW. Reconstruction of chronic ruptures of the distal biceps tendon with use of an Achilles tendon allograft. J Bone Joint Surg Am 2002;84:999-1005.)

The proximal part of the graft is then draped over the host biceps muscle and tendon stump and secured with a running locked no. 1 nonabsorbable suture placed in the aponeurosis. The reconstruction is reinforced with additional "key stitches" and interrupted sutures as necessary (Fig. 3, *B*).[29]

Primary outcomes

Analysis performed within each category of reconstruction for ROM, strength (ie, supination and flexion isometric and isokinetic strength), and PROMs revealed that all treatment groups improved postoperatively; however, there was no significant difference in any outcome variable analyzed between graft sources (autograft vs. allograft) or graft fixation techniques (weave vs. onlay) (Table II). Of note, there was considerable variability in the primary outcomes reported in the included studies. In addition, most of the primary outcomes reflect reporting in less than 40% of the total number of elbows included in the analysis (ie, fewer than 60 elbows of the 157 included from the 24 studies) (Table II).

The reported ROM outcomes in each reconstruction group closely represents the norms found in the general population (Table II).[31] Elbow flexion values demonstrated the largest deviation, with postoperative flexion reported in this study (range, 137.5°-139.8°) slightly lower than those reported by Soucie et al[31] (range, 143.5°-144.6°). Elbow extension (range, 0.8°-1.8°), forearm supination (range, 79.9°-82.8°), and forearm pronation (range, 78.8°-81.5°) were all similar to previously published normative data.[31] Similar trends of improvement were observed in postoperative isometric elbow strength (elbow flexion, 5 $\pm$ 0; forearm supination, 5 $\pm$ 0) as assessed using the Medical Research Council grading system (muscle grading from 0-5) and in isokinetic flexion strength (range, 82.7-84) and supination strength (range, 85.2-89.3) assessed as a percentage of the contralateral (ie, uninjured) arm. Lastly, the top reported PROMs demonstrated improved postoperative scores including the DASH (range, 4.7-11.3), Mayo Elbow Performance Score (range, 93.1-96.4), and the Oxford Elbow Score (range, 43.5-44.7) (Table II).

Spearman rank correlation did not reveal any statistical significance between time from injury to surgery and ROM, strength testing, or PROMs.

Secondary outcomes

Of the 24 studies included, 17 (71%) reported complication data. Based on this data, the overall complication rate for all patients who underwent distal biceps tendon reconstruction was 25.9% (37 of 143 cases). Complications were subcategorized with individual and total complication rates calculated among all groups (Table III).

Table II
Primary outcomes: postoperative range of motion, strength, and patient-reported outcome measures

Outcome	Autograft	Allograft	*P* value	Weave	Onlay	*P* value
Range of motion						
Extension	0.8 ± 1.6 (42)	1.6 ± 2.0 (27)	.67	1.8 ± 1.5 (25)	0.8 ± 1.8 (44)	.35
Flexion	138.6 ± 9.2 (54)	139.4 ± 6.6 (38)	.90	137.5 ± 9.2 (33)	139.8 ± 7.5 (48)	.53
Supination	81.8 ± 4.7 (53)	81.7 ± 4.2 (38)	.95	79.9 ± 3.9 (43)	82.8 ± 4.6 (48)	.36
Pronation	80.7 ± 8.4 (53)	80.2 ± 5.7 (37)	1.00	78.8 ± 9.7 (43)	81.5 ± 5.7 (47)	.83
Strength						
Isometric flexion	5 ± 0 (24)	5 ± 0 (9)	1.00	5 ± 0 (14)	5 ± 0 (19)	1.00
Isometric supination	5 ± 0 (24)	5 ± 0 (9)	1.00	5 ± 0 (14)	5 ± 0 (19)	1.00
Isokinetic flexion	83.2 ± 13.3 (49)	—	—	82.7 ± 16.9 (41)	84.0 ± 7 (8)	.66
Isokinetic supination	85.3 ± 18.5 (49)	89.3 ± 3.2 (8)	.80	85.2 ± 7.5 (48)	87.6 ± 26.7 (9)	.47
Patient-reported outcome measure						
VAS pain	0.5 ± 0 (9)	—	—	0.5 ± 0 (9)	—	—
DASH	11.3 ± 6 (23)	4.7 ± 4.1 (26)	.44	7.0 ± 0 (19)	7.4 ± 6.3 (30)	1.00
qDASH	4.5 ± 0 (1)	4.0 ± 0 (21)	—	4.0 ± 0 (21)	4.5 ± 0 (1)	—
MEPS	94.0 ± 5.9 (33)	95.6 ± 2.9 (57)	.81	93.1 ± 5.0 (56)	96.4 ± 3.3 (34)	.41
OES	43.7 ± 0.6 (3)	44.7 ± 0 (21)	.42	44.4 ± 0.5 (22)	43.5 ± 0.7 (2)	.47

VAS, visual analog scale; *DASH*, Disabilities of the Arm, Shoulder, and Hand; *qDASH*, quick DASH; *MEPS*, Mayo Elbow Performance Score; *OES*, Oxford Elbow Score.
Data represent the calculated mean ± standard deviation (number of elbows with available data) pertaining to the postoperative values. Statistical comparisons between autograft and allograft groups and between weave and onlay groups are presented.
Elbow extension, flexion, supination, and pronation are recorded in degrees. Isometric strength is recorded following the Medical Research Council grading system (muscle grading from 0-5). Isokinetic strength is recorded as a percentage of the contralateral (ie, uninjured/nonsurgical) arm. A dash indicates that there were insufficient data to calculate the mean, standard deviation, and *P* value.

Table III
Secondary outcomes: complications

Reconstruction procedure	Elbows, n	Complications, n (%)								
		LABCN	PIN palsy	SRN	Flexion contracture	HO	Wound dehiscence	HS morbidity	Graft failure	Total
Autograft (weave)	70	4 (5.7)	—	4 (5.7)	—	3 (4.3)	1 (1.4)	14 (20)	2 (2.9)	28 (40)
Autograft (onlay)	16	—	—	—	—	—	—	1 (6.3)	—	1 (6.3)
Allograft (weave)	28	2 (7.1)	—	—	2 (7.1)	1 (3.6)	—	—	—	5 (17.9)
Allograft (onlay)	29	1 (3.4)	2 (6.9)	—	—	—	—	—	—	3 (10.3)
Total	143	7 (4.9)	2 (1.4)	4 (2.8)	2 (1.4)	4 (2.8)	1 (0.7)	15 (10.5)	2 (1.4)	37 (25.9)

LABCN, lateral antebrachial cutaneous nerve (sensory neuritis or numbness); *PIN*, posterior interosseous nerve; *SRN*, superficial radial nerve (sensory neuritis or numbness); *HO*, heterotopic ossification; *HS*, harvest site.

The autograft group experienced a total complication rate of 34% (29 of 86 cases). Of the autograft complications, 51.7% (n = 15) were attributed to harvest site morbidity (eg, quadriceps muscle herniation [n = 12] and pain [n = 3]), and there were equal numbers of sensory neuritis of the LABCN and superficial radial nerve (n = 4 [13.8%]). Heterotopic ossification (HO, n = 3 [10.3%]) and wound dehiscence (n = 1 [3.4%]) were among the other reported complications. No posterior interosseous nerve (PIN) palsies were reported in the autograft group. Two graft failures (6.9%) were reported that underwent revision. Of interest, 28 of the 29 complications occurring in the autograft group were experienced by patients who underwent the weave technique. The allograft group reported a total complication rate of 14% (8 of 57 cases). Within the allograft group, the most frequently reported complication was neuritis of the LABCN (n = 3 [37.5%]) and HO (n = 3 [37.5%]). Flexion contracture (n = 2) and PIN palsy (n = 2) were both reported with a frequency of 25%. The overall difference in complication rates noted between autograft and allograft groups is predominantly accounted for by harvest site morbidity in the autograft group (Table III).

When stratified into fixation technique categories, the weave group experienced a complication rate of 34% (33 of 98 cases). The most frequently reported complication in the weave group was harvest site morbidity, including muscle herniation (12 of 33 cases [36.4%]) and pain (2 cases [6.1%]); such complications are reflective of the graft source and not fixation technique. Following harvest site morbidity, the next most frequently recorded complications were neuritis of the LABCN (n = 6 [18.2%]), followed by superficial radial nerve neuritis and HO at 12.1% (n = 4) each (Table III). Flexion contracture and wound dehiscence were also reported with rates of 6.1% (n = 2) and 3% (n = 1), respectively. Graft failure was reported in 2 cases (n = 2 [6.1%]), both requiring revision surgery.[18,28]

The complication rate for the onlay group was 9% (4 of 45 cases). Of these complications, PIN palsy occurred in 50% of patients (n = 2), whereas 25% of patients experienced LABCN (n = 1) and harvest site pain (n = 1). No reoperations or revisions were reported in the onlay group. Of note, there were no reported cases of radioulnar synostosis in any reconstruction group analyzed.

Analysis of each complication as an independent variable when assessed by both graft source and graft fixation type did not reveal a significant difference. The Spearman rank coefficient did not indicate any strong positive or negative trends when complications were assessed as a function of time from injury to surgery.

Discussion

Existing literature and clinical experience support that nonoperative treatment of chronic distal biceps tendon ruptures may be associated with pain, muscle cramping, and decreased strength and endurance. As a result, reconstruction options have been developed; however, a universally accepted standard of treatment does not exist. Best practice recommendations remain unclear, and evidence-based recommendations are lacking.

A variety of surgical techniques are available for distal biceps reconstruction. This study compiled the available literature and assessed the ROM, strength, PROMs, and complications across graft source (autograft vs. allograft) as well as by graft fixation technique (weave vs. onlay). We hypothesized that better clinical outcomes would be seen in the autograft group; our data reveal that there is no statistical difference in outcomes between the 2 groups. We expected to observe no difference in outcomes when assessing graft fixation technique, and this was supported by our analysis. We anticipated that all outcome measures, regardless of grouping (graft source and fixation technique), would improve postoperatively and our data analysis demonstrated a trend toward improvements, but these were not statistically significant; however, because of the substantially small numbers in the available data (ie, primary outcome data available in less than 40%), the interpretation of such results should be taken with caution. Spearman rank correlation did not reveal any statistical significance between time from injury to surgery and ROM, strength testing, PROMs, and complications.

Within our study, complication data were available from 17 of the included studies (71% reporting rate). The complication rate for the autograft group was 34%, with the most common complication being graft donor site morbidity. Of note, all 12 muscle herniation complications were reported by Morrell et al,[22] in which patients underwent reconstruction with a fascia lata autograft. The overall complication rate in the allograft group was 14%. Despite no statistical significance being reached in complication rates between the 2 graft types, there was a trend in increased complication rates in the autograft group (Table II).

Historically, the orthopedic literature supports allograft inferiority compared to autograft in terms of rerupture rates, and as such we had hypothesized that reoperation and revision rates would be more frequent in the allograft group.[14] Of note, there are no published reports assessing rerupture rates following distal biceps tendon reconstruction. Snir et al[30] report that the biomechanical outcomes were similar for both allograft and autograft groups. Our data yielded no statistically significant difference, and in fact, the only 2 graft failures reported in this study both occurred in the autograft group. The overall rerupture rate in this study was 1.4% and is similar to that reported following primary repair of the distal biceps tendon (1.6%).[7] We can suggest that allograft is comparable to autograft in terms of postoperative outcomes for distal biceps tendon reconstruction.

The predominant graft fixation techniques used across the available literature consist of either a weave technique or an onlay technique, and much less frequently, an end-to-end technique. To our knowledge, there is no evidence to support superiority of one fixation method over the others. Many of the included studies did not separately report preoperative outcome measures and, thus, evaluation of postoperative scores using validated MCIDs was not possible. However, there was a trend toward improved postoperative outcomes (ie, strength and PROMs) for both the weave and onlay groups. Furthermore, noted in the discussion section of all included studies was that patients were satisfied with their surgical outcome with an improvement in overall function and return to activity.

An increased interval in time between injury and surgical reconstruction theoretically makes for a technically more difficult surgery given the degree of tendon retraction, soft tissue adhesions, and limited mobility of the biceps muscle belly and the need for a larger graft to span the residual defect. Functional results may also be theoretically altered by fatty infiltration of the biceps muscle and restoration of postoperative muscle strength, which is also reflective of the time from injury to surgery, as has been demonstrated in other chronic tendon tears including those of the rotator cuff.[12,31,34] We had hypothesized that functional results would deteriorate and that complication rates would increase as a function of time between tendon injury and surgical reconstruction. In addition to the above-mentioned factors, this was also based on studies by Bisson et al[1] and Kelly et al,[16] which revealed an increased incidence, although not significant, in complication rates as the time between tendon injury and surgical repair increased. Our data analysis, however, does not support this as the Spearman rank coefficient demonstrated that there was no significant difference in primary outcomes or complication rates as a function of time from injury. In summary, the ideal surgical candidate for a distal biceps tendon reconstruction includes a patient who reports loss of muscle strength and endurance of elbow flexion and/or forearm supination and has (1) a mobile and supple joint, (2) a functioning biceps muscle and musculocutaneous nerve, (3) absence of active infection, and (4) availability of autograft/allograft tissue.

The overall complication rate of 26% is higher than the complication rate associated with acute repair.[7,16] However, PIN palsy, superficial radial nerve palsy, and rerupture rates closely resembled the rates following acute repair.[7] HO and postoperative elbow stiffness were reported at higher rates following distal biceps reconstruction (ie, 2.8% vs. 0.8% and 1.4% vs. 0.4%, respectively).[7] Graft failure rates were low in this review, only reported in 2 patients in the autograft/weave group. Of interest, the rate of LABCN neuritis was reported at 13% in the Ford et al[7] study, and only at 4.9% in this review. It was noted by Ford et al[7] that there was a significant increase in the rate of LABCN neuritis in the 1-incision group, and the lower rate observed in this review likely reflects the more extensile approach and ability to identify and protect the LABCN during reconstruction surgery.

This review is not without its limitations. Specifically, it is fundamentally limited by the weaknesses of each included study. Sources of bias in this study include: (1) small number of cases per study (and within treatment groups), (2) substantial heterogeneity in reported outcome scores, (3) technique variation across surgeons, (4) inconsistent reporting of pre- and postoperative ROM, strength, and PROMs (ie, less than 40% reporting of primary data), (5) variability in clinical follow-up, and (6) lack of disease-specific outcome scores for patients with distal biceps ruptures. Furthermore, because of the retrospective nature of the included studies and substantial deficiency of reported data, the overall strength is limited.

Conclusion

To our knowledge, this is the first systematic review and meta-analysis conducted on chronic distal biceps tendon reconstruction outcomes. Comparison of postoperative ROM, muscle strength, patient-reported outcome measures, and complication rates demonstrate no statistically significant differences when assessed by graft source or by graft fixation technique. Based on the available literature, we suggest that the reconstruction method used for distal biceps tendon reconstruction can be safely based on surgeon preference. The outcome differences between autograft and allograft was statistically insignificant; however, the complication rate of autograft was more than twice that seen in the allograft group. This was largely due to donor site morbidity in the autograft patients, and thus, the graft source selected should be part of the shared decision-making process. Additional research is required ensuring meticulous data collection and research methodology.

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