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Outcomes of shoulder abduction after nerve surgery in patients over 50 years following traumatic brachial plexus injury

Joshua A. Gillis, Joseph S. Khouri, Michelle F. Kircher, Robert J. Spinner, Allen T. Bishop, Alexander Y. Shin*

Department of Orthopedic Surgery, Mayo Clinic, Rochester, MN, USA

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KEYWORDS
Brachial plexus reconstruction;
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Summary *Purpose:* There is controversy regarding the effectiveness of brachial plexus reconstruction in older patients, as outcomes are thought to be poor. The aim of this study is to determine the outcomes of shoulder abduction obtained after nerve reconstruction in patients over the age of 50 years and factors related to success.
Methods: Forty patients over the age of 50 years underwent nerve surgery to improve shoulder function after a traumatic brachial plexus injury. Patients were evaluated pre- and postoperatively for shoulder abduction strength and range of motion (ROM); Disability of the Arm, Shoulder and Hand (DASH) scores; pain; age bracket; gender; body mass index (BMI); delay from injury to operation; concomitant trauma; severity of trauma; and type of reconstruction.
Results: The average age was 58.2 years (range 50–77 years) with an average follow-up of 18.8 months. The average modified British Medical Research Council (BMRC) shoulder abduction grade improved significantly from 0.23 to 2.03 ($p < 0.005$). Fourteen patients achieved functional shoulder abduction of $\geq$ M3 postoperatively. There was no correlation between age or age range stratification and BMRC grade or those obtaining useful shoulder abduction $\geq$ M3. Active shoulder abduction improved significantly from 18.25° to 40.64°, with no difference on the basis of age or age stratification. There were improved modified BMRC grades with nerve transfers versus nerve grafts. Less patients achieved $\geq$ M3 function if surgery was delayed > 6 months. The mean DASH score decreased from 45.3 to 40.7 postoperatively, and the average pain score decreased from 3.7 to 3.0. Patients with a higher postoperative BMRC grade for shoulder abduction had improved postoperative DASH scores and VAS for pain ($p = 0.011$ and 0.005, respectively).

* Corresponding author: Alexander Shin, Department of Orthopedic Surgery, Mayo Clinic, 200 First Street, SW, 55905 Rochester, MN, USA
E-mail address: shin.alexander@mayo.edu (A.Y. Shin).

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Conclusion: Brachial plexus nerve reconstruction for shoulder abduction in patients over the age of 50 years can yield useful BMRC scores and ROM, and age should not be used to exclude nerve reconstruction in these patients.

Introduction

There are a variety of methods for reconstructing shoulder abduction after a traumatic brachial plexus injury. Typically, nerve repair, nerve grafting, and nerve transfers are performed early to try to restore innervation through the axillary and suprascapular nerves (SSNs). Nerve surgery after brachial plexus injuries in older patients is a relative contraindication, as outcomes are thought to be poor. However, there is conflicting evidence on the relationship between age and the ability to obtain useful shoulder abduction in these patients. Some evidence points toward the ability of younger patients to recover quicker owing to faster axon growth and a stronger regenerative capacity.[1] Older patients, however, are thought to have issues with vascular insufficiency and poor nutritional status, which may affect nerve recovery.[2-4] It has been reported for some shoulder reconstruction options post brachial plexus injury that no patients aged over 50 years were able to regain a useful deltoid function.[5] Given the existing literature, our goal was to determine the outcomes obtained after shoulder nerve reconstruction after traumatic brachial plexus injury in patients over the age of 50 years and factors related to success.

Methods

After approval by the institutional review board, a retrospective review of our brachial plexus database and patient charts was performed. All patients over the age of 50 years who underwent brachial plexus reconstruction to regain shoulder function after a traumatic brachial plexus injury between January 2000 and September 2016 were included. Strengthening The Reporting of OBservational studies in Epidemiology (STROBE) guidelines were used in the preparation of this study.

We evaluated pre- and postoperative shoulder abduction strength and range of motion (ROM); Disability of the Arm, Shoulder and Hand (DASH) questionnaire scores; pain using a visual analog scale (VAS); age bracket; gender; body mass index (BMI); delay from injury to operation; concomitant trauma; severity of trauma; and type of reconstruction. We excluded patients who had other types of reconstruction for shoulder function (i.e., tendon transfers) or other previous brachial plexus reconstructions performed elsewhere. We stratified patients according to their age range and compared those who underwent nerve grafting or transfers to restore shoulder abduction.

Shoulder abduction strength (the primary outcome measure in this study) was graded using a modified British Medical Research Council (BMRC) grade by three senior authors (R.J.S., A.T.B., and A.Y.S.). Each author independently graded shoulder abduction; it was then discussed, and a collaborative grade was obtained if there were disagreements. To obtain a BMRC grade of 3, the patient had to strictly have *active motion equal to passive motion against gravity*. The DASH questionnaire was used to measure patient- reported disability (a scale score ranging from 0 [no disability] to 100 [most severe disability])[6]. The DASH surveys were completed in the clinic at the preoperative appointment and at the postoperative follow-up. The BMRC and DASH questionnaires were both used, as these questionnaires are the standard reporting measures used for brachial plexus outcome studies, thereby allowing comparison with previous reports. Only patients with pre- and postoperative values were considered for the analysis.

Statistical analysis

The data were summarized using means and medians for continuous variables and counts and percentages for categorical variables. Outcomes comprising continuous variables such as preoperative and postoperative DASH scores were compared between the groups using Wilcoxon signed-rank test, whereas categorical variables such as BMRC grading were evaluated using the chi-square test (Kruskal–Wallis test if >2 independent variables and Mann–Whitney U test if ≤ 2 independent variables). Spearman correlation coefficient was used for correlation analysis. Multiple linear regression analysis was also performed for correlated factors. BMRC grades were categorized into two groups: M0, M1, and M2 (not useful shoulder abduction) and M3 and M4 (useful shoulder abduction wherein active motion equaled passive motion). We did not consider M5 in the analysis, as there is a discrepancy between clinical assessment of M5 grade and objective strength measurements in patients with brachial plexus injury[7]. All statistical tests were two sided, and $p < .05$ was considered significant. All statistical analyses were conducted using SPSS for Mac (IBM Corp.)

Results

Seventy patients over the age of 50 years who presented with shoulder weakness/paralysis after a traumatic brachial plexus injury were identified, and 40 of them underwent surgery to improve shoulder function. The average age was 58.2 years (range 50–77 years, 5.6 SD), average BMI was 29.8 kg/m^2 (6.36 SD), and the majority of the patients were men (77.5%). The dominant side was injured in 43.9% of patients. The majority of patients had either a C5,6 or axillary palsy (Table 1). Of the 27 patients with root injuries, 16 were avulsions, five were ruptures, four were not investigated, and two were lacerations. The average time from

Table 1 Demographic information of patients aged more than 50 years undergoing shoulder abduction reconstruction after traumatic brachial plexus injury.

	Number of patients (%)
Sex	
Male	31 (77.5)
Female	9 (22.5)
Age [mean 58.2 years (range 50-77 years, 5.6 years SD)]	
50-60	27 (67.5)
60-70	13 (32.5)
Dominant side involvement	
Yes	18 (43.9)
No	21 (51.2)
Side	
Right	22 (53.7)
Left	19 (46.3)
Injury pattern	
C5,6	13 (32.5)
Axillary	9 (22.5)
C5,6,7	6 (15.0)
Complete	6 (15.0)
C5,6,7,8	2 (5.0)
Upper trunk or upper trunk + C7	2 (5.0)
Posterior cord and suprascapular nerve	1 (2.5)
Injury type	
MVC car or boat	8 (19.5)
Motorcycle	9 (22.0)
Iatrogenic	7 (17.1)
ATV/Snowmobile	8 (19.5)
Fall	5 (12.2)
Gunshot wound	1 (2.4)
Crush	2 (4.9)
Traction	1 (2.4)
DASH	
Preoperative ($n = 28$)	45.3 (15.7 SD)
Postoperative ($n = 23$)	40.7 (22.9 SD)
VAS	
Preoperative ($n = 28$)	3.7 (0-9, 3.7 SD)
Postoperative ($n = 22$)	3.0 (0-8.7, 2.6 SD)

injury to surgery was 6.0 months (0-11 months, 2.4 SD), and average postoperative follow-up was 18.8 months (10.6 SD). The average time from injury to surgery for nerve graft versus nerve transfer was 4.5 versus 6.6 months ($p < 0.05$). There was no difference in mean follow-up between these groups, with 21.0 and 17.8-month follow-up for nerve graft and nerve transfer, respectively ($p = 0.389$).

There were 11 patients who underwent nerve grafting alone, 27 patients who underwent nerve transfers alone, and 2 patients who underwent a combination of nerve graft and transfer. The two patients who underwent combination treatment had a spinal accessory nerve (SAN) transfer to SSN transfer in conjunction with a nerve graft from C5 to the axillary nerve. The following various donor nerves were used for transfer or grafting: the radial nerve (21 patients), SAN (13 patients), C5 (11 patients), and the posterior cord (2 patients). The radial and SAN nerve transfers were performed without the use of an intervening nerve graft. The axillary nerve (30 patients), SSN (12 patients), and upper trunk (six patients) were the recipient nerves used to reconstruct shoulder function (Table 2).

The average modified BMRC for shoulder abduction significantly improved from 0.23 (0-4 range, 0.69 SD) preoperatively to 2.03 (0-4, 1.46 SD) postoperatively. Preoperatively, only one patient (2%) had functional shoulder abduction of $M \geq 3$, which improved significantly to 14 patients (35%) postoperatively (Table 3). This patient underwent a triceps motor branch transfer to the axillary nerve to improve strength. No patients worsened, 30 patients improved, and 10 patients did not have a change in their score. There was no correlation between BMRC grade for shoulder abduction and age (Figure 1). When stratified on the basis of $<$ M3 versus $\geq$ M3, there was no difference according to age. When stratified according to age over or under 60 years, there was no effect on shoulder abduction grade, with no difference in patients obtaining $\geq$ M3. There were significantly higher grades with nerve transfers compared to nerve graft reconstruction ($p = 0.035$). Although there was a trend toward more patients obtaining $\geq$ M3 abduction in those who had a nerve transfer (42.8%) versus nerve graft (16.7%), there was no statistical difference ($p = 0.116$). The average BMRC after nerve graft and transfer was 1.3 and 2.4, respectively (Table 4). There was no difference in BMRC grade achieved based on the nerve donor or recipient (Table 5).

There was no difference in postoperative abduction with high-velocity injuries and no difference in those achieving $\geq$ M3. The shoulder abduction was significantly worse when the time from injury to surgery was greater than 6 months than that when the time was less than 6 months, with less patients achieving $\geq$ M3 ($p = 0.031$) (Table 5). Gender and BMI of the patient had no effect on BMRC grade. Males and females did not differ significantly in age range, injury type, or pattern.

Table 2 Distribution of nerve graft and transfer of donor and recipient nerves in patients aged more than 50 years undergoing nerve surgery for brachial plexus reconstruction after brachial plexus injury.

		Donor Nerves						
		Radial (%)	SAN (%)	Radial/SAN (%)	C5 (%)	C5/SAN (%)	Posterior Cord (%)	Total
Recipient nerves	Axillary	16 (40)	2 (5)	-	2 (5)		2 (5)	22 (55)
	SSN	-	4 (10)	-	-		-	4 (10)
	Axillary/SSN	-		5 (12.5)	1 (2.5)	2 (5)	-	8 (20)
	Posterior division of UT/SSN	-			6 (15)		-	6 (15)
	Total	16 (40)	6 (15)	5 (12.5)	9 (22.5)	2 (5)	2 (5)	40 (100)

Table 3 Shoulder abduction preoperation and postoperation based on age range. BMRC = British Medical Research Council Grade, SD = standard deviation.

Shoulder Abduction BMRC Grade	All (n = 40)	50-54 (n = 11)	55-59 (n = 16)	60-64 (n = 8)	≥65 (n = 5)
Mean (SD)					
Preoperation	0.23 (0.69)	0.27 (0.47)	0.13 (0.34)	0.50 (1.41)	0.00 (0.00)
Postoperation**	2.03 (1.46)*	1.45 (1.50)	2.33 (1.47)	2.48 (1.36)	1.63 (1.46)
Median grade postoperation	2.0	1.0	2.1	2.5	1.5
M < 3 preoperation (%)	39 (98)	11 (100)	16 (100)	7 (88)	5 (100)
M ≥ 3 preoperation (%)	1 (2)***	0 (0)	0 (0)	1 (12)	0 (0)
M < 3 postoperation (%)	26 (65)	9 (82)	9 (56)	4 (50)	4 (75)
M ≥ 3 postoperation (%)**	14 (35)***	2 (18)	7 (44)	4 (50)	1 (25)

* Wilcoxon signed-rank test, $p < 0.005$, improved significantly postoperation.
** Kruskal-Wallis - no difference in postoperative mean MRC score between age range groups ($p = 0.351$).
*** McNemar Change test, $p < 0.005$, improved significantly postoperation.

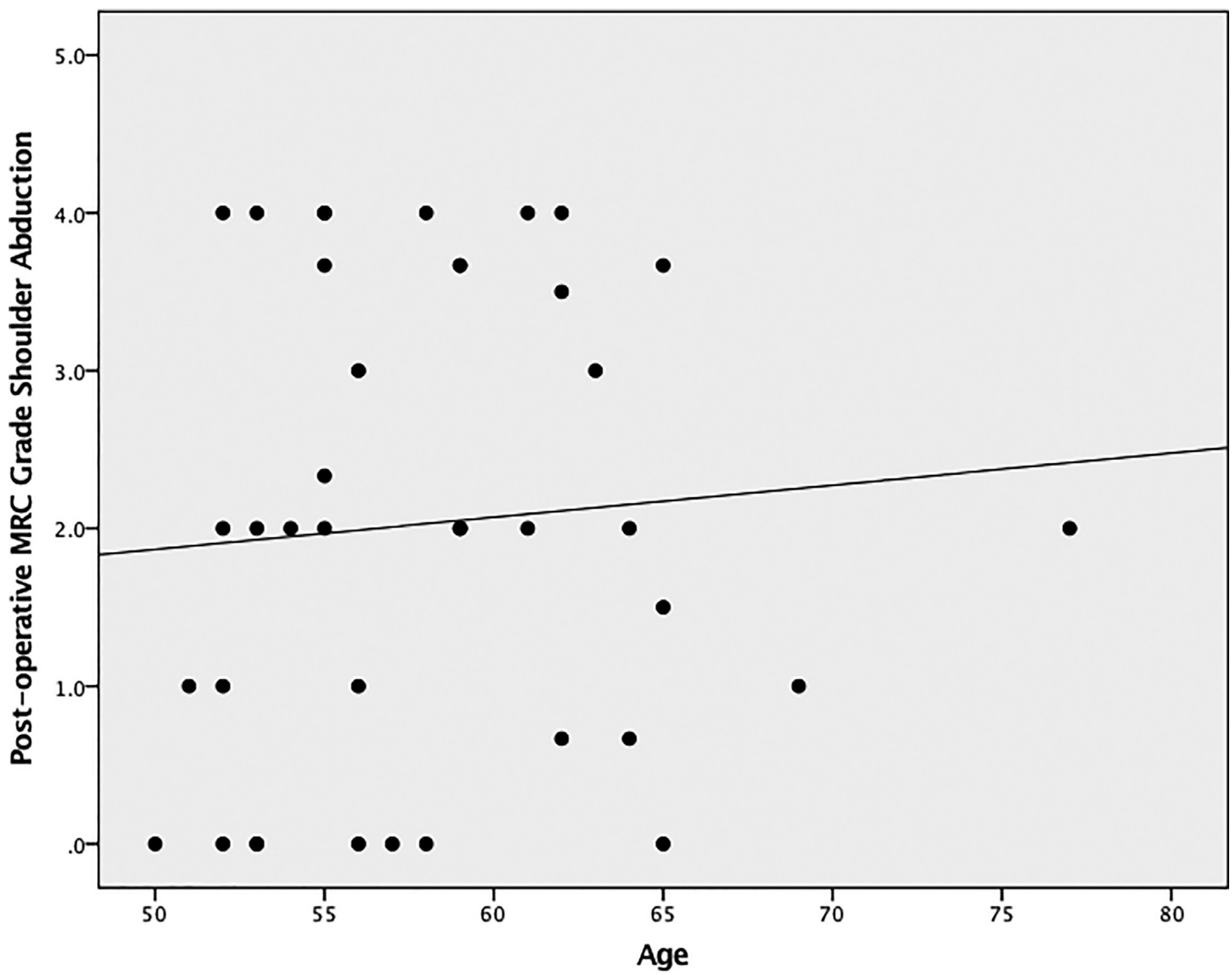

Figure 1 The relationship between deltoid strength, modified BMRC grade, and age (linear regression, $p = 0.553$, $r^2 = 0.006$). BMRC = British Medical Research Council.

The pre- and postoperative passive ROM details are given in Table 6. Active shoulder abduction improved significantly from 18.25° to 40.64° postoperatively. There was a significant correlation with shoulder abduction grade and ROM of the shoulder postoperatively ($p < 0.05$). There was no difference in active shoulder abduction ROM according to age or when stratified older versus younger than 60 years. There was no difference in active shoulder abduction ROM in relation to high-velocity injury or delay to surgery more than 6 months compared to that less than 6 months or with the type of reconstruction (i.e., graft versus transfer; $p = 0.067$). Females obtained more active shoulder

Table 4 Shoulder abduction based on nerve graft versus transfer. BMRC = British Medical Research Council Grade, SD = standard deviation.

Shoulder Abduction BMRC Grade	All (n = 40)	Nerve graft (n = 12)	Nerve transfer (n = 28)
Mean (SD) preoperation	0.23 (0.69) (median = 0.0)	0.1 (0.3) (median = 0.0)	0.3 (0.8) (median = 0.0)
Mean (SD) postoperation	2.03 (1.46) (median = 2.0)*	1.3 (1.3) (median = 1.0)	2.4 (1.4) (median = 2.0)***
≥M3 Preoperative (%)	1 (2.5)	0 (0.0)	1 (3.6)
≥M3 Postoperative (%)	14 (35.0)**	2 (16.7)	12 (42.8)+

* Wilcoxon signed-rank test, $p < 0.005$.
** McNemar Change test, $p < 0.005$.
*** Kruskal-Wallis - $p = 0.035$, transfer better than graft.
\+ Kruskal-Wallis - $p = 0.116$.

Table 5 Factors related to postoperative shoulder abduction MRC grade. DASH = Disability of the Arm, Shoulder and Hand; VAS = Visual analog scale.

Factor	p-value*
Age at the time of surgery	0.553
Age < 60 versus ≥ 60 years	0.758
Sex	0.138
BMI (body mass index)	0.566
Involvement of dominant wrist or not	0.538
Injury pattern	0.936
High velocity	0.341
Time from injury to surgery	0.040
Reconstruction within or after 6 months	0.022
Nerve graft versus transfer	0.035
Nerve donor (e.g., radial versus spinal accessory nerve)	0.089
Nerve recipient (e.g., axillary versus suprascapular nerve)	0.363
DASH postoperation	0.011
VAS postoperation	0.005

* Logrank test for continuous variables and Kruskal-Wallis test for categorical variables.

abduction postoperatively than males (67.2° versus 32.7°, $p = 0.042$).

The mean DASH score decreased from 45.3 (15.7 SD) preoperatively to 40.7 (22.9 SD) postoperatively. The average pain score based on a VAS decreased from 3.7 (0-9, 3.7 SD) preoperatively to 3.0 (0-8.7, 2.6 SD) postoperatively. However, the postoperative DASH and VAS did not change significantly compared to preoperative DASH and VAS ($p = 0.284$ and 0.433, respectively) (Table 1). Patients with higher postoperative shoulder abduction grades had improved postoperative DASH scores and VAS for pain ($p < 0.05$).

Discussion

There are conflicting data regarding brachial plexus outcomes in relation to age at the time of surgery. There are multiple case series suggesting worse outcomes after brachial plexus repair and reconstruction with increasing patient age; however, the majority of cases were unable to reach statistical significance, with only two studies showing a significant correlation (see Table 7). Lee et al. performed a retrospective review of 21 patients who underwent a triceps motor branch to axillary nerve transfer for isolated axillary nerve injuries.[5] They found that delay to surgery, increasing age, and BMI were negatively correlated with outcomes. Patients under 40 years had a 92% success rate (11/12), and those between 40 and 50 years had a 56% success rate (5/9). No patients over 50 years regained a useful deltoid function.[5] Emamhadi et al. analyzed 22 patients aged 16 to 60 years (mean 25.4-years) with C5 and C6 root avulsion who underwent a SAN to SSN transfer to reconstruct shoulder abduction.[8] After an average of 21.7 months, 17 of 22 patients achieved ≥ M3 strength, with a significant negative correlation between motor function and patient age. There was no association between age and shoulder ROM postoperatively.[9]

Bonnard et al. reviewed 121 patients who had a post-traumatic axillary nerve repair, with a majority of patients undergoing neurolysis or grafting. They found a significant

Table 6 Range of motion (ROM) in patients undergoing shoulder reconstruction above the age of 50 years.

	Preoperative ROM (degrees)			Last clinical follow-up, ROM (degrees)			
	N	Mean	SD	N	Mean	SD	P-value*
Passive ROM							
Shoulder abduction	24	97.3	35.8	24	99.8	37.0	0.455
Active ROM							
Shoulder abduction	40	18.25	39.2	39	40.64	47.6	<0.005*
Shoulder flexion				32	47.8	53.6	NA
Shoulder external rotation				28	13.9	23.3	NA

* Wilcoxon signed-rank test.

Table 7 Comparative outcomes of shoulder abduction achieved after brachial plexus injuries from studies that compared age with eventual outcome. BMRC = British Medical Research Council, n. = nerve, recon. = reconstruction, SSN = suprascapular nerve, SAN = spinal accessory nerve.

Study	Procedure	Preoperative diagnosis	Number of patients	Mean age (years)	Mean follow-up (months)	Mean preoperative BMRC shoulder abduction	Mean postoperative BMRC shoulder abduction (%)	Mean postoperative ROM shoulder abduction (°)
Bonnard et al. (1999)[10]	Neurolysis, grafting, or transfer	Axillary n. injury	121	30.1 (9-72)	>18 months	114/121 had no function	103/121 ≥M3 (85.1)	Not stated
Samardzic et al. (2000)[17]	N. graft or transfer of axillary n.	Brachial plexus traction injury	50	(11-57)	>36	Not stated	38/50 “functional recovery” (76)	Not stated
El-Gammal et al. (2002)[13]	Grafting or transfer to SSN, axillary and upper trunk	Brachial plexus injury	32	26 (6-45)	35	Not stated	Not stated	25-90
Wehbe et al. (2004)[11]	Neurolysis or graft	Axillary n.	33	30 (13-70)	>24 months	“all had clinical paralysis”	18/33 ≥M3 (54.5)	Not stated
Terzis and Kostas (2006)[15]	SSN recon. with graft or transfer	Brachial plexus injury	102	25.5 (6-65)	66 (24-168)	0.6-0.7	3.46 ± 0.85 68/148 ≥M3+ (79)	50.19 ± 27.8
Terzis and Barmpitsioti (2010)[12]	Axillary neurolysis, repair, or grafting +/- SSN recon.	Brachial plexus injury	148	26.35 ± 9.91	57.3 ± 33.7	0.33 ± 0.84	2.88 ± 1.09 68/148 ≥M3+ (45.95)	35-101.25
Samardzic et al. (2011)[16]	N. grafts or transfers to axillary n.	Upper brachial plexus traction injury	33	(9-55)	>24	Not stated	25/28 “functional recovery” (89.3)	Not stated
Socolovsky et al. (2011)[18]	Axillary n. grafting	Flail arm	8	23.9 ± 7.0	>24	“complete palsy”	3/8 ≥M3 (37.5)	Not stated
Lee et al. (2012)[5]	Triceps to axillary n. transfer	Isolated axillary n. injury	21	38 (12-41)	21	“failure of EMG or clinical recovery”	3.5 ± 1.1 16/21 ≥M3 (76.2)	119.0
Emamhadi et al. (2016)[8]	SAN to SSN n. transfer	C5/C6 root avulsion	22	25.4 (16-60)	21.7	“nonfunctional”	3.4, 17/22 ≥M3 (77.2)	55.55
Current study	SSN and axillary n. graft and transfer	Brachial plexus injury	40	58.2 (50-77)	18.8	0.23	2.03 (0-4), 14/40 ≥M3 (35)	40.64

downward trend of patients obtaining > M4 results as the age of the patient increased; however, there was no difference in the overall success of the operation.[10] In patients younger than 20 years, 83% achieved ≥ M4, as opposed to 63% in those patients over 35 years. Unfortunately, age over 35 years was not stratified to over 50 years. There was no difference in success of the operation in patients under versus those over 40 years (61% versus 77%). Wehbe et al. also analyzed 33 post-traumatic axillary nerve repairs, 20 of which were nerve grafts and 13 were neurolysis. There was a recovery of M3 function in eight of 14 patients less than 25 years versus in eight of 19 patients older than 25 years. This was not a significant difference.[11] Terzis and Barmpitsioti also studied axillary nerve reconstruction in 148 patients after traumatic brachial plexus injury.[12] They found a trend toward improved deltoid function in patients younger than 20 years than those over 20 years, but it was not significant (mean BMRC 3.18 vs. 2.70).[12] El-Gammal et al. evaluated 32 patients with a traumatic brachial plexus injury who underwent a combination of nerve graft and nerve transfer to reconstruct shoulder abduction. Shoulder abduction was 25° in patients over 40 years and 45° in those under 40 years; however, these results were not found to be statistically significant.[13]

Contradictory evidence also exists regarding age and shoulder abduction outcomes. Ali et al. performed a literature review and meta-analysis of upper brachial plexus injuries to compare the results of nerve repair, nerve transfer, or combined procedures.[14] Their analysis comprised 747 cases of nerve grafting, 2440 cases of nerve transfer, and 587 cases of combined procedures. They determined that nerve transfers were superior to nerve grafting to achieve shoulder abduction, which mirrors our results. Within their analysis, a meta-regression analysis showed that age and time delay to repair had no effect on outcome; however, the number of patients aged over 50 years is not clear.[14] Terzis and Kostas analyzed 102 patients who underwent reconstruction of the SSN with graft or transfer after traumatic brachial plexus injury.[15] They found that patients younger than 20 years had no significant difference in shoulder abduction than those older than 20 years.[15] Similarly, Samardzic et al. evaluated 33 patients, 67.5% of which were under 30 years, who underwent axillary nerve transfers after upper brachial plexus traction injury.[16] There was no correlation between outcome and age.[16] The same group had similar outcomes in 50 patients with brachial plexus traction injuries who underwent reinnervation of the axillary nerve with grafting or transfers. They obtained > M3 function in 76% of their transfers with no difference when comparing the age of the patients less than versus older than 30 years old.[17] Other groups have had similar outcomes with axillary nerve grafting post brachial plexus injury, with no relation with age and BMRC shoulder abduction strength.[18,19] Similar results have been shown in other areas of brachial plexus, radial, and peripheral nerve reconstruction, with no connection between age and surgical outcomes.[20-22]

With the increasing age of patients taking part in more motor sport activities, the number of patients with brachial plexus injury over the age of 50 years has increased in the past several years. Our evidence suggests that patients over 50 years can recover useful shoulder abduction. However, the average modified BMRC grade demonstrated in our population is less than that previously reported in a younger patient cohort. Lee et al. obtained an average BMRC of 3.5, compared to our value of 2.4 after nerve transfer for shoulder abduction.[5] Nonetheless, in their study, no patients over the age of 50 years achieved useful shoulder abduction of ≥ M3, whereas we had 14 out of 40 patients (35%). The percentage of patients successfully obtaining functional abduction is also lower than that reported in other studies, with a lower mean age at the time of surgery (Table 7).[5,8-10] We found that reconstruction with nerve transfers is superior to nerve grafting in this patient population. This finding is consistent with that found in previous literature, along with lower scores after high-energy trauma and delay to surgery. We were likely unable to obtain a difference in those patients achieving ≥ M3 between nerve grafts and transfers due to being underpowered for this subgroup analysis. We did not find any difference in BMRC grade for shoulder abduction in relation to the gender of the patient, BMI, injury pattern, nerve donor or recipient used, high-velocity injury, or involvement of the dominant wrist. Females achieved significantly more active shoulder abduction degrees than males.

We recognize the limitations of this study, including its retrospective descriptive nature. The sample size was a sample of convenience based on all patients who presented during our period, and thus, there is a potential that we did not reach significance on some analyses based on the number of patients. The time to surgery was shorter for the nerve grafting group, as when patients present later in their time course, and our preference is to perform nerve transfers, if donors exist. This is because the donor axons are closer to the end organ and will probably reinnervate before fibrosis, albeit with potentially lesser axons than a nerve graft. This could be one explanation why transfers performed better than grafts in this patient population. We did not include a younger cohort in our series owing to the heterogeneity of case presentations and difficulty in controlling for confounding factors. Future prospective studies with larger populations and direct comparison with matched younger cohorts would be needed to identify a true difference in outcomes from older patients. We did not identify the effect of concomitant trauma on the eventual outcome of these patients. The heterogeneity of the injury mechanism, injury pattern, and reconstruction may have limited the power to detect variable associations with shoulder abduction scores. The BMRC and ROM are subjective measures; however, they were averaged by three senior surgeons, and thus, bias was attempted to be reduced. Our group also strictly grades BMRC according to the original description, where a true M3 occurs when active and passive motions are equal against gravity. This may make our results less encouraging than other reports. It may also be difficult to compare our results with the results of other studies, as there is heterogeneous reporting of pre- and postoperative outcome measures (Table 7).

Notwithstanding these limitations, this study demonstrated that the outcomes of surgical reconstruction of shoulder function with nerve grafting or nerve transfers in patients over the age of 50 years resulted in a measureable improvement in shoulder abduction ROM and modified BMRC score, and this improvement is in contradistinction to that reported in previously published studies that portray a minimalistic outcome for this age group.

Conflict of interest

None.

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