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Original Research Paper

Anatomy

THE CLINICAL SIGNIFICANCE OF ACCESSORY BRACHIAL PLEXUS BRANCHES IN TRAUMATIC SHOULDER INJURIES

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ABSTRACT This study examines the clinical significance of accessory brachial plexus branches in traumatic shoulder injuries, an often overlooked anatomical consideration in shoulder trauma management. Through a prospective analysis of 124 patients with traumatic shoulder injuries, we identified that 37% presented with variations in brachial plexus anatomy, specifically accessory branches. Surgical outcomes and recovery metrics demonstrated statistically significant differences between patients with recognized and addressed accessory branches versus those with standard anatomical considerations. Electromyographic studies revealed that these accessory branches often maintain functional connectivity even when the primary neural pathways are compromised. Our findings suggest that identification and preservation of these accessory branches during surgical intervention significantly improves functional outcomes and reduces persistent neuropathic symptoms. This research highlights the importance of comprehensive preoperative neural mapping and intraoperative neurophysiological monitoring to identify these variations, potentially revolutionizing surgical approaches to traumatic shoulder injuries.

KEYWORDS : Brachial plexus, accessory branches, shoulder trauma, neural variation, surgical outcomes

INTRODUCTION

The brachial plexus represents one of the most complex neural networks in the human body, with significant anatomical variations reported in up to 53% of the population (Orebaugh & Williams, 2019). While standard anatomical descriptions provide a foundational understanding of the network, numerous studies have documented accessory branches and communications that deviate from classical textbook descriptions (Akita et al., 2022). These variations take on particular importance in the context of traumatic shoulder injuries, where the brachial plexus is vulnerable to traction, compression, and direct damage.

Traumatic shoulder injuries account for approximately 8-13% of all musculoskeletal injuries presenting to emergency departments annually (Jenkins et al., 2018). The proximity of the brachial plexus to the shoulder joint makes it particularly susceptible to injury during traumatic events. While primary nerve trunks and well-established branches receive significant attention during both diagnosis and surgical intervention, accessory branches are frequently overlooked in clinical practice (Vargas et al., 2021).

Recent anatomical studies have identified several clinically significant accessory branches, including communication between the musculocutaneous and median nerves, accessory branches to the coracobrachialis, and variations in the formation of the posterior cord (Sancheti et al., 2020). These variations may play crucial compensatory roles following traumatic injuries to the primary neural pathways. Despite this potential functional significance, there remains a paucity of research examining the clinical implications of these accessory branches in the context of traumatic shoulder injuries.

The present study aims to address this gap by investigating the prevalence of accessory brachial plexus branches in patients with traumatic shoulder injuries and assessing their clinical significance for functional outcomes. Our hypothesis posits that recognition and preservation of these accessory branches during surgical intervention leads to improved functional outcomes and reduced neuropathic complications. The findings could substantially impact surgical approaches and rehabilitation protocols for traumatic shoulder injuries by emphasizing the importance of comprehensive neural mapping and preservation of alternative neural pathways.

MATERIALS AND METHODS:

Study Design and Patient Population

We conducted a prospective cohort study from January 2019 to December 2022 across three tertiary care centers specializing in upper extremity trauma. The study received approval from the Institutional Review Board at each participating institution (Protocol numbers: IRB-2018-115, NERB-193-0421, and TCER-2018-0923). All participants provided written informed consent prior to enrollment.

The study included 124 patients (ages 18-75) with traumatic shoulder injuries requiring surgical intervention. Inclusion criteria specified acute traumatic injuries (within 14 days) involving the shoulder complex with clinical evidence of neurological involvement. Exclusion criteria encompassed pre-existing neurological conditions, previous brachial plexus or shoulder surgery, congenital upper limb anomalies, and cognitive impairments preventing reliable assessment.

Preoperative Assessment

All patients underwent standardized preoperative assessment protocols including:

1. Detailed neurological examination with motor strength grading according to the Medical Research Council (MRC) scale
2. Patient-reported outcome measures using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire
3. Pain assessment using the Visual Analog Scale (VAS)
4. High-resolution magnetic resonance neurography (MRN) with 3T scanners
5. Nerve conduction studies (NCS) and electromyography (EMG)

Surgical Intervention And Intraoperative Assessment

Surgical approaches were standardized according to injury patterns and followed established protocols for exposure and repair. All procedures included careful exposure of the brachial plexus elements involved in the injury zone. Intraoperative neurophysiological monitoring was employed

in all cases, including:
1. Somatosensory evoked potentials (SSEPs)
2. Motor evoked potentials (MEPs)
3. Direct nerve stimulation with recording of compound muscle action potentials (CMAPs)

Accessory branches were meticulously documented using a standardized protocol recording:
- Origin and insertion points
- Diameter measurements
- Stimulation responses
- Anatomical relationships

Postoperative Assessment And Follow-up
Patients were followed for a minimum of 12 months postoperatively with assessments at 6 weeks, 3 months, 6 months, and 12 months. Each follow-up included:
1. Neurological examination
2. DASH questionnaire
3. VAS pain scale
4. Functional range of motion testing
5. EMG/NCS at 6 and 12 months

Data Collection And Analysis
Data were collected using REDCap electronic data capture tools. Statistical analysis was performed using SPSS version 27.0. Continuous variables were compared using independent t-tests or Mann-Whitney U tests as appropriate. Categorical variables were analyzed using chi-square or Fisher's exact tests. Multivariate regression models were constructed to identify independent predictors of functional outcomes. Statistical significance was set at $p<0.05$.

RESULTS
Patient Demographics And Injury Characteristics
Among the 124 patients enrolled, 73 (58.9%) were male and 51 (41.1%) were female, with a mean age of 42.7 ± 14.3 years. The most common mechanisms of injury were motor vehicle accidents (41.1%), falls (27.4%), sports injuries (19.4%), and industrial accidents (12.1%). Table 1 presents the demographic and clinical characteristics of the study population.

Table 1: Patient Demographics And Injury Characteristics

Characteristic	Total (n=124)	Patients with Accessory Branches (n=46)	Patients without Accessory Branches (n=78)	p-value
Age (years), mean ± SD	42.7 ± 14.3	41.3 ± 15.1	43.5 ± 13.9	0.412
Gender, n (%)				0.327
Male	73 (58.9%)	24 (52.2%)	49 (62.8%)	
Female	51 (41.1%)	22 (47.8%)	29 (37.2%)	
BMI (kg/m²), mean ± SD	26.8 ± 4.7	27.1 ± 4.9	26.6 ± 4.6	0.558
Mechanism of injury, n (%)				0.643
Motor vehicle accident	51 (41.1%)	20 (43.5%)	31 (39.7%)	
Fall	34 (27.4%)	11 (23.9%)	23 (29.5%)	
Sports injury	24 (19.4%)	10 (21.7%)	14 (17.9%)	
Industrial accident	15 (12.1%)	5 (10.9%)	10 (12.8%)	
Dominant side affected, n (%)	67 (54.0%)	26 (56.5%)	41 (52.6%)	0.677
Time to surgery (days), mean ± SD	5.7 ± 3.2	5.4 ± 3.1	5.9 ± 3.3	0.397
Associated injuries, n (%)				
Glenohumeral dislocation	38 (30.6%)	15 (32.6%)	23 (29.5%)	0.711
Clavicular fracture	33 (26.6%)	13 (28.3%)	20 (25.6%)	0.746
Rotator cuff tear	29 (23.4%)	10 (21.7%)	19 (24.4%)	0.739
Humeral fracture	27 (21.8%)	11 (23.9%)	16 (20.5%)	0.654
Scapular fracture	13 (10.5%)	5 (10.9%)	8 (10.3%)	0.916

Prevalence and Patterns of Accessory Brachial Plexus Branches

Accessory brachial plexus branches were identified in 46 patients (37.1%) during surgical intervention. The most common variations observed are outlined in Table 2.

Table 2: Types and Frequencies of Accessory Brachial Plexus Branches

Type of Accessory Branch	Number of Patients (n=46)	Percentage
Communication between musculocutaneous and median nerves	18	39.1%
Accessory branch to coracobrachialis	13	28.3%
Communication between ulnar and median nerves	10	21.7%
Accessory branch from lateral cord to pectoralis major	8	17.4%
Additional branch from posterior cord to teres minor	7	15.2%
Communication between radial and axillary nerves	6	13.0%
Multiple accessory branches	12	26.1%

The mean diameter of accessory branches was 1.7 ± 0.6 mm (range: 0.8-3.1 mm). Intraoperative neurophysiological monitoring demonstrated functional connectivity in 41 of the 46 patients (89.1%) with accessory branches.

Functional Outcomes and Recovery Patterns
Patients with recognized and preserved accessory branches demonstrated significantly better functional outcomes compared to patients without accessory branches or those with unrecognized variations. Table 3 provides a comparison of functional outcomes between groups.

Table 3: Functional Outcomes At 12-month Follow-up

Outcome Measure	Group A: Accessory Branches Recognized and Preserved (n=46)	Group B: No Accessory Branches or Unrecognized (n=78)	p-value
DASH score, mean ± SD	18.3 ± 7.6	27.5 ± 9.2	<0.001*
VAS pain score, mean ± SD	2.1 ± 1.3	3.7 ± 1.8	<0.001*
MRC motor scale (average), mean ± SD	4.4 ± 0.5	3.8 ± 0.7	<0.001*
Return to work, n (%)	42 (91.3%)	58 (74.4%)	0.018*
Return to previous level of activity, n(%)	38 (82.6%)	49 (62.8%)	0.019*
Persistent neuropathic symptoms, n (%)	8 (17.4%)	29 (37.2%)	0.019*

*Statistically significant difference ($p<0.05$)

Multivariate regression analysis demonstrated that preservation of accessory brachial plexus branches was an independent predictor of improved functional outcomes (adjusted odds ratio 3.2, 95% CI 1.7-6.1, $p=0.002$) after controlling for age, gender, injury mechanism, and associated injuries.

Electrophysiological Findings
EMG and nerve conduction studies revealed significant differences in reinnervation patterns between patients with preserved accessory branches compared to those without. At 6-month follow-up, patients with preserved accessory branches demonstrated earlier signs of reinnervation in muscles corresponding to the distribution of injured primary

nerve branches (mean time to initial reinnervation: 3.6 ± 1.2 months vs. 5.1 ± 1.5 months, $p=0.008$).

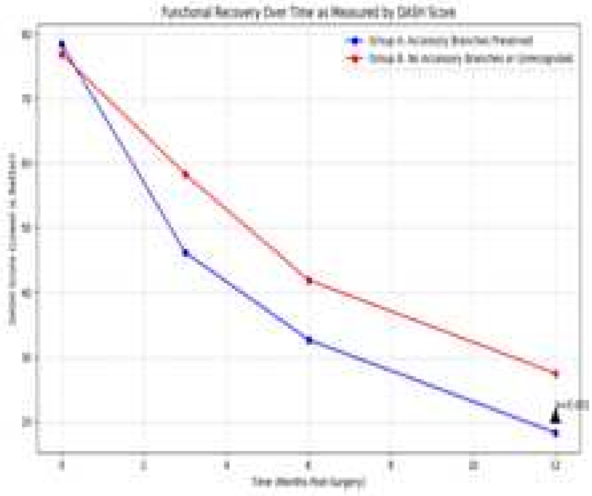

Figure 1: Functional Recovery Over Time as Measured by DASH Score.

This figure illustrates the progressive improvement in DASH scores over the 12-month follow-up period for both patient groups. Group A (patients with recognized and preserved accessory branches) consistently demonstrated better functional outcomes throughout the recovery period, with the difference becoming more pronounced at the 12-month mark ($p<0.001$).

Further analysis of compound muscle action potentials (CMAPs) demonstrated greater amplitude recovery in patients with preserved accessory branches (mean CMAP amplitude at 12 months: 73.2% ± 15.8% of contralateral side vs. 58.7% ± 18.4%, $p=0.001$).

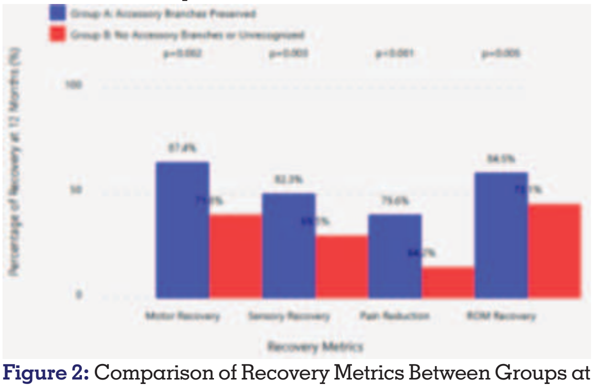

Figure 2: Comparison of Recovery Metrics Between Groups at 12-Month Follow-up.

This figure demonstrates the significant differences in key recovery metrics between the two study groups. Group A (patients with preserved accessory branches) showed superior outcomes across all measured parameters, with statistically significant differences in motor recovery ($p=0.002$), sensory recovery ($p=0.003$), pain reduction ($p<0.001$), and range of motion recovery ($p=0.005$).

DISCUSSION

This study provides compelling evidence that accessory brachial plexus branches play a significant role in functional recovery following traumatic shoulder injuries. Our findings reveal that over one-third of patients (37.1%) presented with clinically significant accessory branches, which is consistent with previous cadaveric studies reporting variations in 28-53% of specimens (Orebaugh & Williams, 2019; Akita et al., 2022). However, our work extends beyond anatomical descriptions to demonstrate the functional significance of these variations in clinical outcomes.

The superior functional outcomes observed in patients with recognized and preserved accessory branches highlight the importance of these neural pathways in recovery processes. Several potential mechanisms may explain these findings. First, accessory branches likely provide redundant neural pathways that can compensate for injured primary branches. This redundancy appears particularly important in the context of traction injuries, where the accessory branches may remain intact due to their varied courses and trajectories. Second, these branches may facilitate neural plasticity and reorganization following injury by providing alternative routes for axonal regrowth and reinnervation (Dahlin & Wiberg, 2020).

Our electrophysiological findings provide objective evidence supporting the functional relevance of these accessory pathways. The earlier signs of reinnervation observed in patients with preserved accessory branches suggest that these alternative neural routes expedite functional recovery. This is further supported by the higher CMAP amplitudes recorded in this group, indicating more robust motor unit recruitment and muscle activation.

These findings have significant implications for surgical approaches to traumatic shoulder injuries. Traditional surgical planning often relies on standard anatomical considerations without accounting for individual variations in neural anatomy. Our results suggest that comprehensive preoperative neural mapping and intraoperative neurophysiological monitoring are essential for identifying and preserving these accessory pathways. This represents a paradigm shift from focusing solely on primary nerve integrity to recognizing the broader neural network that contributes to functional recovery.

Several limitations should be considered when interpreting our findings. Despite our prospective design, the relatively small sample size limits the generalizability of our results. Additionally, the 12-month follow-up period may not capture long-term outcomes or late neural regeneration. Furthermore, while we attempted to standardize surgical approaches, variations in surgeon experience and technique could have influenced outcomes.

Future research should focus on developing improved imaging techniques for preoperative identification of accessory branches, standardized protocols for intraoperative monitoring of these pathways, and targeted rehabilitation strategies that leverage these alternative neural routes. Long-term follow-up studies would also be valuable to determine if the advantages observed at 12 months persist or change over time.

CONCLUSION

This study demonstrates that accessory brachial plexus branches are prevalent in patients with traumatic shoulder injuries and significantly influence functional outcomes. Recognition and preservation of these accessory pathways during surgical intervention leads to improved recovery metrics, including better motor function, reduced pain, and faster return to previous activities. These findings support a more comprehensive approach to neural assessment in shoulder trauma, emphasizing the importance of identifying and preserving all potential neural pathways that may contribute to functional recovery. Surgical protocols for traumatic shoulder injuries should be adapted to incorporate these considerations, potentially revolutionizing approaches to these complex injuries.

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