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Original article

Incidence and predictors of radial nerve palsy with the anterolateral brachialis splitting approach to the humeral shaft

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ABSTRACT

Purpose: Fractures of the humeral shaft are common and account for 3%–5% of all orthopedic injuries. This study aims to estimate the incidence of radial nerve palsy and its outcome when the anterior approach is employed and to analyze the predictive factors.

Methods: The study was performed in the department of orthopaedics unit of a tertiary care trauma referral center. Patients who underwent surgery for acute fractures and nonunions of humerus shaft through an anterior approach from January 2007 to December 2012 were included. We retrospectively analyzed medical records, including radiographs and discharge summaries, demographic data, surgical procedures prior to our index surgery, AO fracture type and level of fracture or nonunion, experience of the operating surgeon, time of the day when surgery was performed, and radial nerve palsy with its recovery condition. The level of humerus shaft fracture or nonunion was divided into upper third, middle third and lower third. Irrespective of prior surgeries done elsewhere, the first surgery done in our institute through an anterior approach was considered as the index surgery and subsequent surgical exposures were considered as secondary procedures.

Results: Of 85 patients included, 19 had preoperative radial nerve palsy. Eleven (16%) patients developed radial nerve palsy after our index procedure. Surgeons who have two or less than two years of surgical experience were 9.2 times more likely to induce radial nerve palsy ($p = 0.002$). Patients who had surgery between 8 p.m. and 8 a.m. were about 8 times more likely to have palsy ($p = 0.004$). The rest risk factor is AO type A fractures, whose incidence of radial nerve palsy was 1.3 times as compared with type B fractures ($p = 0.338$). For all the 11 patients, one was lost to follow-up and the others recovered within 6 months.

Conclusion: Contrary to our expectations, secondary procedures and prior multiple surgeries with failed implants and poor soft tissue were not predictive factors of postoperative deficit. From our study, we also conclude that radial nerve recovery can be reasonably expected in all patients with a postoperative palsy following the anterolateral approach.

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Introduction

The anterolateral approach and its modifications first described by Henry¹ is widely employed for exposures of the humerus for various pathological conditions and humeral shaft fractures which account for 3%–5% of all orthopaedic injuries.² The radial nerve, with its circuitous relationship to the humerus, is of special interest with any surgical exposure of the humeral shaft. The radial nerve is

tightly bound by the lateral intermuscular septum as the nerve enters the anterior compartment and it is susceptible to injury at this level.³ The aim of this study was to estimate the incidence and to determine the possible predictive factors for a postoperative radial nerve palsy with the anterior approach and to document its natural history.

Materials and methods

General data

This study, performed in the department of orthopaedics unit 1 of a tertiary care trauma referral center in South India, was

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approved by the Institutional Review Board (IRB min No-8405). Patients who underwent surgery for acute fractures and non-unions of humerus shaft through an anterior approach from January 2007 to December 2012 were included.

The inclusion criteria was all humeral shaft fractures and nonunion of the humerus shaft. Patients who had the followings were excluded: (1) fixation through posterior approach; (2) nailing for humerus; (3) intra-articular fracture; (4) tumors of humerus; (5) preoperative radial nerve palsy; (6) cervical spine injuries; (7) brachial plexus injury; (8) vasculitis and connective tissue disorder; and (9) open humerus shaft fractures. Irrespective of prior surgeries done elsewhere, the first surgery done in our institute through an anterior approach was considered as the index surgery and subsequent surgical exposures were considered as secondary procedures.

We retrospectively analyzed online medical records, patient charts, operation notes, radiographs and discharge summaries. Patient demographic data, comorbidities, associated injuries, timing of surgery, number of surgical procedures prior to the index surgery, AO fracture type and level of fracture or nonunion, indication for index surgical procedure, experience of the operating surgeon, time of the day when surgery was performed and chronology of radial nerve palsy together with its

recovery were documented. We defined experience as number of years since completion of residency program. The first group had surgeons with ≤ 2 years of experience and the other group had >2 years experience. The patients were also divided into two groups according to the time of surgery – surgery done between 8 a.m.–8 p.m. in one group and evening 8 p.m. – 8 a.m. in the other group.

The level of humerus shaft fractures or nonunion was divided into upper third, middle third and lower third. In patients who underwent surgery for humerus shaft fractures, AO classification was employed. The indication for index surgical procedure was either an acute fracture or a nonunion. Nonunions encountered were either infected or not infected with or without implant failure. Secondary surgeries included implant removal or exchange and bone grafting procedures through an anterolateral approach. We defined postoperative radial nerve palsy as complete absence of brachioradialis contraction with wrist and finger drop with or without complete sensory deficit in the first dorsal web space. We defined recovery based on the Louisiana State University Health Sciences Center criteria, i.e. grade-5, full recovery of the brachioradialis, forearm supination and wrist extension with active finger & thumb extension at least against gravity & some resistance.⁴ In patients with radial nerve palsy, the period of recovery and other

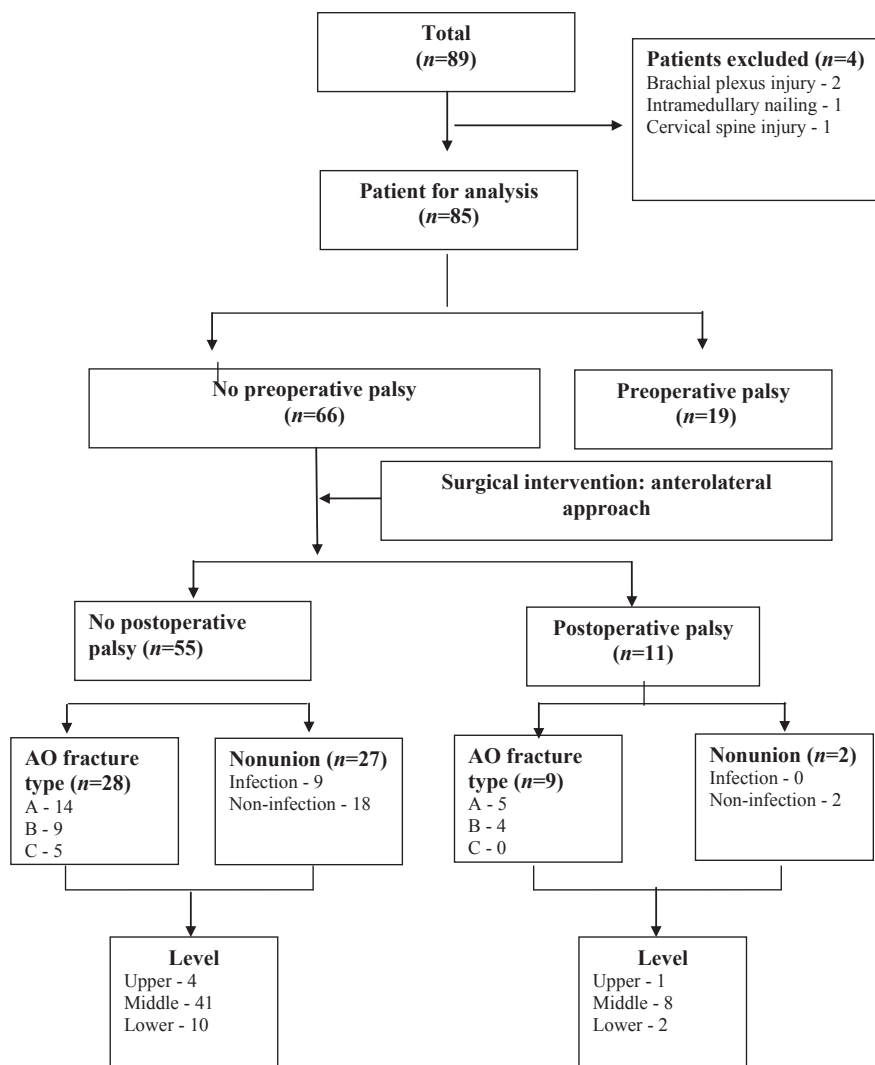


Fig. 1. Algorithmic representation of patient distribution in different groups.

procedures, if performed (nerve exploration, neurolysis, repair, nerve grafting or tendon transfers), were also documented.

Surgical technique

With the patient positioned supine and the arm stretched out on a hand table, the humerus was exposed through an anterolateral incision. The bulk of the biceps was retracted medially and the brachialis muscle was identified and split along its axis to expose the lateral aspect of the humeral shaft. If required, the insertion of the deltoid was partially elevated to ensure space for plate osteosynthesis. The radial nerve was not routinely visualized or isolated even in distal third shaft fractures. Any further procedures, manipulation, reduction and fixation maneuvers were performed with the elbow flexed. In patients who had prior surgeries or if they had implants in situ, the prior skin incision was utilized; however, deep dissection proceeded with biceps retraction and brachialis splitting to expose the humerus or the implant with further exposure subperiosteally. The wounds were closed in layers under a suction drain and postoperative neurology were documented and rechecked within 12 h or earlier.

Statistical analysis

The data was collected into an epidata form created for the study. The frequency and percentage were calculated for post-operative palsy. Chi-square or fisher's exact test was used to analysis risk factors with palsy. Logistic regression was done with those significant at 20% level of significance. SPSS 17.0 was used for analysis.

Results

From January 2007 to December 2012, a total of 85 patients underwent a surgical procedure on the humerus through an anterior approach. Among them 19 patients had radial nerve palsy at presentation (prior to our index procedure) and were not included in our analysis. As a result altogether 66 patients were included in this study, including 52 (78%) males and 14 (21%) females. The mean age of patients was 42.7 years.

The indication for the index surgical procedure was an acute fracture in 37 patients, nonunion in 20 patients and infected nonunion in 9 patients. Nonunions and infected nonunions accounted for a significant number of patients in view of this tertiary referral centre. The level of fracture/nonunion and distribution of AO fracture types are shown in Fig. 1. Of the 66 patients, 11 (16%) developed radial nerve palsy after the index procedure: 9 received surgery for acute trauma and the rest 2 for nonunion without infection or prior implants.

Of the 11 patients with radial nerve palsy, only 1 patient was lost to follow-up. All the other patients recovered within 6 months. Two patients showed full recovery within three weeks. All operative procedure in these patients was performed by either trainee registrars or junior consultants. Distribution of AO fracture classification/nonunion along with recovery pattern is shown in Table 1. The risk factors and incidence of postoperative palsy is

listed in Table 2. Patient operated by surgeons who have ≤ 2 years of surgical experience were 9.2 times more likely to develop radial nerve palsy as compared to those operated by surgeons with >2 years experience ($p = 0.002$). Patients who had surgery between 8 p.m. and 8 a.m. were about 8 times more likely to have palsy as compared to patients who had surgery between 8 a.m. and 8 p.m. ($p = 0.004$). People who had AO type A fractures is 1.3 times more likely to have palsy as compared with type B fractures but the difference was not significant ($p = 0.338$) Table 3 shows the logistic regression results of variables that can independently produce nerve injury.

Table 2
Analysis of variables for radial nerve palsy.

Variables	Palsy		p Value
	Yes	No	
Surgical experience			
≤2 years	10 (33.3)	20 (66.7)	0.002
>2 years	1 (2.8)	35 (97.2)	
Timing of surgery			
8 a.m. – 8 p.m.	4 (8.3)	45 (91.7)	0.004
8 p.m. – 8 a.m.	7 (41.2)	10 (58.8)	
AO classification			
Type A	5 (23.8)	16 (66.7)	0.338
Type B	4 (33.3)	8 (66.7)	
AO trauma			
Open	1 (14.3)	6 (85.7)	1.000
Closed	8 (25.0)	24 (75.0)	
Uninfected nonunion			
With implant failure	0 (0)	10 (100)	0.474
Without implant failure	2 (20.0)	8 (80.0)	
Level			
Upper 1/3	1 (25.0)	3 (75.0)	0.898
Middle 1/3	8 (16.0)	42 (84.0)	
Lower 1/3	2 (16.7)	10 (83.3)	
Comorbidity			
Diabetes	1 (11.1)	8 (88.9)	0.488
Hypertension	2 (33.3)	4 (66.7)	
Associated injuries			
Other long bones	1 (20.0)	4 (80.0)	1.000
Poly	1 (20.0)	4 (80.0)	
Infected nonunion			
With implant failure	0	4 (6.0)	Not applicable
Without implant failure	0	3 (4.5)	
Soft tissue			
Good	0	2 (3)	Not applicable
Poor	0	1 (1.5)	

Table 3
Logistic regression of factors which can independently produce nerve injury.

Variables/Risk	OR	95% CI	p value
Surgery experience			
≤2 Years	1.000	0.98–85.81	0.052
>2 Years	9.17		
Timing of surgery			
8 a.m. – 8 p.m.	7.70	1.88–31.45	0.004
8 p.m. – 8 a.m.			
AO classification			
Type A	1.30	0.24–7.07	0.763
Type B	1.00		

Table 1
AO classification of the fracture pattern and duration of recovery in the 10 patients with radial nerve palsy.

AO type/Nonunion	No. of cases	Recovery within three weeks	Recovery in three weeks to six months
A	5	1	4
B	4	1	3
Nonunion	1	0	1

Discussion

The radial nerve winding around the humerus and “tethered” within the lateral intermuscular septum is known to be always at risk with fractures and surgical exposures of the humeral shaft. The anterolateral approach which requires splitting of the brachialis may be theoretically safe as the radial nerve is not directly dealt with or explored. In his classic manuscript Henry¹ describes the split brachialis belly as a buffer against the radial nerve and even goes on to claim that in all his exposures he encountered only a single radial nerve injury. As the patient is positioned supine there is an added advantage of easy positioning and anaesthesia, especially in multiple injured patients.² With the increase in operative procedures for the management of humerus shaft fractures/nonunion, iatrogenic acute radial nerve palsies can no longer be considered as rare events.^{5,6}

In our series of 66 patients, the incidence of postoperative deficit was found in 11 patients (16%). In our center, procedures on the humeral shaft are routinely performed through the anterior brachialis splitting approach and are usually performed by trainee registrars and junior consultants (≤ 2 years experience). The incidence of radial nerve palsy for various approaches to the humerus is difficult to ascertain from the existing literature. In a meta-analysis by Shao et al⁷ the overall radial nerve palsy in humerus fractures was 11.8%. However incidence of postoperative deficit following the anterolateral approach is obscure as various studies tend to involve a combination of approaches and fixation modalities for humerus shaft fractures and nonunions. Wang et al⁸ have documented deficit in the range of 4%–5%, but these studies failed to exclude patients with a preoperative deficit. In the series by Wang et al⁸ the mean time to beginning of clinical recovery was 16 (5–30) weeks. In our series the documented postoperative deficit was 16% with most recovered in 3–6 months. In addition we have noticed that two of our patients showed recovery within a period of 3 weeks which is much earlier than the duration described by Wang et al.

Shao et al⁷ in their meta-analysis found the prevalence of radial nerve palsy to be more common with transverse and spiral fracture patterns and fractures involving the lower and middle third humeral shaft. Similarly in our series AO type A fractures accounted for 55% of postoperative deficits which never occurred in patients with an upper third fracture/nonunion ($p = 0.338$). In this study experience of the operating surgeon (≤ 2 years vs. > 2 years) and timing of surgery in a day (8 a.m.–8 p.m. vs. 8 p.m.–8 a.m.) was the significant predictive factor for postoperative radial nerve palsy ($p < 0.05$). The reason for increased cases of radial nerve palsy at night times is probably may be due to fatigue of surgical team.

The incidence of postoperative radial nerve palsy in our series is unusually high (16%) as compared with other studies. We attribute this to various causes both analytical and otherwise as the 16% recorded here excludes those with a preoperative deficit. Other possible causes would be inadequate experience of the operating surgeon, enthusiastic preservation of “biologic” soft tissue, improper retraction or placement of hardware and reduction instruments. The soft tissue sleeve is more likely to be intact following a lower energy fracture. Hence inadequate release coupled with overzealous retraction and reduction maneuvers may account for radial nerve deficits.

We also stress on nonoperative treatment options now more than ever, which are known to have good union rates with low complications and problems and continue to offer and encourage this treatment modality in most patients with isolated injuries. Considering the incidence of postoperative palsy, we recommend alternate approaches^{9,10} to the humerus be employed in centers

unfamiliar with the brachialis splitting anterolateral approach. We have instituted regular cadaveric dissection training programs and tutorials for our trainee registrars to ensure adequate knowledge on anatomy of surgical exposures.

We now perform minor alterations to the existing approach such as subperiosteal elevation of the brachialis laterally with careful release of the lateral intermuscular septum to prevent tethering and adequately mobilize the radial nerve, letting it fall away from the humeral shaft. This release of the intermuscular septum under vision is stressed in a modified posterior approach to the humeral shaft.¹¹ We also stress that all manipulation and reduction maneuvers be performed with the elbow flexed. We now stress on this step during exposure as we feel that neuropraxia of the radial nerve occurs due to the tethering effect of the intact septum which would occur in lower energy injury patterns (spiral and short oblique). This is probably the reason why deficits are less common with higher energy patterns. This claim is yet to be verified with cadaveric and larger clinical studies.

In conclusion, the primary aim of this study was to identify predictive factors for iatrogenic radial nerve palsy when the anterolateral brachialis splitting approach was used. We found that oblique-transverse low velocity fracture patterns in the middle-distal third shaft region, surgeries performed by surgeons with ≤ 2 years operating experience and surgeries done at 8 p.m.–8 a.m. were high risk factors to develop a radial nerve deficit after operation. Contrary to our expectations, secondary procedures and prior multiple surgeries with failed implants and poor soft tissue were not predictive factors for postoperative deficit. This series though have mixture of fractures and nonunion, we mainly concentrate at the anterolateral approach rather than type of fractures. From our study, we also conclude recovery can be reasonably expected in all patients with a postoperative palsy following the anterior approach.

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