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Original Research Article

A Study on Patient Outcomes, Rotator Cuff Integrity and Shoulder Function after Intra Medullary Nailing of Diaphyseal Fractures of Humerus

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Abstract:
The surgical management of humeral diaphyseal fractures have different inherent draw backs owing to the complex anatomy, the unique biomechanical characteristics of the humerus which are often overlooked and characteristics of the arm and shoulder with their anatomical considerations also play a role. Antegrade intramedullary nailing in humeral shaft fracture allows a stable fixation with satisfactory outcomes. The antegrade nailing is a better option in younger patients, and in humerus with moderately wide or wide medullary canals. This study has been performed on 60 patients with humeral shaft fractures. The functional status of the shoulder is assessed post operatively at three months with Constant-Murley scores and the level of proximal tip of the intra medullary interlocking nail.
Keywords: Fracture shaft of the humerus – proximal entry point – rotator cuff integrity – shoulder function.

Introduction

The humerus shaft fractures have been very common occurrence in a trauma setting. The humeral shaft fracture has been associated with comparable results with conservative and surgical managements based on location of the fracture. In fact, the surgical management has different inherent drawbacks owing to the complex anatomy, the unique biomechanical characteristics of the humerus which are often overlooked and characteristics of the arm and shoulder with their anatomical considerations also play a role.

Humerus being a non-weight-bearing bone can have limitations and or disadvantages due to no additional advantage with dynamization, dynamic fixation, disadvantage of non-unions, uneven intramedullary canal, access and entry points through rotator cuff.

Shoulder impairment remains an important complication of intramedullary nailing. The procedure involving the splitting of supraspinatus tendon to expose humeral head for nail insertion has been attributed for it, even though it is followed by the repair of the tendon.[1] Patients in modern times have been more satisfied with faster union and quick return to preinjury activities while preserving the movements at nearby joints. [2,3].

The other treatment modalities following humeral shaft fractures, like bracing or plating with prolonged immobilization in the pre-operative period can be considered to be the precipitating factor for limitation of movements.[4-8] The stiffness and discomfort of the shoulder joint are commonly encountered issues with these fractures, which are often complained irrespective of the method adopted for treatment.These symptoms take several weeks' time and intensive physiotherapy for regaining movements.

Relevant anatomical considerations about shoulder joint:

The fibrous capsule of the shoulder joint is covered and supported by the tendons of supraspinatus superiorly, infraspinatus and teres minor posteriorly, sub-

scapularis anteriorly and by the long head of triceps inferiorly.

The muscles which produce movements at the glenohumeral joint are principally deltoid, pectoralis major, latissimus dorsi and teres major. These long muscles converge on the humerus, acting as mechanical advantage on a joint which, as a result of glenoid shallowness and capsular laxity, is relatively unstable. The long muscles are counteracted by the rotator cuff, a group of short muscles (subscapularis, supraspinatus, infraspinatus and teres minor) which are attached nearer to the joint, and which centre the head of the humerus in the glenoid fossa through the midrange of motion, when the capsuloligamentous structures are lax. Flexion at the shoulder joint is produced by Pectoralis major (clavicular part), deltoid (anterior fibres) and coracobrachialis assisted by biceps. The sternocostal part of pectoralis major is a major force in flexion forwards to the coronal plane from full extension.

Extension at the shoulder joint is produced by Deltoid (posterior fibres) and teres major, from the dependent position. When the fully flexed arm is extended against resistance, latissimus dorsi and the sternocostal part of pectoralis major act powerfully until the arm reaches the coronal plane.

Abduction is produced by Deltoid initially, its effect is mainly upward and, unless opposed, this would displace the humerus upwards. Subscapularis, infraspinatus and teres minor exert downward traction and so apply an opposing force: together with deltoid they constitute a ‘couple' to produce abduction in the scapular plane.

Internal rotation is produced by Pectoralis major, deltoid (anterior fibres), latissimus dorsi, teres major and, with the arm pendent, subscapularis.

External rotation is produced by Infraspinatus, deltoid (posterior fibres) and teres minor. Lateral rotation is important for clearance of the greater tubercle and its associated tissues as it passes under the coracoacromial arch, as well as for relaxation of the capsular ligamentous constraints.

The subacromial space is bounded inferiorly by the humeral head, and superiorly by the anterior edge and inferior surface of the anterior third of the acromion, coracoacromial ligament and acromioclavicular joint, forming the coracoacromial arch. Impingement of the rotator cuff tendons on the undersurface of the coracacromial arch can cause stiffness and painful movements. The cuff normally impinges against the coracoacromial arch when the humerus is abducted, flexed and internally rotated.

There are many Vulnerable structures around the shoulder that could be injured during antegrade intramedullary nailing include the axillary nerve, the circumflex artery, the long head of biceps, and the deltoid. These structures are usually injured by the proximal locking bolts, and modern targeting devices have not abolished this complication, A rotational error for proximal locking bolts can breach the bone and tendon in the bicipetal groove. [9-16]. All the possible injuries are in addition to the breech of superior joint capsule and supra spinatus tendon. The antegrade nailing is a better option in Younger patients and in humerus with moderately wide or wide medullary canals.[17]

The antegrade procedure has been implicated for postoperative shoulder pain and stiffness, which are problems due to the intra-articular entry portal and the violation of the rotator cuff. Humerus, being a non-weight-bearing bone, can be immobilized internally without the widest/strongest nail. During antegrade humeral nailing, reaming could cause further injury to the rotator cuff after the incision is made and with the repeated usage and maneuvering for insertion and withdrawal of several sharp reamers. The sutured rotator cuff could act as a sealed enclosure for the by-products of reaming and their accumulation underneath may trigger congestion physically as well as with subsequent inflammation.

After a failed conservative trial, the nailing cannot take advantage of fresh fracture hematoma. For all these reasons, intramedullary nailing of humeral shaft fractures should be performed sooner than later in order to take advantage of the fresh haematoma. Furthermore, the rotator cuff could act as a filter for the by-products of reaming and their accumulation underneath may play a role in the pathogenesis of problems that some patients experience postoperatively. The heat-induced and soft tissue injury, segmental necrosis can trigger several deleterious events post operatively.[18-20]

The humerus fracture cannot be effectively dynamized as humerus is not a weight bearing bone. For all these reasons, intramedullary nailing of humeral shaft fractures can be performed to allow rapid shoulder and elbow joint functional recovery and prompt return to work and activities.

Our study is aimed at finding a possible correlation between the soft tissue injury caused in the procedure for fracture fixation of humeral shaft in the three fifths of diaphysis treated with a proximal entry for intra medullary nailing.

Materials and Methods

This study has been performed on 60 patients with humeral shaft fractures treated in our institution between January 2022 to March 2023. The inclusion criteria for study are patients from 18 - 45 years of age presenting with simple, closed humeral shaft fractures with angular and linear deformities, with consecutive sampling technique: where in all patients presenting with humerus shaft fracture meeting the inclusion criteria in the study duration are included.

Exclusion criteria for our study are patients with pathological fractures, open fractures, and with diagnosed preoperative rotator cuff lesions, limitation of movements at shoulder preoperatively, bruising around shoulder, associated ipsilateral fractures in the upper limb or with preoperative shoulder impairment were excluded.

All these patients are initially evaluated for any life-threatening injuries thoroughly. They are sufficiently stabilized and a pre anaesthetic checkup has been carried out to establish the safety in taking them up for surgical procedure. These patients are treated with closed manipulation and internal fixation with intra medullary nailing with interlocking nail with proximal entry point. Patients are positioned in supine posture with sufficient padding for the scapula and forearm on a side arm board.

The skin is thoroughly scrubbed and drapped to give access to the skin from the shoulder to elbow joints. The humerus head is accessed with an insertion started with a 2-3 cm skin incision which is made from the anterolateral edge of the acromion obliquely forward. In the subcutaneous plane and deltoid muscle are incised in line with the fibres to reach the subacromial bursa and rotator cuff. The entry point of the nail is verified with an image intensifier.

The rotator cuff is then incised in the direction of the supraspinatus tendon about 1.5 cm, as near as the musculotendinous portion to avoid injury to the supraspinatus footprint. A 2 mm K wire is passed after checking the rotation of the proximal fragment. An entry point thus marked is further extended in the medullary canal with bone awl later. A guide wire is passed through the proximal fracture fragment, through the fracture and into the distal fragment. The nail was inserted through the reduced fracture site and was fixed proximally and distally with self-tapping cortical screws.

The precautions are to avoid lateral entry points breaching the cuff and bone corresponding to the footprint of supra spinatus and to keep the nail size to be buried to cortical bone. The repair of the soft tissues is meticulously done at the all the soft tissue layers that are incised.

In the post operative period arm pouch is used for four weeks and elbow Range of Motion (ROM) has started from first post operative day. Shoulder passive and active assisted ROM were started from post-operative day 10 after suture removal.

Active shoulder exercises were started at four weeks and active resistance exercises were started at six weeks. Patients were followed-up at the intervals of six weeks, three months and six months post operatively. Radiographs with Anteroposterior (AP) and lateral views were taken for six weeks and three months follow-up to assess union at the fracture site. The breach of rotator cuff tendon and lesions after humeral intra-medullary nailing are quite evident with technique as the entry point has to breach the joint capsule and rotator cuff as well.[21,22]

The breach of rotator cuff is assessed in terms of functional status following recovery from the soft tissue injury by plotting against the level of the proximal tip of the nail in relation to the length at the level of proximal end of the humerus in post operative radiographs.

The deepest point of the slot at the tip of the interlocking nail used for the humerus measures to 4 mm from the tip. This length of the nail if seen as proud from the proximal cortical end of the humerus is obviously in the sub acromial space. There are three possible situations either the nails is totally buried (B), or in line with proximal end of humerus (L) or protruding from the proximal end of the humerus(P).

The functional status of the shoulder is assessed post operatively at third post operative month with Constant-Murley scores. This score considers the Pain, Activity, Motion and Strength for assessment which totals up to 100. The Constant-Murley scores can assess shoulder disorders in general by combining subjective and objective measurements viz., pain (15 points), activities of daily living (20 points), strength (25 points) and the range of motion (40 points).

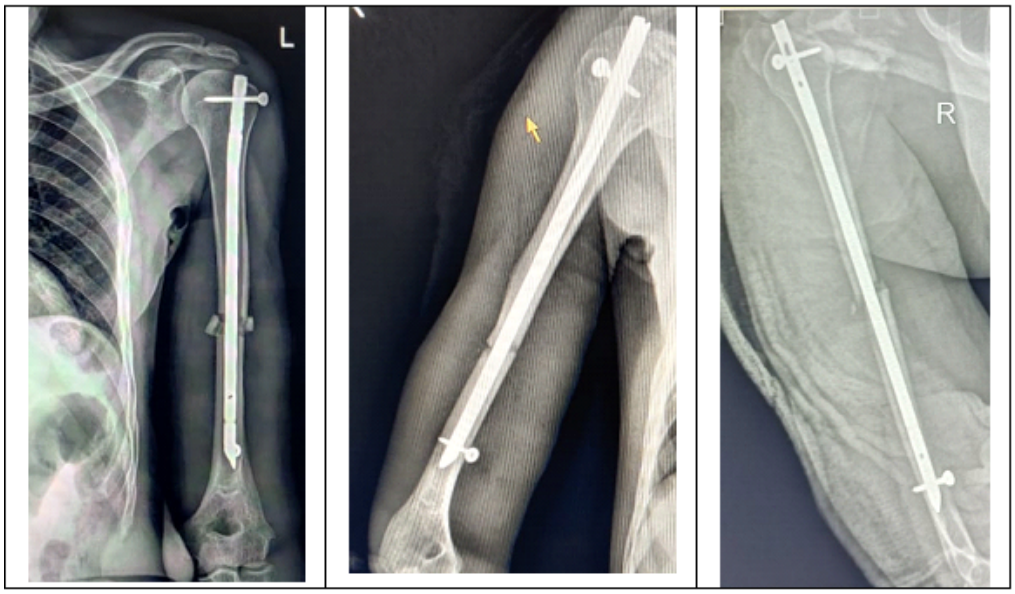

Figure 1: Levels of Proximal tip of IL Nail Humerus

Results

The study has analyzed the outcomes considering the Level of the proximal tip of the nails and Constant – Murley shoulder outcome score.

Data is subjected to analysis using IBM SPSS version 20 software (IBM SPSS, IBM Corp., Armonk, NY, USA). Descriptive statistics, Kolmogorov Smirnov test to check the normality of the data, one way analysis of variance with Tukey's posthoc tests for multiple pairwise comparisons were done to analyze the study data. Box and whisker plot was used for data presentation.

Table 1: Comparison of mean Constant – Murley shoulder outcome score based on position of proximal tip of the IL nail

Position	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		F value	P value
					Lower Bound	Upper Bound		
Buried (B)	19	89.00	3.416	0.784	87.35	90.65	11.15	<0.001*
In line (L)	22	89.41	2.737	0.584	88.20	90.62		
Protruded (P)	19	83.58	6.203	1.423	80.59	86.57		

One way analysis of variance; p≤0.05 considered statistically significant; * denotes statistical significance.

Table 2: Multiple pair wise comparisons of mean Constant – Murley shoulder outcome score based on position of proximal tip of the IL nail

Reference Position	Comparison Position	Mean Difference	P value	95% Confidence Interval	
				Lower Bound	Upper Bound
Buried	In line	-0.409	0.951	-3.66	2.84
	Protruded	5.421*	<0.001*	2.05	8.79
In line	Buried	0.409	0.951	-2.84	3.66
	Protruded	5.830*	<0.001*	2.58	9.08

Tukey's post hoc tests; * denotes significance.

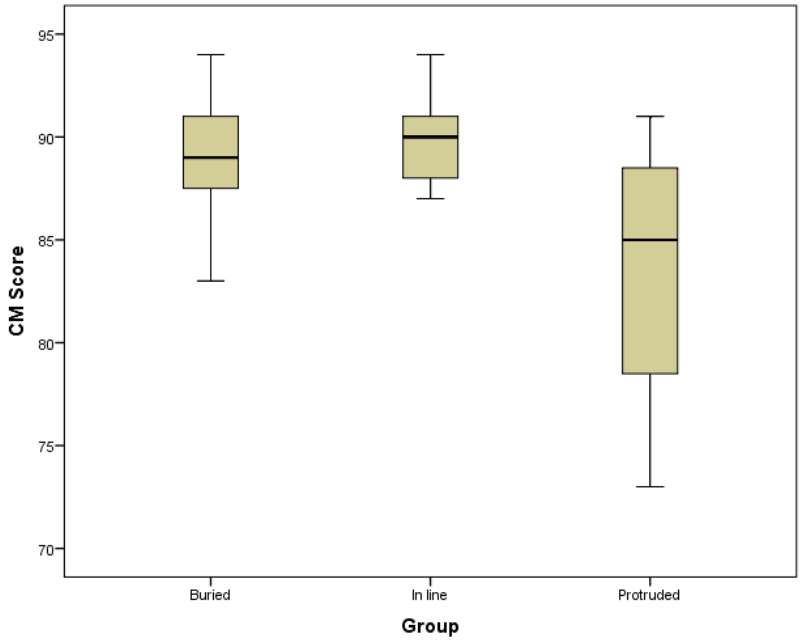

Figure 2: Box and whisker plot showing comparison of mean Constant – Murley shoulder outcome score based on position of proximal tip of the IL nail

There was significant difference in the Constant – Murley shoulder outcome score (CM score) based on the position of proximal tip of the IL nail (F=11.15; P<0.001*). It was observed that highest mean CM scores were observed when the nail is in line with the proximal cortical end of the humerus (89.41±2.73). Least mean CM score was noted in the group with protrusion of nail out of the proximal cortical end of the humerus (83.58±6.2). In post hoc analysis, it was noted that there was no significant difference between groups where the nail was buried or in line with the proximal cortical end; however, both these groups had significantly higher mean scores compared to the group where the nail was protruded.

Discussion

There is a high incidence of asymptomatic rotator cuff tears in the general population which can be more significant than the controlled stab incisions made for accessing head of humerus to make an entry point.[23] The interlocking nail of humerus has an advantage of early mobilization and restoring functional capacity especially in young patients to prevent loss of productive days. The results of this study suggest that the antegrade humeral nailing provides an acceptable functional result on the operated shoulder.

The impact of the procedure will be with less deleterious effects provided the soft tissues are gently handled and hardware is used as per the space available for fixation. The procedure involving the splitting of supraspinatus tendon to expose the humeral head and for subsequent nail insertion need not be attributed to shoulder impairment even though it is followed by the repair of supraspinatus tendon provided the post operative mobility starts as soon as possible. The nail size to certain extent can influence when protruding into the sub acromial space. The incision on the supra spinatus is better placed as medial as possible in the musculotendinous junction and totally avoiding the footprint on the greater tuberosity of humerus. The rotation of the proximal fragment has to be taken into consideration to avoid too medial or too lateral entry points. The rotation of the external jig is better aligned with the forearm to avoid injury to the long head of Biceps in the bicipital groove.

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