Functional outcome in surgically treated proximal humerus fractures with and without rotator cuff tear

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Abstract

Proximal humerus fractures are the second most common type of fractures in incidence among upper extremity fractures after distal radius fractures. With the relatively recent advent of locking plate technology and advances in surgical techniques, a greater proportion of the proximal humerus fractures are being treated surgically than in the past. Rotator cuff muscles are the main stabilizer of the shoulder joint and are torn in case of proximal humerus fractures. Their simultaneous repair along with the fixation of proximal humerus overcomes the need for multiple surgeries on later date. This study was a prospective observational study with an aim to find the incidence of rotator cuff injury and the functional outcome following repair in comparison to intact cuff in patients with proximal humerus fractures. The patients were subjected to MRI shoulder to know the rotator cuff status preoperatively and findings compared intra-operatively. The subjects were divided into 2 groups based on rotator cuff status. Cuff tears were repaired simultaneously while fracture fixation. The patients were asked to maintain arm pouch for a period of 6 weeks and followed by shoulder rehabilitation exercises. The functional outcome were then assessed at 12 weeks and 24 weeks post-surgery. The functional outcome was comparatively better in subjects who had intact rotator cuff, compared to torn rotator cuff in proximal humerus fractures at both 12 and 24 weeks follow-up. Complications like stiffness and pain was more common in patients with torn rotator cuff.

Keywords: proximal humerus fracture, rotator cuff, PHILOS plating, DASH score, ASES score

1. Introduction

The shoulder joint is a ball and socket type of synovial joint, in which proximal humerus forms one of its components. This joint stability depends on the skeletal framework along with coordinated musculotendinous units holding it together. Proximal humerus fractures constitute of about 4-5% of all the fractures in our body, and they account for 45% of all the various types of humeral fractures. Proximal humerus fractures are the second most common type of fractures after distal radius fractures in fractures of upper extremities [1]. When considering adults over the age of 40 years, the incidence rate of proximal humerus fractures increases to 76% [2]. These fractures have a bi-modal distribution occurring either in young people following high energy trauma or in elderly with low-velocity injuries like simple fall [3]. Most proximal humerus fractures are either un-displaced or minimally displaced and can be treated non-surgically [4]. Up to 80% of proximal humeral fractures can be treated conservatively, resulting in good satisfactory results [4]. Nonsurgical options focus on early functional exercises to achieve a functionally acceptable range of motion (ROM). For the 15% to 20% of displaced proximal humerus fractures can be benefited by surgical fixation. The incidence of proximal humerus fractures increases with age and it causes considerable morbidity among the elderly population and it consumes significant health care resources [5]. Although proximal humeral fractures are more frequently seen at advanced ages, the presence of associated chronic rotator cuff injuries has not been adequately studied [6]. With the relatively recent advent of locking plate technology and advances in surgical techniques, a greater proportion of the proximal humerus fractures are being treated surgically than in the past [1]. In proximal humerus fractures, the focus is mostly on the skeletal abnormality and its reconstruction, while the surrounding musculotendinous unit (rotator cuff) damage and its repair are often ignored because of lack of visualization of rotator cuff on plain radiograph [6].
Full-thickness cuff tears are more frequent in patients for more than 60 years old [7]. To add to it, visualization of these structures face an additional diagnostic problem as it would require extensive soft tissue stripping during surgery to see its intactness [8]. Although various surgical techniques have been described for the unstable proximal humerus fractures, proximal humeral internal locking systems (PHILOS) are increasingly popular for treating these fractures because they offer improved biomechanical properties by providing divergent and convergent fixed-angle screws that improve fixation and pull-out strength in osteoporotic bone [9]. Many factors are contributing to post-surgical joint stiffness/restriction, of which loss of integrity of the rotator cuff is one of them [10]. The integrity of the rotator cuff can be assessed by modalities like arthroscopy, USG, MRI. It would tell us the degree of tear and the status of each muscle of the rotator cuff. Few studies were done in trying to find out the prevalence of cuff tears in proximal humerus fractures by various radiological modalities [10, 11] but there are very few studies trying to find out the post-surgical functional outcome [12]. Although the importance of an intact rotator cuff has been emphasized for a good clinical outcome since the studies by Neers, the effect of rotator cuff repairs on the results has not been adequately investigated [9]. The purpose of this study is to find out the functional outcome in patients of proximal humerus fractures with rotator cuff tear and comparing it with patients with intact rotator cuff in proximal humerus fractures.

2. Materials and Methods
2.1 Study design
Prospective observational study.

2.2 Study population
All the patients who have attained skeletal maturity of proximal humerus and admitted to Justice K.S. Hegde charitable hospital with proximal humerus fracture.

2.3 Study setting
Department of orthopaedics in Justice K.S Hegde Hospital affiliated to K.S Hegde Medical Academy under Nitte (Deemed to be University). Hospital based study.

2.4 Study period
November 2018 – March 2020.

2.5 Method
All the patients diagnosed with proximal humerus fracture by radiography (x-ray) were taken up for the study after meeting the inclusion criteria. The fractures were classified into types based on Neer’s classification. MRI shoulder was done to know the pre-operative rotator cuff status. These findings were verified intra-operatively. Based on the rotator cuff intactness, the patients were divided into 2 groups, group 1 were the subjects with torn cuff and group 2 were patients with an intact cuff. All the patients were taken up for surgical fixation of fracture in the form of open reduction and internal fixation with PHILOS plate by deltopectoral approach. Associated cuff tears were repaired simultaneously during the primary surgery with ethibond suture material. All the patients had similar post-operative rehabilitation protocol where arm pouch was given for 6 weeks, followed by shoulder ROM exercises were started. Functional assessment was done at 12 weeks and 24 weeks post-op by DASH and ASES scores.

Fig 1: Showing supraspinatus (Yellow) and subscapularis (Green) tendon tear in case 14

2.6 Inclusion criteria
- All skeletally mature patients presenting with proximal humerus fracture. (Age more than 19 years)
- Patients voluntarily willing to participate in the study and come for follow-up at 12, 24 weeks post-surgery.

2.7 Exclusion criteria
- Patients more than 80 years of age.
- Isolated GT fractures of proximal humerus diagnosed radiologically.
- Patients with previous h/o injury/illness/surgery to the affected shoulder.
- Patient with low intensity injury leading to fracture of proximal humerus (Suspecting Pathological fracture).
- Presence of prior neurological deficits in the upper limb to be assessed.
- Patients not willing to participate in the study and any loss of follow-up.

3. Results and Discussion
All the subjects who meet the inclusion criteria and diagnosed with proximal humerus fracture were taken for the study. They underwent pre-operative MRI to know the rotator cuff status and later cross-verified intra-operatively. Group allocation was done based on the rotator cuff intactness. Group-1 were subjects with proximal humerus fractures and torn rotator cuff, while group-2 were subjects with proximal humerus fractures and intact rotator cuff. Statistical analysis was done using SPSS software.
3.1 Age distribution
The age was divided into 2 groups with age less than 50 years in one group and above 50 years in another. It was noticed from the study that most of the subjects with rotator cuff tears belonged to age group more than 50 years with a mean age group of 60.80 years. Most of the subjects in group 2 had age of less than 50 years with a mean age group of 48 years.

3.2 Incidence
A total of 24 subjects were included in the study by the end of study period of which 10 patients had rotator cuff injury which was noted intra-operatively. Hence from our study it can be concluded that the incidence rate of rotator cuff tears in proximal humerus fractures is 41.6%.

In comparison to another study done by Nanda R, Goodchild L, Gamble A, Campbell RSD, Rangan A [4]. They studied 85 proximal humerus fractures of which 43 patients had rotator cuff tear, with an incidence rate of 41.7%.

Choo A, Sobol G, Maltenfort M, Getz C, Abboud J [1] conducted a study to find out the prevalence of rotator cuff tears in proximal humerus fractures and it was found out that the rate was 8.6%.

3.3 Mode of injury
The study groups were divided based on 3 different modes of injuries which included fall from height, Road traffic accidents (RTA) and slip and fall. Even though slip and fall was the most common mode of injury in both group 1 and group 2, RTA was the mode of injury which lead to rotator cuff tears in younger subjects.

In comparison to one of the studies done by Rocco Erasmo, Giovanni Guerra, Luigi Guerra [13] which included 82 study subjects it was found that most of them had slip and fall as the most common mode of injury followed by RTA. It was concluded from the study that high velocity injury was the cause for rotator cuff tears in younger age groups.

Another study done by Gaheer, Rajinder Singh, Hawkins [14] studied the functional outcome of 3 and 4 part fractures fixed by PHILOS plating. It was found in their study that RTA was the most common mode of injury followed by slip and fall.

3.4 Arm affected
All the subjects in the study group were right hand dominant. From the study it was found that most of the subjects in group 1 had left arm affected, constituting about 60%. Most of the subjects in group 2 had right hand affected, which constituted about 71.43%.

3.5 Neer’s classification of fractures
All the patients were radiographically assessed and they were classified according to Neer’s classification into 2-part, 3-part and 4-part fractures. There were total of 8 (2-part) fractures, 10 (3-part) fractures and 6 (4-part) fractures. Most of the subjects in group 1 had 3-part fractures whereas group 2 had 2 part fractures. In our study it was noted that severity of fractures increased with age along with increased incidence of rotator cuff injury. In young subjects 3 and 4 part fractures were due to high velocity injuries like RTA.

In a study conducted by Gaheer, Rajinder Singh, Hawkins [14] it was noted that RTA was the most common mode of injury and severity of fracture increased with increasing age and the functional outcome was better in younger subjects compared to elderly. It was also inferred from the study that valgus angulation had a better outcome compared to varus angulation of humeral head post-surgical fixation and associated complications were also more in varus than valgus head.

In another study conducted by Halfen, Tobias, Siebenbürger [15] all the 2-part fractures were taken in the study and functional outcome between intramedullary nailing and PHILOS plating was studied. In their study it was noted that most of the subjects had age group less than 50 years and there was no significant difference in the functional outcome during 6 and 12 months follow-up. It also showed that they all had better outcomes and less disability following surgery.

3.6 DASH scores
All the subjects were assessed by DASH scores at 12 weeks and 24 weeks follow-up to know their functional outcome, pain and disability due to fracture and to know any difference between subjects from group 1 and group 2. It was observed from the study that both the groups had improved DASH scores from 12 weeks to 24 weeks but the group 2 had better scores compared to group 1 at both 12 and 24 weeks. Statistically it was a significant co-relation with a p-value of 0.0001. It can be concluded from the study that rotator cuff integrity plays a role in deciding the functional outcome of surgically treated proximal humerus fractures by ORIF and Intact rotator cuff has better outcome compared to torn cuff.

In line with a study done by Neslihan AKSU, Ömer ASLAN, Ayhan Nedim KARA [2] where simultaneous repair of rotator cuff was done during fracture fixation and were followed up (mean follow-up period of 17 months). It was concluded from the study that there was no significant difference in functional outcome between both the groups (i.e. between simultaneous repair group and intact cuff group).
In another study done by Tang Ying Ji, Tao Z, Li J, Yin Z [10]. They compared the functional outcome between simultaneous repair and delayed repair (>3 months following fracture fixation) of rotator cuff in subjects with proximal humerus fractures. Simultaneous repair was done by open method and delayed repair by arthroscopic method. It was concluded from the study that simultaneous repair subjects had a better outcome compared to delayed repair (assessed by constant murphy score and UCLA scores).

### Table 1: DASH scores of subjects

| Time period | Groups     | Mean  | SD    | SE  | t-value | P-value |
|-------------|------------|-------|-------|-----|---------|---------|
| 12 weeks    | Group 1    | 39.38 | 13.86 | 4.38|         |         |
|             | Group 2    | 19.08 | 7.66  | 2.05| 4.6083  | 0.0001* |
| 24 weeks    | Group 1    | 21.93 | 13.45 | 4.48|         |         |
|             | Group 2    | 8.57  | 4.18  | 1.16| 3.3862  | 0.0029* |
| Changes     | Group 1    | 15.71 | 6.73  | 2.24|         |         |
|             | Group 2    | 9.80  | 3.90  | 1.08| 2.6109  | 0.0167* |

### 3.7 ASES scores

All the subjects were followed up at 12 and 24 weeks follow-up. It was observed from the study that both the groups had improved ASES scores from 12 weeks to 24 weeks but the group 2 had better outcome compared to group 1 at both 12 and 24 weeks. Statistically it was a significant co-relation with a p-value of 0.0006. It can be inferred from the study that intact rotator cuff subjects had less disability and better functional outcome compared to subjects with torn and repaired rotator cuff.

In comparison to study conducted by Neslihan AKSU, Ayhan ASLAN, Ayhan Nedim KARA (2) where simultaneous repair of rotator cuff was done during fracture fixation and were followed up (mean follow-up period of 17 months). It was concluded from the study that there was no significant difference in functional outcome between both the groups (i.e. between simultaneous repair group and intact cuff group).

### Table 2: ASES scores of subjects

| Time period | Groups     | Mean  | SD    | SE  | t-value | P-value |
|-------------|------------|-------|-------|-----|---------|---------|
| 12 weeks    | Group 1    | 41.75 | 14.71 | 4.65|         |         |
|             | Group 2    | 65.98 | 9.72  | 2.60| -4.8714 | 0.0001* |
| 24 weeks    | Group 1    | 67.06 | 14.74 | 4.91|         |         |
|             | Group 2    | 85.00 | 5.05  | 1.40| -4.0932 | 0.0006* |
| Changes     | Group 1    | -23.63| 8.33  | 2.78|         |         |
|             | Group 2    | -18.05| 5.94  | 1.65| -1.8398 | 0.0807 |

### 3.8 Co-relation between MRI and intra-OP rotator cuff status

All the subjects were assessed pre-operatively by MRI to know the rotator cuff status and it was cross verified intra-operatively. Group 1 had subjects with rotator cuff tear, which included both partial and complete tears of rotator cuff. MRI showed 3 subjects with complete tear which was cross verified intra-operatively and was true. While 10 subjects had partial tear on MRI, only 7 were noted intra-operatively and rest 3 had intact cuff.

For the final assessment and group allocation intra-operative rotator cuff status was considered. In total there were 3 subjects with complete tear, 7 subjects with partial tear and 14 subjects with intact rotator cuff. All the subjects with partial tear had supraspinatus tear in them and associated tears, where 4 had infraspinatus and 1 had teres minor and 1 with subscapularis tear.

Coming to sensitivity of detection of cuff tears pre-operatively by MRI imaging, it was noted that 3 patients who were found to have partial tear on MRI had intact cuff, when cross verified intra-operatively. From our study it was found that the sensitivity of MRI imaging was 70%.

In comparison to a study done by Gallo RA, Altman DT, Altman GT [5], it was observed that MRI had a sensitivity of 94% and it was better than Ultrasound scan which had a sensitivity of 82%.

From the date gathered from the study, DASH scores and ASES scores of group1 (i.e. simultaneous repair of torn rotator cuff during fracture fixation) at 12 weeks and 24 weeks follow-up were compared with similar scores at same time period of surgically treated proximal humerus fractures without rotator cuff repair. It was observed that the scores were better in group with repair than non-repair at both 12 and 24 weeks, showing better functional outcome and reduced disability following surgery. The following tables show the scores from various studies which were found on PubMed search engine. Hence from this data it can be concluded that simultaneous repair of rotator cuff improves the overall functional outcome of surgically treated proximal humerus fractures.

### Table 3: DASH scores comparing between repair and non-repair groups

| Study                  | Mean DASH score 12 weeks | Mean DASH score 24 weeks |
|------------------------|--------------------------|--------------------------|
| Plath et al. [17]      | 52.0                     | 45.0                     |
| Hengg et al. [18]      | 31.0                     | 19.6                     |
| Helfen et al. [19]     | 47.2                     | 40.1                     |
| Our study              | 28.3                     | 14.8                     |

### Table 4: ASES scores comparing between repair and non-repair groups

| Study                  | Mean ASES score 12 weeks | Mean ASES score 24 weeks |
|------------------------|--------------------------|--------------------------|
| Helfen et al. [15]     | 47.6                     | 64.3                     |
| Our study              | 55.8                     | 76.21                    |
Illustrations of cases – No. 1 (Case 5)

Pre-operative X-ray

Partial Cuff tear - SS

MRI showing Partial SS tear (Red arrow) and Post-op images after PHILOS plating.
Functional outcome at 24 weeks follow-up

Restricted abduction

Restricted forward flexion
ILLUSTRATION NO.2 (Case No. 12)

Intra-op images showing partial tear of SS & IS (A); Repair of same and PHILOS plating (B)

Pre-op Image

Post-op Image
ILLUSTRATION No. 3 (Case No. 3)

Intra-op image with complete tear of cuff & Post-op PHILOS Plating

Functional outcome at 24 weeks follow-up
With restricted flexion, abduction and internal rotation
Table 5: Master chart

| Sl. No. | IP No. | Date of Sx | Age | Gender | Trauma | Affected hand | Dominant hand | Neer’s Classification | MRI RC status | Intra-op RC status | DASH scoring | DASH scoring | ASES scoring | ASES scoring | Complications |
|---------|--------|------------|-----|--------|--------|---------------|---------------|----------------------|---------------|-------------------|-------------|-------------|-------------|-------------|---------------|
| 1       | 18076037 | 08-11-2018 | 64  | Male   | Slip and fall | Left | Right | 4 part | Partial tear | Intact | 28.3 | 12.2 | 53.34 | 67.3 |          |
| 2       | 18083239 | 09-11-2018 | 46  | Female | Slip and fall | Right | Left | 2 part | Partial tear | Intact | 17.5 | 6.7 | 58.3 | 83.3 |          |
| 3       | 18088685 | 09-12-2018 | 30  | Male   | Fall from height | Left | Right | 3 part | Complete tear | Complete tear | 47.5 | 20.8 | 31.6 | 68.3 | Stiffness |
| 4       | 18095499 | 06-01-2019 | 40  | Male   | RTA | Left | Right | 4 part | Intact | Intact | 13.3 | 5 | 74.9 | 91.6 |          |
| 5       | 18096554 | 01-01-2019 | 60  | Female | RTA | Left | Right | 3 part | Partial tear – SS | Partial Tear – SS | 40 | 15 | 48.3 | 83.32 |          |
| 6       | 18098791 | 07-01-2019 | 28  | Male   | Fall from Height | Right | Left | 2 part | Partial tear | Intact | 10.8 | 5.8 | 78.3 | 89.9 |          |
| 7       | 18098946 | 08-01-2019 | 50  | Female | Slip and fall | Right | Left | 3 part | Partial tear | Intact | 20.8 | 9.2 | 69.9 | 81.6 | Pain |
| 8       | 18116356 | 04-03-2019 | 33  | Male   | RTA | Right | Left | 2 part | Intact | Intact | 18.3 | 8.3 | 69.3 | 88.3 |          |
| 9       | 18121916 | 03-03-2019 | 44  | Male   | RTA | Left | Right | 4 part | Partial tear – SS | Intact | 20.6 | 9.8 | 68.3 | 82.3 |          |
| 10      | 19012669 | 05-05-2019 | 70  | Female | Slip and fall | Right | Left | 2 part | Partial tear | Intact | 35.8 | 20 | 50 | 73.3 |          |
| 11      | 19021186 | 04-06-2019 | 66  | Female | Slip and fall | Right | Left | 2 part | Partial tear | Intact | 30.3 | 13.3 | 51.6 | 81.6 |          |
| 12      | 19024413 | 03-06-2019 | 76  | Male   | Slip and fall | Right | Left | 3 part | Partial tear – SS, IS and Minor | Partial Tear – SS, IS | 55 | 34.9 | 26.6 | 53.2 |          |
| 13      | 19039961 | 05-07-2019 | 44  | Male   | RTA | Left | Right | 4 part | Partial tear | Partial tear | 21.7 | 6.7 | 58.3 | 86.6 |          |
| 14      | 19040867 | 01-08-2019 | 71  | Female | RTA | Right | Left | 3 part | Partial tear – SS, IS and Sub | Partial tear – SS, IS and Sub | 39.2 | 25.8 | 41.6 | 64.9 | Stiffness |
| 15      | 19042194 | 05-08-2019 | 75  | Female | Slip and fall | Left | Right | 3 part | Complete tear | Complete tear | 40 | 24.2 | 40 | 58.3 |          |
| 16      | 19046671 | 14-08-2019 | 60  | Female | Slip and fall | Right | Left | 4 part | Partial tear – SS, IS and Minor | Partial Tear – SS and IS | 33.3 | 15 | 38.3 | 59.9 |          |
| 17      | 19048442 | 20-08-2019 | 42  | Male   | Slip and fall | Right | Left | 2 part | Partial tear | Intact | 17.5 | 5.8 | 68.3 | 88.3 |          |
| 18      | 19052504 | 11-08-2019 | 30  | Female | RTA | Left | Right | 2 part | Partial tear – SS and Minor | Intact | 15.8 | 6.7 | 65.3 | 84.99 |          |
| 19      | 19067798 | 03-10-2019 | 71  | Female | Slip and fall | Right | Left | 4 part | Complete tear | Complete tear | 38.3 | 30.8 | 39.9 | 58.33 | Stiffness |
| 20      | 19077482 | 12-11-2019 | 56  | Female | RTA | Right | Left | 3 part | Partial tear | Intact | 17.5 | 8.3 | 63.3 | 81.6 |          |
| 21      | 19077807 | 14-11-2019 | 54  | Male   | Fall from height | Right | Left | 3 part | Partial tear – SS | Partial Tear – SS | 11.7 | 8.3 | 76.6 | 89.9 |          |
| 22      | 19110344 | 01-03-2020 | 54  | Male   | RTA | Left | Right | 2 part | Partial tear – SS | Partial Tear – SS | 16.3 | 8.3 | 71.3 | 82.3 |          |
| 23      | 20001082 | 25-03-2020 | 49  | Male   | Slip and fall | Right | Left | 3 part | Partial tear – SS and Sub | Partial Tear – SS | 9.2 | 4.2 | 78.3 | 88.33 |          |
| 24      | 20002605 | 02-03-2020 | 67  | Female | Slip and fall | Left | Right | 3 part | Partial tear – SS and Sub | Partial Tear – SS | 62.5 | 50.8 | 21.6 | 41.6 | Stiffness |
| 25      | 19062241 | 16-09-2019 | 61  | Male   | Slip and fall | Left | Right | 4 part | Partial tear | Intact | 28.3 | 53.34 |          | Plate backout |
| 26      | 19076610 | 10-11-2019 | 76  | Male   | Slip and fall | Right | Left | 3 part | Partial tear – SS, IS and Minor | Partial Tear – SS, IS | 55 | 26.6 |          | Died |          |

Abbreviations

|        | ASES                        | DASH                      |
|--------|-----------------------------|---------------------------|
|        | American Shoulder and Elbow Surgeons Standardized Shoulder Score. | Disability of Arm, Shoulder and Hand score. |
|        | IS                          | Rotator cuff              |
|        | Minor                       | Teres Minor               |
|        | RC                          | Stiffness                 |
|        | RTA                         | Road Traffic Accident     |
|        | SS                          | Supraspinatus             |
|        | Sub                         | Subscapularis             |
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