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ASSESSMENT OF FUNCTIONAL OUTCOME OF PHN IN PROXIMAL HUMERUS FRACTURE: A CLINICAL STUDY

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Abstract

Background: By reviewing our institution's experience and relevant current literature, this study aims to evaluate the functional outcome of proximal humerus fracture parts 2 and 3 following surgical treatment of unstable or displaced proximal humeral fractures with the proximal humerus nail.

Objective: To evaluate the functional outcomes of proximal humerus fractures of NEER classification part-2, part 3, managed by internal fixation with the intramedullary proximal humerus nail on the basis of Constant-Murley scores (CMS).

Methods: Twenty-three patients with proximal humeral fractures were surgically treated with the proximal humeral nail. Neer's classification was used to classify the fractures. Patient demographics, mechanism of injury, duration of surgery, time to healing, and any complications were recorded. The Constant Shoulder Score was used to evaluate the functional outcome. In addition, a literature review was performed to evaluate overall healing and complication rates.

Results: The mean age was 51.10 years, and the female-to-male ratio was 1.88:1. A total of 65.2% of injuries were due to a fall on level ground. A total of 69.56% of patients had NEER part 2 and 30.44% of patients had NEER part 3. The percentages of excellent, good, fair, and poor outcomes were 18%, 54%, 18%, and 9%, respectively. The percentage of excellent/good outcomes was 75% for NEER Part 2 and 66.6% for NEER Part 3. The percentages of superficial skin infection, rotator cuff stiffness, screw out (late), and screw impingement complication were 4.5%, 4.5%, 9.0%, and 4.5%, respectively

Conclusions: The Proximal humerus nail was found to be an effective implant for stabilisation of proximal humeral fractures. Functional outcome is for the vast majority of the

cases excellent or good, but in part 3 fracture patients a lower Constant score can be expected.
Keywords: Proximal humerus fracture, Proximal humerus nail, Constant Murley score, NEER Classification

1. INTRODUCTION

Proximal humeral fractures (PHFs) have become an increasingly common problem in our society in recent decades, and these fractures are defined as fractures at or proximal to the surgical neck of the humerus. As the world population has reached an older age, these fractures are becoming more common [1]. In addition, the prevalence of proximal humerus fractures continues to increase, especially in the female population [2]. They are the second most common upper extremity fracture and the third most common non-vertebral osteoporotic fracture after proximal femur and distal radius fractures, accounting for 10% of fractures in the population over 65 years of age [3-7].
In 2000, more than 706,000 proximal humerus fractures were reported worldwide [8].In adults, a unimodal distribution is seen with a peak at age 84 years in both men and women [9,10]. After 40 and 60 years of age, the incidence increases exponentially by almost 40% per 5 years in both women and men [10,11,12]. As a result, women are more commonly affected than men, with men accounting for only 15% to 30% of the total fracture burden [13]. Patients with proximal humerus fractures are on average 63 years old [6], with affected men being on average 8 years older than affected women (66 vs. 74 years) [14].
Osteoporosis is a major risk factor for PHF, and the incidence of PHF is also higher in people with visual impairment, hearing aid users, diabetes mellitus, depression, alcohol use, anticonvulsant treatment, and maternal history of hip fracture [15-20]. However, both calcium intake and hormone replacement therapy have been identified as protective factors [22,23].
Fractures of the proximal humerus increase the likelihood of fractures of the proximal femur and distal radius in the future. [24] Compared with matched pairs without proximal humerus fractures, patients with PHF have a fivefold higher risk of hip fractures. [25,26] Patients with proximal humerus fractures have a 2.5 times higher risk of vertebral fracture and a 2.8 and 2 times higher risk of upper and lower extremity fracture, respectively [27]. Nearly half of all proximal humerus fractures occur at home as a result of falls from flat surfaces [28,29]. In the elderly over 60 years of age, over 90% of proximal humerus fractures are due to falls from a standing position. In younger populations, these fractures are the result of higher energy trauma, falls from great heights, traffic accidents, sports injuries, or assaults [30,31]. Three main types of loading appear to be responsible for proximal humerus fractures: compressive loads applied to the glenoid by the humeral head, bending forces applied at the level of the surgeon's neck, and tensile loads generated by the rotator cuff at the greater and lesser tuberosities. The fracture pattern of the proximal humerus is influenced by bone quality, kinetic energy transmitted to the shoulder, and the position of the upper extremity at the time of injury.
The majority of proximal humerus fractures are solitary events [32,33]. However, associated injuries are also possible. Court-Brown et al.[33] discovered in one of the largest proximal humerus fracture series that 90% of proximal humerus fractures in patients aged 10 to 99 years were solitary events. Other musculoskeletal injuries were sustained by 97 of 1,015 patients (10%), including distal radius fractures in 3% and proximal femur fractures in 2% of cases. In polytrauma patients with proximal humerus fractures, single life-threatening and other injuries should not be overlooked.

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Despite the high incidence of these injuries in the general population, there remains a comparative lack of high-quality evidence on their treatment, particularly with regard to the more complex proximal humerus part 3 and part 4 fractures. Options for surgical fixation have increased over the past two decades. A 2012 Cochrane review of 23 randomised controlled trials concluded that there was insufficient evidence to make recommendations [12]. There is considerable heterogeneity between studies, making conclusions difficult. In general, minimally displaced fractures, poor surgical candidates, and low-demand patients are treated conservatively. Displaced, comminuted, or angulated fractures that occur in good surgical candidates are treated with percutaneous pinning techniques, intramedullary nailing, plating, or endoprosthesis. In this study, we aim to evaluate the functional outcomes of proximal humerus fractures of NEER classification part- 2, part 3, managed by internal fixation with the intramedullary proximal humerus nail on the basis of Constant-Murley scores (CMS).

2. MATERIALS AND METHODS

This observational retrospective and prospective study was conducted in the Department of Orthopaedics, Nehru Hospital, B.R.D. Medical College, Gorakhpur, U.P. All patients with proximal humerus fracture with two or three fragments with or without metaphyseal extension according to Neer classification were studied. Diagnosis was made using true anteroposterior (AP) and y-views radiograph of the shoulder and when necessary, CT scan to accurately assess the fracture pattern. Surgical profile blood investigation done for pre anaesthetic clearance and surgical fitness.
This study was conducted in accordance with the principles of the Declaration of Helsinki. All patients signed informed consent about the treatment they underwent and the processing of their personal data for each patient gender, age at the time of surgery, follow-up time, dominant limb, type of trauma (low or high energy), complications and revision surgery recorded. All the pre-operative, post-operative and follow-up radiological images studied and functional outcomes were analyzed. Patients with skeletally matured, NEER'S two parts, three part fractures of the proximal humerus and close fracture were included. Patients with immature skeletons, distal neurovascular deficit, head injuries, NEER'S 1 part, 4 part fractures, NEER'S 2 part Greater tuberosity or lesser tuberosity fractures, and coexisting acute systemic infections were excluded.
All patients were admitted to the operating room according to the usual preoperative protocol. Patients were placed supine on a radiolucent table with the arm free under brachial block or general anesthesia. Fracture reduction was performed either by traction and manipulation through adduction and rotation movements of the arm or by joystick maneuvers with K-wires. A diagonal skin incision was made approximately 5 cm anterolateral to the acromion. After splitting the fibers of the deltoid muscle longitudinally along their fibers between the anterior and middle thirds of the deltoid muscle. Under direct observation, the rotator cuff is cut along its fibers. Full-thickness sutures to protect the cuff from damage during reaming of the humeral canal. A threaded pin used as a "joystick" in the posterior humeral head to derotate the head to a reduced position. The entry point for the nail was then established through the cuff gap posterior to the intra-articular portion of the biceps tendon and approximately 1.5 cm medial to the most medial edge of the greater tuberosity (also the junction between the head and the tuberosity) to ensure a rigid and firm hold of the humeral head fragment while avoiding damage to the supraspinatus attachment.

The entry point was placed using a bone awl. The guide wire was placed and advanced under fluoroscopy. After the entry point was created and the guide wire was passed over the

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fracture site, the Entry Cuff Guard was used to retract the soft tissue of the rotator cuff to visualize the bone. Sequentially larger burs were used to ream the humerus, usually 1.0 to 1.5 mm larger than the nail diameter. The proximal reamer is advanced carefully, sparing the rotator cuff. After reaming, the second-generation proximal humeral nail (PHN) was inserted using the mounted primary tang. The nails were inserted with a rotational motion. Each step was analyzed under the presentation of the C-arm. Once reduction was achieved after full advancement of the nail, the two proximal lateral locking screws were inserted using the primary cig. The required lengths of the locking head screws were determined using a direct measuring device. The number of proximal locking screws for fracture fragment acquisition depends on the fracture configuration and bone quality and ranges from three to five screws. We routinely attempted to insert the medial calcar screw except in cases where it could not be optimally positioned. Proximal anterolateral and posterolateral locking was accomplished by attaching secondary cigs to the primary assembly. All proximal locking screws were placed unicortically. AP views (internal and external rotation) and axillary views at 90 degrees to each other were used to visualize screw placement. Finally, distal locking was performed through the primary cig. The wound was closed in layers and an aseptic dressing was applied. The shoulder was immobilized with a universal shoulder brace. The sutures were removed 10 to 14 days after surgery

Once patients are able to tolerate pain, active extension exercises of the elbow, wrist, and hand, as well as pendulum exercises, are recommended. Passive forward extension and external rotation are allowed depending on the degree of fracture stability achieved and the quality of the bone. Passive range-of-motion exercises are often continued during the sixth postoperative week. Transition to strengthening exercises occurs three months after initiation of actively assisted range of motion.

Functional outcomes were assessed at final follow-up using the Constant-Murley score. The Constant-Murley score (CMS) was introduced in 1987 as an instrument to assess overall shoulder function independent of diagnosis. It was approved and recommended by the Executive Committee of the European Society of Shoulder and Elbow Surgery and has since been widely used as an assessment tool. The CMS scale assesses four components of shoulder pathology, two of which are subjective: Pain and activities of daily living (ADL), and two are objective: range of motion (ROM) and strength require physical assessment and are answered by

Pain felt during normal activities of daily living was scored as follows: no pain = 15 points, mild = 10, moderate = 5, and severe = 0 points.

The ADL component is worth a maximum of 20 items and assesses limitations in routine work, leisure activities, uninterrupted night sleep, and arm posture to a certain degree. The first two items were originally graded as follows: no limitation = 4, moderate = 2, and severe = 0 points. In the most recent edition, a VAS was proposed for both questions, whereas the score range for the other two remained unchanged. Night sleep is scored as follows: not impaired = 2, occasionally disturbed = 1, always disturbed = 0 points. Finally, arm posture is scored as follows: to waist = 2, xiphoid = 4, neck = 6, head = 8, above head = 10 points.

In the ROM section, four active ranges of motion are scored with ten points each: painless forward and lateral movement, external and internal rotation. In the seated position, degrees of elevation are measured with a goniometer, and scores range from 0°-30° = 0 to 151°-180° = 10 points. External rotation is determined by five unsupported hand movements, for each of which two points are awarded: Hand behind head with elbow forward, hand behind head with elbow back, hand on head with elbow forward, hand on head with elbow back, and complete elevation. The thumb is recommended as a pointer for internal rotation to the following anatomical landmarks: lateral thigh = 0, buttock = 2, lumbosacral junction = 4, waist = 6, 12th dorsal vertebra = 8, and interscapular area = 10 points.

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The strength component is scored as 25 points. At baseline, subjects were instructed to use an unsecured cable tensiometer or spring scale, and scoring was based on the tensile force a subject could sustain up to 90° of abduction. This is done at 90° abduction with the hand pointing downward using either a dynamometer or a defined spring balance technique, according to the revised recommendations. Three consecutive repetitions should be used as the maximum value. If the required abduction is not achieved, the subject will receive 0 points.

Statistical Analysis

The collected data were entered into MS Excel 2010 and the qualitative variables, expressed as proportions, and the quantitative variables, summarized as mean and standard deviation, were statistically analyzed. The Chi-square test was used to compare the categorical variables. The p value 0.05 was considered significant.

3. RESULTS

The percentage of age groups ≤20 years, 21-30 years, 31-40 years, 41-50 years, 51-60 years, and > 60 years was 4.35%, 0.00%, 8.70%, 34.78%, 30.43%, and 21.74%, respectively. Of the 23 patients, a total of 8 (34.78%) were male and 15 (65.22%) were female, with the percentage of female:male ratio 1.88:1. The percentage of patients who were housewife, worker, professional, or student was 65.22%, 21.74%, 8.70%, and 4.35%, respectively. A total of 13.045 patients had hypertension, and 4.35% of patients had DM.

Table 1: Baseline characteristics of the patients

		n	%
Age (years)	≤20 years	1	4.35
	21-30 years	0	0.00
	31-40 years	2	8.70
	41-50 years	8	34.78
	51-60 years	7	30.43
	>60 years	5	21.74
	Mean	51.104	
Gender	Male	8	34.78
	Female	15	65.22
Occupation	Housewife	15	65.22
	Labour	5	21.74
	Skilledwork	2	8.70
	Student	1	4.35
Hypertension	Yes	3	13.04
	No	20	86.96
DM	Yes	1	4.35
	No	22	95.65

Table 2 shows the distribution of patients by injury type, injury site, and NEER'S classification. Of the 23 patients, 26.08% had a road traffic accident, 65.2% had a fall on level ground, and 8.70% had a fall from a great height as the injury type. A total of 60.8% had a right-sided injury and 39.13% had a left-sided injury. The percentage of NEER part 2 and NEER part 3 were 69.56% and 30.44%, respectively.

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Table 2: Distribution of patients by injury type, injury site, and NEER'S classification

		n	%
Mode of injury	Road traffic accident	6	26.08
	Fallon level ground	15	65.2
	Fall from height	2	8.70
Side of injury	Right	14	60.8
	Left	9	39.13
NEER'S Classification	NEER Part 2	16	69.56
	NEER Part 3	7	30.44

Values are presented as mean, median, SD deviation, minimum, and maximum. The mean duration of surgery (min) was 84.65±13.09 with a range of 50-110. The mean length of stay (days) was 6.04±1.58 with a range of 3-9 days. The range of Constant Shoulder Score was 46-90, and the mean constant shoulder score was 74.00±14.09 (Table 3).

Table 3: Details of duration of procedure (min), length of stay (days) and Constant shoulder score

	Mean	Median	Std. Deviation	Minimum	Maximum
Duration of surgery (min)	84.65	82.00	13.09	50	110
Duration of stay(days)	6.04	6.00	1.58	3	9
Constant shoulder score	74.00	79.00	14.09	46	90

One patient lost to follow-up was excluded from the examination. The percentage of excellent, good, fair, and poorwere18%,54%,18%and9%, respectively. The percentage of excellent, good, fair, and poor were18.75%, 56.25%, 18.75%, 6.25% in NEER part 2 and 16.6%, 50%, 16.6%, and 16.6% in NEER part 3. The functional outcome was not significantly different in between NEER Part 2 and NEER Part 3 (Table 4).

Table 4: Association of functional outcomes according to consent shoulder score in NEER part 2 and part 3

		NEER Part 2		NEER Part 3		**Total**	**p-Value**
Functional outcomes	**Constant Score**	**n**	**%**	**n**	**%**		
Excellent	≥ 86	3	18.75	1	16.6	4 (18%)	0.739
Good	71–85	9	56.25	3	50	12 (54%	
Fair	56–70	3	18.75	1	16.6	4 (18%)	
Poor	55	1	6.25	1	16.6	2 (9%)	
Total		16	100	6	100	22	

The percentages of superficial skin infection, rotator cuff stiffness, screw out (late), and screw impingement complication were 4.5%, 4.5%, 9.0%, and 4.5%, respectively (Table 5).

Table 5: Details of complications

Complication	n	%
Superficial skin infection	1	4.5

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Rotator cuff stiffness	1	4.5
Screw backing out (Late)	2	9.0
Screw impingement	1	4.5

4. DISCUSSION

Proximal humerus fractures (PHFs) have become an increasingly common problem in our society in recent decades as the world population has reached an older age and the incidence of these fractures has increased [1]. In addition, the prevalence of proximal humerus fractures continues to increase, especially in women [2]. Osteoporosis is a major risk factor for PHF in women [15], and the incidence of PHF is also higher in people with visual impairment, hearing aid users, diabetes mellitus, depression, alcohol use, anticonvulsant medication, and a history of hip fracture in the mother [15-20].

In 2000, more than 706 000 fractures of the proximal humerus were reported worldwide [8] Notwithstanding the high incidence of these injuries in the population, there remains a comparative vacuum of high-level evidence on their treatment, particularly with regard to the more complex fractures of the third and fourth parts of the proximal humerus. In 2012, a Cochrane review of 23 randomised controlled trials concluded that there was a lack of sufficient evidence to make treatment recommendations [12]. There is considerable heterogeneity between studies, making conclusions difficult. In general, minimally displaced fractures, poor surgical candidates, and low-demand patients are treated conservatively. Displaced, comminute, or angulated fractures that occur in good surgical candidates are treated with percutaneous pinning techniques, intramedullary nailing, plating, or arthroplasty.

In our study, PHF was frequently found at an age greater than 40 years, with a mean age of 51.104 years (range 20-88 years). Passaretti D et al [34] observed that the mean age of patients with proximal humerus fractures was 54.83 ±19.01 (21-84) years. Hao et al. (2017) [35] reported that the mean age was 55.7 ± 18.0 years. Thyagarajan et al. (2009) [36] showed that the distribution of patients among the age groups 15-35 years, 36-55 years, 56-75 years, and 76-95 years was 17.24%, 24.14%, 31.03%, and 27.59%, respectively.

In our study, we found that of the 23 patients, 8 (34.73%) were male and 15 (65%) were female, with a female-to-male ratio of 1.8:1. Similarly, patel et al (2022) reported that proximal humerus fractures were more common in females (64.29%), with a female-to-male ratio of 1.8.[37] Adedapo et al (2001)[38] observed the gender of patients with 338 females (71%) and 139 males (29%). Wong et al. (2016)[39] noted that the majority of patients were female, which corresponds to the gender most commonly affected by this fracture. Contrary, Sharma et al (2019) reported that the most of the patients were males (73.5%).[40]

In this study, the fracture was most commonly caused by falls on level ground (65.21%0), followed by road traffic accidents (26.08%) and falls from height (8.70%). Vijayvargiya et al. (2016) [41] reported that the most prevalent injury type was a fall (53.8%), followed by a road traffic accident (46.2%), which is consistent with the study by Herscovici et al. (50% fall injuries, 47.5% road traffic accidents).[42] (46.7%). Contrary, Sharma et al (2019) observed that the most common type of injury (73.5%).[40]

In our study, NEER part 2 (69.65%) was the most common type of fracture, while NEER part 3 was 30.44%. Sharma et al (2019) found that Neers 3 part (44.1%) was the most common type of fracture.[40]

The percentage of housewives, labourers, skilled workers and students were 65.22%, 21.74%, 8.70% and 4.35%, respectively. The percentage of falls from height, falls on level ground, and road traffic accidents were 8.70%, 65.21%, and 26.08%, respectively. It is noted that women fall more frequently than men in old age, resulting in fractures.

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In our study, the percentage of right and left sided injuries were 60.8% and 39%, respectively. In the study by Kandel et al, 34 cases (57%) were right-sided and 26 cases (43%) were left-sided, which is consistent with Joshi et al (63.3% right-sided and 36.7% left-sided) and Azhagan et al (75% right-sided and 25% left-sided).[43]

In our study the mean constant shoulder score was 74.00±14.09 with 46-90 range. Congia et al. (2020) reported that the mean Constant Shoulder Score was 81.5, and functional outcomes were excellent in 24/38 patients.[44] All fractures healed in a mean time of 3.7 months. Additional surgery was performed in five patients. Complications included penetration of the material into the joint (n = 2), a dislodged screw (n = 1), shoulder impingement due to protrusion of the nail (n = 2), and superficial infection (n = 1).

In the present study, the functional outcome was 18%, 54%, 18%, and 9% (excellent, good, fair, and poor, respectively). Sharma et al. (2019) [40] reported that of the 15 cases in the PHN group, five cases (33.3%) had an excellent outcome, and seven cases (46.7%) had a satisfactory outcome. One case (6.7%) had a satisfactory outcome, and two cases (13.3%) had an unsatisfactory outcome.

In our study, we use the second-generation proximal humeral nail [PHN] because third generation PHNs are not available. Four angle-stable locking screws are used proximally and two screws distally on the proximal humeral nail. Patients were 35% male and 65% female. The proportion of falls from height, falls on level ground, and traffic accidents were 8.70%, 65.21%, and 26.08%, respectively. Overall, in 22 patients, 18% of outcomes were classified as excellent, 54% as good, 18% as satisfactory, and 9% as poor. In the NEER Part 2 fracture group, outcomes were excellent, good, satisfactory, and poor in 3 (18.7%), 9 (56.25%), 3 (18.7%), 1 (6%), respectively. In the NEER part-3 fracture group, outcomes were excellent, good, fair, and poor in 1 (16.6%), 3 (50%), 1 (16.6%), and 1 (16.6%), respectively. Sosef et al [45] reported on a series of 33 elderly patients. Functional outcomes were satisfactory to excellent according to the CM -score, with a mean of 62, with 4-part fractures having the lowest scores. In our study, there were 22 samples at 1-year follow-up. CM SCORE was 74, and functional outcomes were also excellent to satisfactory according to the CM -score, and better outcomes were found for second- part fractures compared with third-part fractures. Mittelmeier et al [46] reported good healing and functional outcomes with an average CM score of 78 points. The main complications were 9 AVN, 3 infections, and 26 screw dislocations. Gradl et al.[47] also found mainly AVN and secondary screw dislocations as complications and reported a mean CM of 79 points at 1 year. Matthews had comparable results [45-47]. Thanasas et al. found that the incidence of avascular necrosis was 7.9%, screw dislocation 11.6%, and reoperation 13.7% [48].

In our study, superficial skin infections occurred after one week, which were treated with irrigation and dressing, rotator cuff stiffening, screw impingement complication, which occurred as a late complication in one case, and screw backout, which was noted as a late complication in two patients. To date, no patients have been found to have avascular necrosis (AVN). More complications were noted in part 3 fractures than in part 2 fractures. In our study, all fractures united by 13 weeks (n = 22/22). Our complication rate was 22.7% (n = 5/22). The size and length of the humeral nails also proved to be appropriate for our northern Indian population. This study is not without limitations. Our study had a small sample size of 22 patients, and there were no advanced PHNs of the 3rd generation present. In addition, a postoperative follow-up period of 12 months is a relatively short period. Future research is needed to determine the benefit of PHN in 3rd degree fractures.

5. CONCLUSIONS

The average age for proximal humerus fractures is 51 years, with a slight preponderance of women. The main cause of fracture is a fall to the ground. Overall, 18 % of outcomes were excellent, 54% were good, 18% were fair, and 9% had a poor outcome. NEER Excellent to good outcomes were found in 75% of NEER'S Part 2 fractures after proximal humeral nailing. Thus, we conclude that PHN is promising and can be used in fixation of proximal humerus fractures NEER part 2. NEER in cases of proximal humerus fractures, part 3, a lower constant Murley score and complications are still expected. The short duration of the procedure, limited exposure and soft tissue damage, and preservation of periosteal blood are major advantages of PHN surgery. However, further studies with large sample size and duration are needed to draw further conclusions.

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