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Research Article

Proximal Humeral Fracture; Predictors of Functional and Radiologic Outcome

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Abstract

Background: Despite the high prevalence of proximal humeral fracture, one of the most prevalent osteoporotic fractures, its treatment has always been challenging. Here we are going to determine the factors that affect the outcomes of such fractures.
Methods: The present retrograde cohort study was conducted in a tertiary trauma center during 2015-2020. The Neer classification was used to classify fracture severity. Patients' functional status was measured using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire and Constant-Murley Score (CMS). Patients were selected thorough purposive sampling method.
Results: The study participants included 70 patients with a mean age of 50.47 ± 16.73 years. The 3 treatment options of open reduction and internal fixation (ORIF) (39 cases; 52%), hemiarthroplasty (3 cases; 4%), and conservative treatment (33 patients; 44%) were considered. Malunion was the most prevalent complication in the study population (9 cases; 12%). The mean DASH score of the participants was 29.91 ± 20.43. The mean DASH score in patients of over 65 years of age was higher than in those under 65 years (36.97 vs. 28.14; P = 0.136). The score in patients underwent surgery (ORIF and hemiarthroplasty) showed a significant difference compared to the patients who were treated non-surgically (P = 0.050). The mean CMS of participants was 64.09 ± 22.71. The mean age of patients classified as "poor" was significantly higher than the "excellent" group (P = 0.041). The mean visual analogue scale (VAS) score of the participants was 2.80 ± 2.49. The VAS score was significantly higher in patients with more severe fracture based on the Neer classification (P = 0.050).
Conclusion: The present study results showed the significant effect of age, fracture severity, and underlying disease on the proximal humeral fracture outcome. A longer follow-up period was observed in patients who had better functional outcomes. However, more studies with larger sample size are required to evaluate proximal humeral fracture outcomes in order to help us to improve outcomes and reduce complications.

Keywords: Humerus; Proximal Humeral Fracture; Arthroplasty

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Background

Proximal humeral fractures account for 6% of all fractures (1). The incidence of fractures has tripled since 1970 and is expected to triple again by 2030 as a result of aging and increasing osteoporotic fractures (2, 3). Proximal humeral fractures are the third most common osteoporotic fractures after distal radius fractures and vertebral fractures (4). Osteoporotic fractures lead to significant use of health care resources, including more than 400,000 hospitalizations, 3.4 million outpatient visits, and 179,000 nursing home visits in the United States in 1995 (5).

Despite the relatively high prevalence and growing trend of this type of fracture, its treatment has always been challenging and controversial (6). In non-surgical treatment, especially in cases with severe displacement, acceptable results have not been achieved (7, 8). Although arthroplasty controls patient's pain, in some cases, it has resulted in shoulder dysfunction (9).

Open reduction and internal fixation (ORIF), which can be performed in various techniques (cerclage wiring, screw fixation, intramedullary nailing, etc.), improve the patient's pain and function, but can increase the risk of avascular necrosis (AVN) due to the possibility of damage to adjacent arteries (7, 10).

Proximal humeral fracture outcome can be affected by various factors such as age, type of fracture, underlying disease, and type of treatment (6). In addition, postoperative rehabilitation programs can improve outcomes and reduce complications (11).

The prevalence of proximal humeral fractures, as one of the most common types of osteoporotic fractures, is increasing and controversies still exist about the treatment. In addition, due to the absence of a fracture registry in most developing countries, the data on fractures from this region are limited (12-14).

Therefore, we thought it necessary to examine the characteristics, consequences, and complications of the proximal humeral fracture. We aimed to gain a more accurate understanding of the consequences and complications to guide us in designing and implementing the most appropriate interventions that improve outcomes.

Methods

The present retrograde cohort study evaluated the outcomes of proximal humeral fracture in patients treated in a tertiary trauma center (Shariati Hospital) during 2015-2020. Patients' demographic information

including age, gender, and their past medical history, and patients' fracture characteristics including fracture side and type of treatment were extracted from the health information system (HIS) of the hospital. Patients were divided into 3 groups according to their age, young adults (18-45 years old), middle-aged adults (46-60 years old), and old adults (> 60 years old) (15).

The Neer classification was used to classify the fracture severity. Patients' functional status was measured using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire and Constant-Murley Score (CMS). Patients were divided into subgroups based on their functional status; into 3 subgroups according to the DASH score [DASH score: ≤15 as without functional difficulty (WOFD), DASH score: 16-40 as with functional difficulty but active (WFDA), and DASH score: ≥41 as unable to work (UW)] (16, 17), and 4 subgroups according to the CMS (CMS: 0-55 as poor, 56-70 as moderate, 71-85 as good, and 86-100 as excellent) (18). Shoulder radiographs were used to evaluate postoperative complications including AVN, degeneration, dislocation, angulation, malunion, and nonunion.

To overcome covid-19 limitations, questionnaires were completed using phone calls and messenger applications (WhatsApp). Questionnaires were sent to patients and more information was provided to patients by phone call if necessary. To facilitate the completion of the physical examination part of the CMS, in addition to providing further explanations on the phone, images were prepared for each question. Patients' radiologic images were collected by messenger applications in order to assess complications.

Participants were selected using purposive sampling, so all patients who met the inclusion criteria were included. SPSS software (version 25, IBM Corp., Armonk, NY, USA) was used for data analysis. Descriptive data were reported using abundance, percentage, mean, and standard deviation. The qualitative and quantitative information were analyzed using chi-squared and t-test, respectively. A P-value of less than 0.05 was considered significant.

Results

Baseline Documentation

Patient Demographics (Age, Gender, and Underlying Disease): The participants included 70 patients with a mean age of 50.47 ± 16.73 years. In addition, 44% (30 patients) of the participants were young adults, 36% (26 patients) were middle-aged adults, and 20% (14 patients) were old adults. Moreover, 57.3% of the participants were men and 42.7% were women. The most prevalent underlying disease was hypertension (HTN) which was seen in 13 patients (17.3%) (Figure 1).

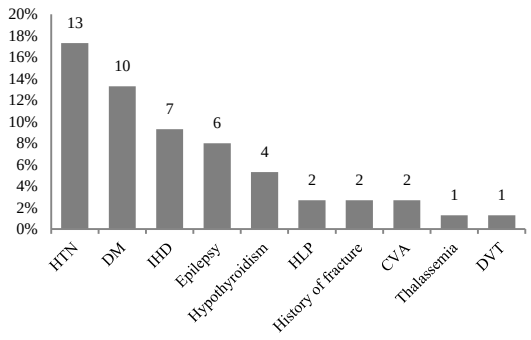

Figure 1. Participants' underlying diseases

Fracture Characteristics (Fracture Side, Site of Proximal Humeral Fracture, and the Neer Classification): The results showed that 65 patients (92.85%) had unilateral fractures and 5 (7.15%) had bilateral fractures. The surgical neck was the part with the highest rate of fracture (49.3% of cases) (Figure 2).

According to the Neer classification, 13 patients (17.3%) were classified as class 1, 29 patients (38.7%) as class 2, 11 patients (14.7%) as class 3, 8 (13.3%) as class 4, and 14 patients (18.7%) as class 5.

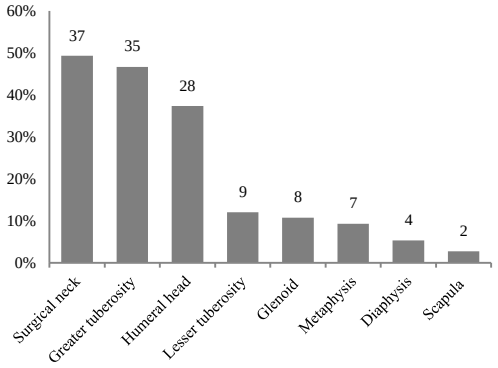

Figure 2. Fracture site

Treatment Profile and Complications: The 3 treatment options of ORIF (39 cases; 52%), hemiarthroplasty (3 cases; 4%), and non-operative treatment (33 patients; 44%) were considered for patients with proximal humeral fracture. Malunion was the most common complication in our study population [in 9 cases (12%)]. Moreover, 3 patients (4%) needed revision surgery in our study (Figure 3).

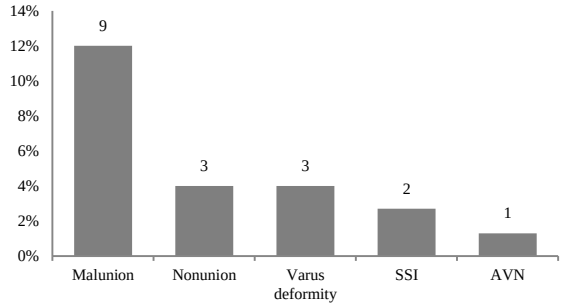

Figure 3. Complications

The Neer classification system was used to assess the severity of proximal humeral fracture. There was no statistically significant difference between Neer classes based on age (P = 0.164), underlying disease (P > 0.050), and complications (P > 0.050). The severity was higher in men than women (P = 0.006), and in patients with bilateral shoulder fracture than unilateral fracture (P = 0.004). Patients who had received more aggressive treatment had experienced more severe fracture (P = 0.0001). Non-operative treatment was performed more in patients who were categorized as class 1 and 2 according to the Neer classification system. ORIF was the most used treatment in class 2 and 3, and arthroplasty was used only in class 4 and 5 (Table 1). Furthermore, the study showed that patients who required revision surgery had had a more severe fracture than patients who did not (P = 0.041).

Table 1. Fracture severity in different type of treatment

	Neer [n (%)]					P-value
	I	II	III	IV	V	
Treatment						
ORIF	0	18 (46.2)	7 (17.9)	4 (10.3)	10 (25.6)	0.0001
Non-operation	13 (39.4)	11 (33.3)	4 (12.1)	2 (6.1)	3 (9.1)	
Hemiarthroplasty	0	0	0	2 (66.7)	1 (33.3)	

ORIF: Open reduction and internal fixation

Functional Outcomes

DASH Score: The mean DASH score of the participants was 29.91 ± 20.43; 29.3% of patients were placed in the "WOFD" group, 44.0% in the "WFDA" group, and 26.7% in the "UW" group. The mean DASH score was not significantly different between gender groups, in unilateral fracture vs. bilateral, and in patients suffering from complications compared with other patients (P = 0.163, P = 0.935, and P > 0.050 respectively). Moreover, there was no significant difference among patients who underwent revision surgery and others. Although the mean DASH score was higher in patients of over 65 years of age compared to under 65 years, the difference was not statistically meaningful (36.97 vs. 28.14; P = 0.136). The mean age of patients classified as "WFDA" was significantly higher than the "WOFD" group (mean difference: 12.01; P = 0.039).

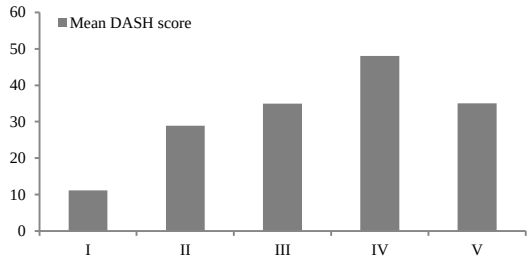

Figure 4. Mean DASH score in Neer classification groups
DASH: Disabilities of the Arm, Shoulder, and Hand

The comparison of different classes of the Neer classification according to their functional status showed that the DASH score in class 1 was lower than other classes. Fractures with higher severity were associated with a higher DASH score (Figure 4, Table 2).

Table 2. Comparison of DASH score among Neer classification groups

NEER groups		Mean difference	P-value
I	II	-17.74	0.084
	III	-23.74	0.047
	IV	-36.83	0.001
	V	-23.89	0.027
II	III	-5.99	0.928
	IV	-19.08	0.152
	V	6.14	0.896
III	IV	-13.09	0.662
	V	0.15	> 0.999
IV	V	12.94	0.631

DASH: Disabilities of the Arm, Shoulder, and Hand

Patients with HTN and hypothyroidism had a higher DASH score than patients without these underlying diseases (P = 0.045 and 0.039, respectively).

Mean DASH score in patients who underwent surgery (ORIF and hemiarthroplasty) was higher compared to patients who were treated non-surgically (P = 0.050) (Tables 3 and 4).

Table 3. Comparison of DASH score among treatment groups

		No.	Mean DASH score	SD	P-value
Treatment	Operation	42	32.3	19.96	0.050
	Non-operation	33	26.85	20.93	

DASH: Disabilities of the Arm, Shoulder, and Hand; SD: Standard deviation

Table 4. Comparison of DASH score among treatment groups

		No.	Mean DASH score	SD	P-value
Treatment	ORIF	39	30.71	19.62	0.097
	Non-operation	33	26.85	20.93	
	Hemiarthroplasty	3	53.03	12.55	

DASH: Disabilities of the Arm, Shoulder, and Hand; SD: Standard deviation

Mean clinical follow-up period was significantly longer in groups with a lower DASH score. The mean clinical follow-up period was 33.50, 20.25, and 18.35 months in the "WOFD", "WFDA", and "UW" groups, respectively (P = 0.002) (Tables 5 and 6, and Figure 5).

Table 5. Mean follow-up period in different DASH score groups

DASH groups	Mean follow-up period	SD
Without functional difficulty	33.5	15.31
With functional difficulty but active	20.25	14.98
Unable to work	18.35	15.67

DASH: Disabilities of the Arm, Shoulder, and Hand; SD: Standard deviation

Constant-Murley Score: The mean CMS of participants was 64.09 ± 22.71 which was significantly lower than the reference range for the participants' age (88.50 ± 5.26 years; P = 0.001).

Table 6. Comparison of mean follow-up period among DASH score groups

DASH groups	DASH groups	Mean difference	P-value
With functional difficulty but active	Without functional difficulty	13.24-	0.010
	Unable to work	1.9	0.910
Without functional difficulty	Unable to work	15.15	0.008

DASH: Disabilities of the Arm, Shoulder, and Hand

The results showed that 29 (38.7%) of patients had poor, 17 (22.7%) had moderate, 14 (18.7%) had good, and 15 (20.0%) had excellent functional status. Mean CMS in the poor, moderate, good, and excellent groups was 13.71 ± 41.41, 5.34 ± 64.11, 5.10 ± 78.21, and 4.82 ± 94.73, respectively.

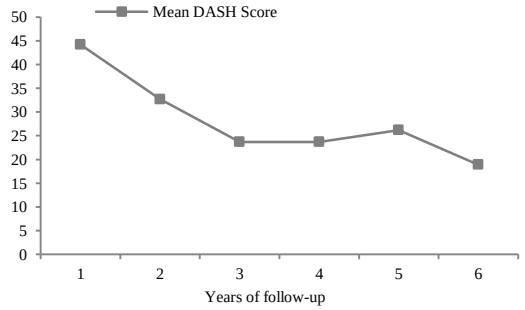

Figure 5. Trend of DASH score according to follow-up period
DASH: Disabilities of the Arm, Shoulder, and Hand

Mean CMS was not significantly different between age groups, gender groups, between the unilateral and bilateral fracture groups, and treatment groups (P = 0.126, 0.157, 0.679, and 0.496, respectively). There was no statistically significant difference in CMS among patients suffering from complications compared with others except in patients who had developed AVN and malunion (P = 0.040 and 0.045, respectively). No meaningful difference was observed in the mean follow-up period between different CMS groups; however, there was a longer follow-up in the excellent group compared to others (Figure 6). Moreover, there was no significant difference among the patient who had undergone revision surgery and other patients (P = 0.213).

The mean age of patients classified as "poor" was significantly higher than the "excellent" group (mean difference: 15.08; P = 0.041).

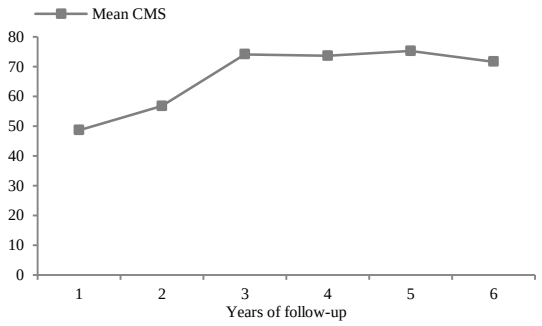

Figure 6. Trend of CMS according to follow-up period
CMS: Constant-Murley Score

Comparing different classes of Neer classification according to their functional status showed more severe fractures had lower CMS. CMS was higher in class 1 compared to the other classes, this difference was significant except between class 1 and 2 (Figure 7, Table 7).

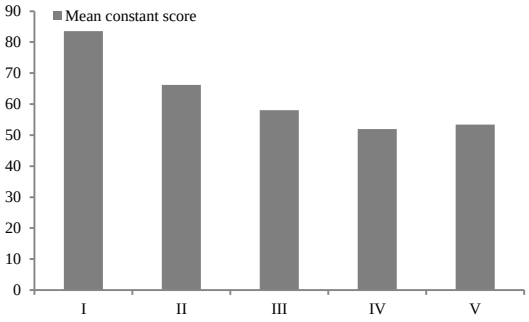

Figure 7. Mean Constant score in Neer classification groups

Patients with HTN, ischemic heart disease (IHD), history of fracture, and hypothyroidism had lower CMS than patients without these underlying diseases (P = 0.023, 0.026, 0.001, and 0.001, respectively).

Table 7. Comparison of DASH score among Neer classification groups

NEER groups		Mean difference	P-value
I	II	17.366	0.099
	III	25.448	0.029
	IV	31.538	0.010
	V	30.181	0.003
II	III	8.082	0.804
	IV	14.172	0.431
	V	12.815	0.325
III	IV	6.091	0.969
	V	4.734	0.979
IV	V	-1.357	> 0.999

DASH: Disabilities of the Arm, Shoulder, and Hand

Visual Analogue Scale (VAS) Score: Pain severity was evaluated using the VAS scoring system. Mean VAS score was 2.80 ± 2.49 and there was no significant difference in VAS score among the age groups (P = 0.249), gender groups (P = 0.498), unilateral and bilateral fracture groups (P = 0.283), treatment groups (P = 0.621), between patients with specific complication and patients without such complications (P > 0.050), and between patients who needed revision surgery and others (P = 0.600). VAS score was significantly higher in patients with more severe fractures based on the Neer classification (P = 0.05) (Figure 8). Patients with a history of epilepsy and thalassemia reported a higher VAS score than patients without these two underlying diseases (P = 0.0001 and 0.019, respectively).

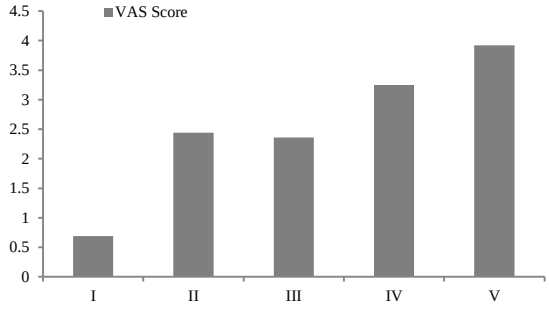

Figure 8. Mean VAS score in Neer classification groups
VAS: Visual analogue scale

However, there were only 6 cases with past medical history of epilepsy and 1 with thalassemia in our study and the results may not be statistically valuable (Figure 9).

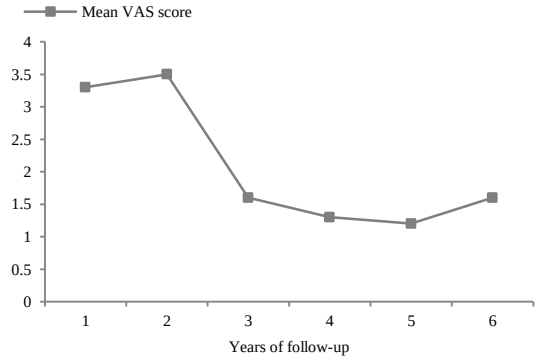

Figure 9. Trend of VAS score according to follow-up period
VAS: Visual analogue scale

Discussion

The present study was conducted to investigate the outcomes of proximal humeral fractures in 70 patients treated in a tertiary trauma center during 2015-2020. In this study, patients were divided into different groups based on their age, gender, and fracture side, site of proximal humeral fracture, type of fracture, Neer classification, underlying diseases, and type of treatment. To evaluate outcomes, the functional status of each patient's shoulder was evaluated using DASH and VAS questionnaires. Radiological images were used to evaluate complications such as malunion, nonunion, and AVN.

The effect of age on outcomes of proximal humeral fracture was also evaluated. Generally, older patients had poorer outcomes. The present study showed that the mean age of patients in the "WOFD" group was significantly lower than the "WFDA" group. Similar results were found based on CMS, which showed that the mean age of patients classified as "poor" was significantly higher than the "excellent" group. Although mean DASH score was higher in older age groups, the difference was not statistically significant. Grawe et al. examined the outcomes of 3-part and 4-part fractures of the proximal humerus in 45 patients, they found that, although patients over 65 years of age had poorer functional status than those under 65 years, this difference was not statistically significant (CMS: 88.58 vs. 82.5, P = 0.070; DASH score: 11.67 vs. 12.5, P = 0.460) (19).

In a study by Kruithof et al. on 410 patients with proximal humeral fracture, the mean DASH score in patients under 65 years of age was significantly better than in those over 65 years (P < 0.001) (20). Hinds et al. evaluated the outcomes of surgical treatment (locked plating with fibular strut allograft augmentation) in different age groups (21). They found no significant differences in patients' function (based on the DASH score, CMS, and UCLA Shoulder Rating Scale), radiological outcomes, and complications between the two elderly (over 65 years) and non-elderly (under 65 years) groups (21). Guity et al. assessed the outcomes of proximal humeral fracture on 39 patients who had undergone hemiarthroplasty (22). They indicated that patients' functional status worsened with age (P < 0.050) (22). Therefore, the functional status of patients with proximal humeral fracture has an inverse relationship with age, i.e., older patients are more likely to have weaker function than younger ones.

There was no significant difference in DASH and CMS between the gender groups in the present study, although men had better functional scores than women (DASH score: Male: 27.06 vs. Female: 33.73; CMS: Male: 67.30 vs. Female: 59.78). Kruithof et al. reported a higher mean DASH score in women (7.05) compared to men (3.33); this difference was statistically meaningful (20). This difference between men and women may be due to men's higher muscular strength and physical activity, which cause better restoration in shoulder function after proximal humeral fracture. Thus, men with proximal humerus fracture have slightly better functional status than women, but the relationship between gender and functional status is still unclear.

Patients in class 1 of the Neer classification had significantly lower mean DASH scores and higher CMS compared to patients in grades 3, 4, and 5 (DASH score P = 0.047, 0.001, and 0.027, respectively; CMS P = 0.029, 0.010, and 0.003, respectively). Kruithof et al. showed that patients with more severe proximal humeral fractures had a worse functional condition (mean DASH score in 2-part fractures: 5.83, 3-part fractures: 6.67, and 4-part fractures: 14.17; P = 0.024) (20). However, in a study by Grawe et al., who examined the outcomes of 3-part and 4-part proximal humeral fractures, the functional status of patients with 4-part fractures was better than those with 3-part fractures (19). This difference was not significant (CMS: 68.44 for 3-part fractures vs. 72.75 for 4-part fractures, P = 0.65; DASH score: 15.83 for 3-part vs. 8.75 for 4-part fractures, P = 0.03). According to the author's, this unexpected result may be due to the small sample size of the study or because most patients with 4-part fractures were associated with valgus impaction which is associated with better treatment results (19). Accordingly the functional status of patients with proximal humeral fracture has an inverse relationship with fracture severity, i.e., patients with more severe fractures (higher Neer classification) are more likely to have poorer function.

The present study evaluated the effect of underlying disease on functional outcome of proximal humeral fracture. Patients with HTN and hypothyroidism showed poor function based on the DASH score. According to CMS, patients with HTN, IHD, history of fracture, and hypothyroidism showed poor outcomes. Hypothyroidism-induced myopathies or the negative effects of thyroid hormone deficiency on bone mineralization may cause such results. Microvascular disturbances seen in patients with HTN and IHD may have adverse effects on the bone union process. History of fracture may be a representative of low bone quality and also concurrent disabilities that interfere with adherence to rehabilitation program. However, we found no study which reported the adverse effects of HTN, history of fracture, IHD, and hypothyroidism in patients with proximal humeral fracture, so further studies appear to be necessary to confirm or deny such effects. In a study conducted by Kruithof et al. on 410 patients with proximal humeral fractures, mean DASH score in diabetic patients (17.5) was significantly higher than non-diabetics (6.67) (P = 0.018) (20). In our study, DASH score was higher in diabetic patients than non-diabetics (DASH score: 78.39 vs. 39.28; P = 0.101). This association can be due to the negative effects of high blood sugar on muscle, bone, and articular cartilage, and also diabetes-related vasculopathy. Thus, patients with an underlying disease (hypothyroidism, HTN, IHD, diabetes, and history of previous fracture) may have a worse functional status, but more investigation is required to determine the exact relationship.

The mean follow-up period of patients in our study was 23.56 ± 16.23 months, i.e., at the time of the study, an average of 23.56 months had elapsed since the treatment of patients. We found that patients with a better functional status had a longer follow-up period. Patients in the "WOFD" group had a significantly longer follow-up period compared to the "WFDA" group (P = 0.01) and to the "UW" group (P = 0.008). Olerud et al. showed that patients' postoperative function improved significantly over time (CMS between 4 and 12 months: 50.1 vs. 59.4; P < 0.001), although this improvement was not statistically significant according to the DASH score (DASH score between 4 and 12 months: 36.8 vs. 33.8) (23). This improvement could be due to rehabilitation exercises and a gradual improvement in muscle strength around the joint. Rath et al. showed that rehabilitation measures (including inactive and active exercises) have a significant impact on patient's outcome (CMS: 40-95 after rehabilitation; satisfaction: 42-95 percent) (11). In addition, increasing the quality of the newly made bone at the fracture site following activity and weight bearing can be a reason for the improvement of patients' function over time. However, Guity et al., who examined the outcomes of hemiarthroplasty on proximal humeral fractures, found that mean CMS was inversely related to the time elapsed since the treatment (P < 0.050) (22). According to their findings, mean VAS score was directly related to the time elapsed since surgery (P < 0.050). Their results showed that patients' functional status deteriorates and their pain worsens over time (22).

Therefore, there is a relationship between functional status and follow-up duration, i.e., patients who have a shorter follow-up period are more likely to have weaker function. In addition, improvement in function mostly occurred in the first 3 years after treatment, which emphasizes the importance of timely postoperative rehabilitation programs.

This difference between the findings of Guity et al. and other studies may be due to the nature of arthroplasty compared to other treatment options; the greater usage of artificial joint may damage the prosthesis.

Conclusion

The present study showed the significant effect of age, fracture severity, and underlying disease on the proximal humeral fracture outcome. Older patients and those who had more severe fractures had poorer functional status.

Patients with more severe fractures are more likely to experience complications such as malunion and AVN.

In addition, it was indicated that patients who had a longer follow-up period showed better functional outcomes. To improve proximal humeral fracture outcomes and reduce its complications, it is recommended that more studies with larger sample sizes be conducted to investigate the factors affecting outcome and complications.

Conflict of Interest

The authors declare no conflict of interest in this study.

Acknowledgements

None.

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