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Effect of Deltoid Tuberosity Index on the Outcome of Proximal Humeral Fracture Treated with a Locking Plate

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Abstract

Background: In the elderly, proximal humerus fractures are not unusual. The treatment of these injuries are often complicated.
Objectives: This study aimed to evaluate the effect of deltoid tuberosity index on the outcome of proximal humeral fractures treated with a locking plate.
Methods: One hundred consecutive patients with displaced fractures of the proximal humerus had open-reduction and internal fixation using a locking plate. The patients were divided into two main groups (low density group) DTI<1.4 and DTI>1.4 (normal density group) and at the end of the study, treatment and failure were assessed in the two groups.
Results: In this study, 100 patients with proximal humeral fracture who were candidates for locking plating surgery were evaluated. The mean of DTI in all patients was 1.48 with a minimum of 1.10 and a maximum of 2.20. Based on the Pearson correlation coefficient, with increasing age, the constant score decreased in the studied patients, which was statistically significant (r=-0.216, p-value = 0.031). Also, in patients with DTI less than 1.4 and more than 1.4, the Constant score was 73.02 and 77.88, respectively. This difference was not statistically significant (p-value=0.054). There was a statistically significant relationship between Constant Score, DTI and patients' gender (p-values0.05). While there was no statistically significant relationship between fracture type and constant score. Pearson correlation coefficient between DTI and age of patients was -0.30, which decreased with increasing age of patients. This was statistically significant (r=-0.30, p-value=0.003).
Conclusion: The results of this study show that the deltoid tuberosity index can be effective on proximal humoral fracture surgery treated with locking plating.

Keywords: Deltoid Tuberosity Index, Proximal Humerus Fractures, Constant Score.

Introduction

Proximal humerus fractures (PHFs) are frequent and account for 4–6% of all fractures,[1-3] PHFs are more common in women over the age of 60 years due to osteoporosis,[4,5] and adult proximal humerus fractures account for up to 5% of all fractures.[6] The frequency of these fractures appears to have risen in recent decades in tandem with the rise in the proportion of older adults.[7] According to several scholars, up to 85% of cases do not need surgery.[8-10] Despite this, there seems to be a shift toward further surgical intervention, which has been due to improved plating systems and the promotion of reverse shoulder replacement as a treatment choice.[11-14] A pain-free shoulder with an optimal range of motion according to the individual's precise functional criteria is the desired outcome for a patient with a PHF.[11,12]

General treatment for proximal humeral fractures is also debatable, and choosing an appropriate time for surgery to achieve a satisfactory outcome remains challenging, especially in the elderly. The majority of nondisplaced or minimally displaced proximal humeral fractures should be treated conservatively.[13]

Locking plate, tension band, percutaneous K-Wire, intramedullary nails, and hemiarthroplasty replacement are all suggested for displaced and unstable fractures. External fixation is widely used of these surgical procedures for the majority of fractures.[14-16]

The use of anatomically preshaped locking plates for proximal humerus fractures (PHF) became the mainstay of operative care after encouraging preliminary findings.[17-19] However, increased use of these plates is associated with a high rate of complications, which could lead to challenging revision cases with restricted outcomes.[20-22]

On the other hand, bone density is an indicator of the efficiency of the surgical reduction and screw cutout. Cortical

bone thickness assessments on AP views of the shoulder can be used to determine density. Figure-1 shows a technique in this area called deltoid tuberosity index.[23-25]

Objectives

Therefore, this study aimed to attempt to explain the influence of deltoid tuberosity index on the outcome of proximal humeral fracture treated with a locking plate.

Figure-1. shows the DTI methods for calculating bone density in an anterior-posterior view of the shoulder. The deltoid tuberosity index is abbreviated as DTI.

Materials and Methods

In the present study, from May 2019 to May 2020, 100 consecutive patients with displaced fractures of the proximal humerus had open-reduction and internal fixation with a locking plate. The proximal humeral interlocking plate was used to treat 100 cases of proximal humeral fractures.

Of the participants, 34 cases were female and 66 were male with a mean age of 45.11 years (22 to 83). Seventy-three patients were injured in the crash, twenty-two in a road accident and seven in a direct assault. In this study, the inclusion criteria included proximal humeral fractures of types 2, 3, and 4. The exclusion criteria included arm fracture, concomitant elbow, and shoulder fracture, and lower limb fractures or fractures associated with neurovascular injury, obese patients, patients undergoing chemotherapy, and patients treated with surgery (non-locking plating methods). A senior orthopedic surgeon handled all of the cases. Prophylactic intravenous antibiotics were given to the patients.

All of the fractures were consistent with the criteria introduced by Neer et al.,[26] for operative care, which included an angulation of the articular surface of more than 45 degrees or a displacement of more than 1 cm between the main fracture parts.

The patients were studied inhomogeneous groups using deltoid tuberosity index and constant score based on age and sex. The patients were divided into two main groups (low-density group) DTI <1.4 and DTI> 1.4 (normal density group) and at the end of the study, treatment failure was assessed in two groups. The patients were matched based on age, sex, and type of fracture by a statistician. Facial radiographs were taken in the internal rotation of the arm and the deltoid tuberosity index was calculated according to the formula.

Measurement of the Deltoid Tuberosity Index

The arm must be internally rotated (lying on the abdomen) to calculate the deltoid tuberosity index on an AP radiograph of the shoulder, as it is with proximal humerus fractures. The deltoid tuberosity index is calculated at the point where the outer cortical boundaries become parallel, which is directly proximal to the deltoid tuberosity. At this measure, it is determined by dividing the outer cortical diameter by the inner endosteal diameter (Figure-2)

Statistical analysis

SPSS (Version 22) was used to conduct statistical analysis (SPSS, Chicago, Illinois). The Mann-Whitney U tests were used to make comparisons. The significance level was considered as a P-value of less than 0.05.

Ethical Consideration

The research was accepted by the institutional review board, and the written consent form was obtained from the patients to use and report their anonymized data.

Results

In this study, 100 patients with proximal humeral fracture and candidates for locking plating surgery were evaluated. OF them, 34% (34 patients) were female and 66% (66 patients) were male. The mean age of men and women was 41.68 and 51.76 years, respectively.

Figure-2. In a 64-year-old woman, an AP radiograph reveals a proximal humerus fracture. The deltoid tuberosity index is calculated at the point where the outer cortical boundaries become parallel, which is directly proximal to the deltoid tuberosity (asterisks). The ratio between the outer cortical and inner endosteal diameters (a/b) is determined at this step.

In general, 50% of fractures were 2 part type, 27% were 3 part type and 23% were 4 part type fractures.

The mean of DTI in all patients was 1.48 with a minimum of 1.10 and a maximum of 2.20. For 64 patients, the DTI was greater than 1.4, and 36 was less than 1.4. In 100 patients, the mean (standard deviation) constant score was 76.13 (12.09). Based on the Pearson correlation coefficient, with the increasing age of patients, the constant score decreased in the studied patients, which was statistically significant (r=-0.216, p-value=0.031).

Figure-3 shows the Constant Score distribution chart based on the age of the patients. Also, in patients with DTI less than 1.4 and more than 1.4, the Constant score was 73.02 and 77.88, respectively. This difference was not statistically significant (p-value=0.054) (Table-1).

The mean constant score was higher in men than women, there was a statistically significant relationship between Constant score and patients' gender (p-value=0.018).

Also, the mean constant score had the highest value in 3 part fractures and the lowest in 2 part fractures, but no statistically significant difference was observed between Constant Score and the type of fracture (p-value=0.59).

Table-2 presents the frequency distribution of patients in the Constant Score classes based on gender, type of fracture, and the amount of DTI.

There was a statistically significant relationship between Constant Score and DTI and patients' gender (p-value=<0.05), while there was no statistically significant relationship between fracture type and constant score.

In the studied patients, the rate of failure fixation in all patients was 7% (7 cases).

For patients with a DTI of less than 1.4% (2 cases) and those with a DTI of more than 1.4%, the rate was 7.8% (5 cases), there was no statistically significant relationship between Failure Fixation and DTI.

Table-3 shows the amount of Failure Fixation in different groups.

Also in terms of the gender frequency distribution of individuals based on DTI, 38.20% of women with DTI had less than 1.4%, while this amount was 34.80% for men. On the other hand, 61.80% of women had more DTI than 1.4%, while this amount was 65.20% for men. There was no statistically significant relationship between DTI and gender (p-value=0.73), (Table-4).

Pearson correlation coefficient was used to investigate the relationship between DTI and patients' age. Pearson correlation coefficient between DTI and age of patients was -0.30, which decreases with increasing age of patients. This was statistically significant (r=-0.30, p-value=0.003), (Figure-4).

Discussion

The management of proximal humerus fractures is debatable. There is insufficient evidence to make recommendations, according to a Cochrane study of 23 randomized controlled trials.[27] Conclusions are difficult to establish because there is substantial heterogeneity among studies.

Generally, for patients with proximal humerus fractures, a preoperative evaluation of local Bone Mineral Density (BMD) should be part of the care plan, and the measurement should be fast and clear on a fracture radiograph.[28,29]

The techniques used have some limitations; for example, the gold standard for assessing osteoporosis, the dual-energy x-ray absorptiometry (DXA) measurement, is not specific for the distal femur and is often unavailable in the event of an acute fracture. However, peripheral quantitative CT (pQCT) can be used for local analysis, but the measurement is difficult and requires special training.[30]

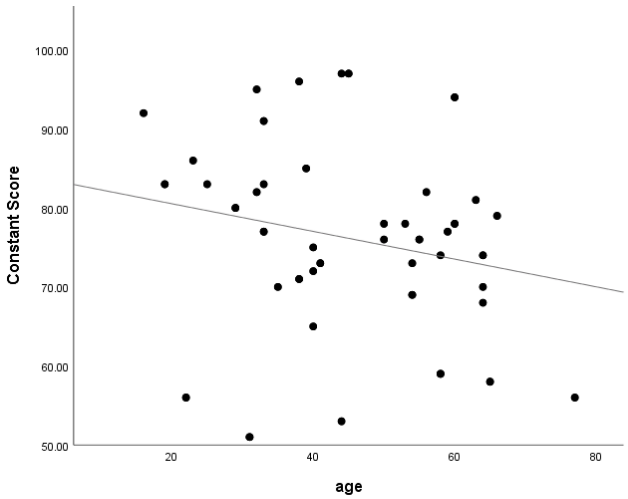

Figure-3. Correlation between patients' age and Constant Score

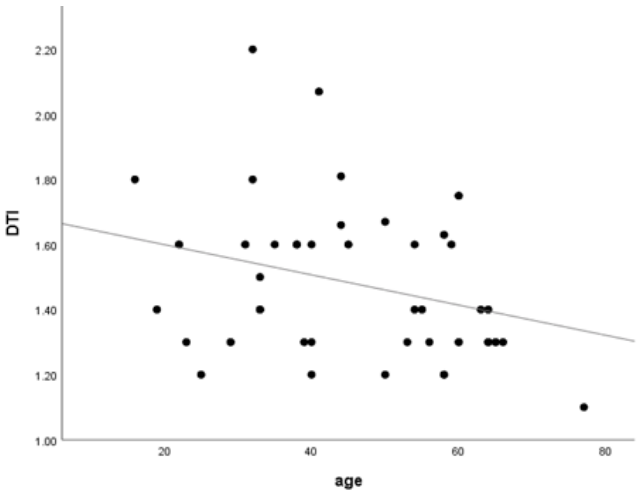

Figure-4. Correlation between patient age and DTI

Table-1. Constant Score in different groups

		N	Mean	Std. Deviation	p-value
Fx Type	2part	50	75.26	13.61	0.59
	3part	27	78.15	9.38	
	4part	23	75.65	11.63	
Gender	Female	34	72.18	11.19	0.018
	Male	66	78.17	12.12	
DTI	<1.4	36	73.03	9.89	0.054
	>=1.4	64	77.88	12.93	

Table-2. Frequency distribution of patients in Constant Score classes based on gender, type of fracture and DTI

		Constant Score				p-value
		Poor	Fair	Good	Excellent	
gender	women	11(32.35)	17(50)	4(11.76)	2(5.88)	0.033
	men	12(18.18)	23(34.85)	16(24.24)	15(22.73)	
FX Type	2part	16(32)	15(30)	10(20)	9(18)	0.15
	3part	2(7.41)	16(59.26)	4(14.81)	5(18.52)	
	4part	5(21.74)	9(39.13)	6(26.09)	3(13.04)	
DTI.cat	<1.4	12(33.33)	13(36.11)	11(30.56)	0(0)	0.001
	>=1.4	11(17.19)	27(42.19)	9(14.06)	17(26.56)	

Table-3. Failure Fixation rate in all patients

		Failure Fixation		p-value
		Failed	Normal	
DTI	<1.4	2(5.56)	34(94.44)	>0.99
	>=1.4	5(7.81)	59(92.19)	
gender	Men	0(0)	34(100)	0.09
	women	7(10.61)	59(89.39)	
FX Type	2part	2(4)	48(96)	0.51
	3part	3(11.11)	24(88.89)	
	4part	2(8.7)	21(91.3)	

Table-4. Gender frequency distribution of individuals based on DTI

		DTI.cat		p-value
		<1.4	>=1.4	
gender	men	13(38.20)	21(61.80)	0.73
	women	23(34.80)	43(65.20)	

Furthermore, the Tingart measurement, although useful for assessing local bone quality on AP radiographs, appears to have some significant disadvantages in proximal humerus fractures, as the fracture lines can obscure the levels of measurement.[31]

As a result, we assume the deltoid tuberosity index is a basic radiographic method that can be used to diagnose proximal humerus fractures.

Spross implemented the deltoid tuberosity index (DTI) in the AP view of the shoulder more recently. The DTI is calculated proximal to the deltoid tuberosity, where the outer cortical border parallelizes. The outer cortical diameter is separated by the inner endosteal diameter at this stage. A DTI <1.4 indicates low humeral head bone mineral density. The DTI has the advantage that, unlike the Tingart calculation, no magnification adjustment is needed, and the measurement area is not usually affected by the fracture.[32]

The osseous changes of the humeral shaft with age were identified by Mantila Roosa et al.[33] The strong correlation between the DTI and Constant Score, age, is likely applied to clinical practice and may be useful to predict proximal humeral fracture treated with a locking plate. According to them, periosteal bone apposition causes the outer cortical diameter to expand, but the inner diameter expands much faster. This may explain why radiographic measurements in this region are related to age, and why the deltoid tuberosity index is calculated using a simple ratio of the outer cortical and inner endosteal diameters. In this study, we discovered that there is a correlation between patient age and DTI, with patients' DTI decreasing as they get elderly, which was statistically significant. The deltoid tuberosity index was strongly correlated with Constant Score in our study. In this study, it was found that clinically useful threshold values for the deltoid tuberosity index less than 1.4 for determining proximal humerus bone consistency.

Conclusions

Proximal humerus fractures are typical in the elderly. Since this is a common fracture, finding the best treatment still remains a challenge. The majority of PHFs should be treated with caution. Fixation with locking plates is an acceptable treatment option. The results of this study showed that the deltoid tuberosity index can be effective on the results of proximal humoral fracture surgery treated with locking plating. However, according to the results and findings of this study, more studies are needed to achieve more documented results.

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None.

Authors' Contribution

All authors pass the four criteria for authorship contribution based on the International Committee of Medical Journal Editors (ICMJE) recommendations.

Conflict of Interests

The author(s) declared no conflicts of interest with respect to the study, authorship, and/or publication of this paper.

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