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Original article

Evaluation of Outcome of Internal Fixation of Pathological Humeral Fractures

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Abstract

Background: Pathological humeral shaft fracture occurs late in the evolution of tumoral, and it is an important negative prognostic and morbidity factor, causing pain, as well as loss of limb function and independent living. **This study aimed to** evaluate functional, oncological outcome following internal fixation for pathological humeral fractures. **Methods:** This prospective cohort study included 20 patients who were candidate for internal fixation of pathological humeral fractures (metabolic, benign & pathological causing humerus fracture). All studied cases were subjected to general examination, radiological assessment (X-ray CT scan, magnetic resonance imaging (MRI) with contrast, technetium bone scan, biopsy in case of 1ry lesion unknown, and PET scan in metastasis, and tumor markers). **Results:** The MSTS score had a median value of 5, with a narrow range between 4 and 5. Regression was observed in 60% of the cases. However, progression of the disease was noted in 40% of the cases. A high incidence of metastasis was reported, with chest metastasis occurring in 70% of the patients and visceral metastasis in 75%. Time of presentation significantly differed according to oncological outcome (P = 0.045). No significant differences were observed regarding age, gender, risk factor, site, approach, method of fixation, and augmentation by cement, operation time, blood loss, radial nerve injury, mechanical failure, non-union, infection, hospital stay and MSTS according to oncological outcome. **Conclusion:** Both intramedullary nailing and plating are safe and effective surgical methods for treating metastatic lesions in humeral shaft fractures. The INF group demonstrated a significantly lower incidence of postoperative radial nerve palsy than the PF group.

Keywords: Outcome; Fixation, Pathological; Humeral fractures.

Introduction

The frequency of bone tumor conditions, especially of bone metastatic disease, increased markedly in recent years, and long bones are frequent sites of this type of lesion. The humerus is the second bone most affected by metastatic disease in the appendicular skeleton (ranging from 16 to 20% of the cases), followed by the femur (1, 2).

Metastatic humeral lesions are mostly lytic and are associated with bone fragility and increased risk of fracture; however, only 8 to 10% of these lesions evolve to an established or impending fracture. Pathological humeral fractures account for 16 to 39% of all pathological fractures in long bones (1-3).

As a general rule, the pathological humeral shaft fracture occurs late in the evolution of tumoral and it is an important negative prognostic and morbidity factor, causing pain, as well as loss of limb function and independent living; moreover, it often requires supportive care, including hygiene measures, which significantly reduces the quality of life of these patients in their supposed little time left (approximately 1 year after the appearance of bone metastases in disseminated tumor disease) (1, 4).

The conservative treatment option with immobilization of the pathological humeral fractures had poor results, with insufficient pain reduction and little function improvement, mainly due to the reduced consolidation potential of these lesions because of the biological and mechanical effects of the tumor (1-5). As such, osteosynthesis is the current gold standard treatment for diaphyseal humeral fractures in patients with disseminated tumor disease who do not present with contraindications to the procedure (1, 2).

This treatment is essentially palliative and aims at the immediate effective stabilization of the fracture (since one cannot expect or wait for consolidation), pain relief, and recovery of limb mobility, seeking to restore functional independence and quality of life as early as possible, preferably without further surgical intervention. The reduced invasiveness and minimal tissue aggression of the surgical technique, as well as good results in immediate stabilization, pain relief and rapid functional recovery, as well as the reduced rate of surgery-related complications (1, 2).

The aim of this work was to evaluate functional, oncological outcome following internal fixation for pathological humeral fractures.

Patients and methods

This prospective cohort study included 20 patients who were candidate for internal fixation of pathological humeral fractures fractures (metabolic, benign &

pathological causing humerus fracture), at Benha University hospital, Elkasr El Einy University hospital, Nasser National Institute through 6-12 month from April 2021 to March 2024.

An informed written consent was obtained from the patients. Every patient received an explanation of the purpose of the study and had a secret code number. The study was done after being approved by the Research Ethics Committee, Faculty of Medicine, Benha University.

Inclusion criteria were patients who underwent fixation for pathological humeral fractures due to [metabolic pathological humeral fractures, benign tumors causing humeral fractures and metastasis causing humeral fractures}.

Exclusion criteria were comatosed patient, 1ry sarcomas, recurrent sarcomas, fungating sarcomas, presence of active infection, and pathological humeral fracture due to chronic osteomyelitis

All studied cases were subjected to the following: Detailed history taking, including [personal history including age, sex, occupation, special habits of medical importance and pre-injury function, history of present illness, mechanism of injury, side affected, time since injury, past history and medical comorbidities]. **Full clinical examination: General examination including [**the patient general condition. Vital signs, any previous scars. Chest abdomen and pelvis were examined carefully.]. **Local examination**: of the affected limb as regards swelling size extent, neurovascular examination, scars, deformities, and range of motion of the nearby joints. **Radiological assessment:** x-ray was taken for the affected limb including joint above and joint below the lesion with at least 2 views at least antero-posterior and lateral views, cross table lateral plain. CT scan of the affected bone done for most of the cases with 3-Dimension reconstruction without contrast. CT chest without contrast with 3millimeter cuts was done. Magnetic resonance imaging (MRI) with contrast of the whole affected bone was done for the tumor extent, relation of the tumor to neurovascular structure in order to plan the surgery and intramedullary tumor extension. Technetium bone scan was done for some patients who were in doubt of the diagnosis. **Biopsy:** in case of primary lesion unknown, CT guided biopsy from the lesion was done in specialized center experienced in musculoskeletal CT guided biopsy taking. **PET scan**: in metastasis, and tumor markers.

Operative intervention: Preoperative antibiotic used as per protocol, general anesthesia and patient positioning was lateral decubitus in 8 patients and supine or beach chair position in 12 patients. **Distal humeral fracture: posterior approach:** We choose method of fixation according to age, site of fracture and bone stock / quality. Implants used for intramedullary fixation of the humerus range from both flexible nails

and Kirschner wires to the current trend of more rigid locking humeral nails. From a biomechanical standpoint, the intramedullary positioning of these devices places them in line with the mechanical axis of the humeral diaphysis, thereby subjecting the implant to lower bending loads. In turn, by being centrally positioned, the nail functions in a ‘‘load-sharing’’ capacity and mitigates the potential effects that stress shielding may play as compared with compression plating. **Open reduction and internal fixation (ORIF)**: Interest in dual plating of humeral shaft fractures has led to a number of recent biomechanical studies to demonstrate its effectiveness. Dual plates may be beneficial to improve stability of the construct and also to assist with provisional fixation of the reduction. In comparison, when faced with poor bone quality, the use of locking plates may be advantageous. In the setting of osteoporosis, locking plates may provide better stability and avoid the inherent risks of fixation failure and nonunion that could occur with standard plates.

Post-operative care: The patients stayed at the hospital for average was 3-5 days post-operative. The suction drain was evacuated daily and removed when the fluid collection in the drain was below 50 ml. Post-operative pain management was done for all patients according to the guidelines. Post-operative antibiotics were given for average 7 days. The dressing was changed, and the wound was cleaned with removal of suction drain and before discharge from the hospital.

Follow up protocol: Stitches were removed from 14-21 day's post-operative. Every patient was put in an arm sling or humeral brace according to the rigidity of internal fixation immediately post-operatively. Every patient was examined for vascular and neurological status. The arm sling was removed after three to six weeks, and active shoulder exercises were allowed. Check X-rays (anteroposterior and lateral views) were obtained after two, six, and twelve weeks, then monthly till radiological union, then at the end of follow up. The mean follows up period was twenty-four weeks. Follow up visits were continued for at least 2years and in some patients extended our study for 7 years.

Outcome assessment: The functional outcome was assessed each follow up visit using Musculo-skeletal Tumor Society Scoring system (MSTS) which is applied to either upper limb or lower limb (6). Oncological assessment was done by detecting local tumor recurrent or distant or lung metastasis by clinical (follow up visit for local tumor recurrent) and radiological assessment (X-ray and MRI). **Assessment of the complications** Intraoperative, early postoperative and complications during the period of follow up will be reported.

Approval code: MD 8-4-2021

Statistical analysis:

Statistical analysis was done by SPSS v28 (IBM©, Armonk, NY, USA). Shapiro-Wilks test and histograms were used to evaluate the normality of the distribution of data. Quantitative parametric data were presented as mean and standard deviation (SD) and were analyzed by ANOVA (F) test with post hoc test (Tukey. Qualitative variables were presented as frequency and percentage (%) and were analyzed utilizing the Chi-square test. A two tailed P value < 0.05 was considered statistically significant. Spearman correlation was done to estimate the degree of correlation between two quantitative variables. The overall diagnostic performance of each test was assessed by ROC curve analysis. The area under the curve (AUC) evaluates the overall test performance.

Case presentation:

Case 1: Male patient, 63 year old, was referred to us in 2023 with swelling and pain of arm after trivial trauma. the type of tumor (malignant) History of melanoma & metastatic melanoma to humerus casuing fracture. The radiological assessment was performed **[Figure 1]**. **Operative details:** The plan was fixation of fracture with intramedullary nail with minimal incision, less blood loss, short operative time Antegrade approach was used. The wound healed in good manner. Patients received postoperative adjuvant chemotherapy as per protocol. **Functional outcome:** The patient followed up for 6 months, His last MSTS was 25 at last follow up visit, The range of motion of his elbow was from (0-130). **Oncological outcome:** At last, follow up, regression of tumor, no local recurrence, No chest metastasis.

Case 2: male patient, 67 year old, was referred to us in 2023 with swelling and pain of arm after trivial trauma**.** the type of tumor (benign) pathological humeral fracture on UBC. The radiological assessment was performed **(Figure 2) Preoperative CT showing fallen leaf sign of U Operative details:** The plan was fixation of fracture with philos plate, transdeltiod approach was used, The wound healed in good manner. **Follow up:** The patient followed up for 2 years as per protocol of follow up visits. **Functional outcome:** MSTS was 20 at last follow up, Range of motion: 10-110**. Oncological outcome:** Chest metastasis: there was no chest metastasis at last follow up which was assessed non-contrast CT. Local recurrence: there was no local recurrence at last follow up.

Results

Table 1 shows the demographic, clinical characteristics, surgical details and operative characteristics of the studied patients. There was an even distribution between the deltopectoral and posterior approaches; each was employed in 50% of the cases. Regarding the method of fixation, nails were the most used technique, accounting for 55% of the cases, followed by plates at 35%, and K-

wires being the least utilized at 10%. Additionally, augmentation by cement was applied in 40% of the cases. The mean operation time was recorded at 177 ± 25 minutes. The median blood loss during the operations was noted to be 928 ml, with a range spanning from 200 to 1800 ml.

Radial nerve injury was observed in 5% of the cases. Mechanical failure occurred in 10% of the patients. Non-union was reported in 25% of the cases. Infection was noted in 20% of the patients. The median duration of hospital stay was 5 days, with a range from 2 to 18 days. The MSTS score had a median value of 5, with a narrow range between 4 and 5. Regarding oncological outcomes, regression was observed in 60% of the cases. However, progression of the disease was noted in 40% of the cases. Additionally, a high incidence of metastasis was reported, with chest metastasis occurring in 70% of the patients and visceral metastasis in 75%. **Table 2**

Time of presentation significantly differed according to oncological outcome (P = 0.045). No significant differences were observed regarding age, gender, presence of risk factor, site, approach, method of fixation, and augmentation by cement, operation time, blood loss, radial nerve injury, mechanical failure, non-union, infection, hospital stay and MSTS according to oncological outcome. **Table 3**

No significant differences were observed according to age, gender, risk factor, site, time of presentation, approach, method of fixation, augmentation by cement, operation time, blood loss, radial nerve injury, mechanical failure, non-union, infection and hospital stay. **Table 4.**

We use in the study Ante grade nail & locked plate. Specific type of nail and plates does not affect the result of the study**.**

Table 1: Demographic, clinical characteristics, surgical details and operative characteristics of the studied patients

		n (%)
Demographics		
Age (years)		48 ±16
Sex	**Males**	7 (35%)
	Females	13 (65%)
Clinical characteristics		
Risk factor		16 (80%)
Site	**Proximal humerus**	5 (25%)
	Mid shaft humerus	7 (35%)
	Distal humerus	8 (40%)
Time of presentation	**One-day**	12 (60%)
	Two-day	5 (25%)
	Three days	3 (15%)
Surgical details		
Approach	**Deltopectoral**	10 (50%)
	Posterior	10 (50%)
Method of fixation	**Plate**	7 (35%)
	Nail	11 (55%)
	K-wires	2 (10%)
Augmentation by cement		8 (40%)
Operative characteristics	**Operation time (min.)**	177 ±25
	Blood loss (ml)	928 (200 - 1800)

Table 2: Complications and outcome of the studied patients

		n (%)
Post-operative findings n (%)	**Radial nerve injury**	1 (5%)
	mechanical failure	2 (10 %)
	Non-union	5 (25%)
	Infection	4 (20%)
Hospital stay (days)	5 (2 - 18)	
Outcomes	**MSTS score**	5 (4 - 5)
Oncological outcome	Regression	12 (60%)
	Progression	8 (40%)
Chest metastasis	14 (70%)	
Visceral metastasis	15 (75%)	

Table 3: Demographics, clinical characteristics, surgical details, operative characteristics, complications, MSTS score in relation to oncological outcome

		Oncological outcome		
		Regression (n = 12)	**Progression (n = 8)**	**P-value**
Age (years)		51 ±15	44 ±18	0.35
Sex	**Males**	8 (66.7%)	5 (62.5%)	1.0
	Females	4 (33.3%)	3 (37.5%)	
Risk factor		10 (83.3%)	6 (75%)	1.0
Site	**Proximal humerus**	5 (41.7%)	0 (0%)	0.099
	Mid shaft humerus	4 (33.3%)	3 (37.5%)	
	Distal humerus	3 (25%)	5 (62.5%)	
Time of presentation	**One-day**	9 (75%)	3 (37.5%)	0.045
	Two-day	3 (25%)	2 (25%)	
	Three days	0 (0%)	3 (37.5%)	
Approach	**Deltopectoral**	5 (41.7%)	5 (62.5%)	0.65
	Posterior	7 (58.3%)	3 (37.5%)	
Method of fixation	**Plate**	6 (50%)	1 (12.5%)	0.094
	Nail	6 (50%)	5 (62.5%)	
	K-wires	0 (0%)	2 (25%)	
Augmentation by cement		5 (41.7%)	3 (37.5%)	1.0
Operation time (min.)		178 ±25	176 ±27	0.916
Blood loss (ml)		872 (200 - 1800)	1213 (400 - 1800)	0.343
Radial nerve injury		0 (0%)	1 (12.5)	0.4
mechanical failure		1 (8.3%)	1 (12.5)	1.0
Non-union		3 (25%)	2 (25)	1.0
Infection		1 (8.3%)	3 (37.5)	0.255
Hospital stay (days)		6 (2 - 18)	4 (2 - 12)	0.571
MSTS		5 (4 - 5)	5 (4 - 5)	0.473

Table 4: Demographics, clinical characteristics, surgical details, operative characteristics, complications in relation to functional outcome (MSTS score)

		MSTS		
		Below five (n = 5)	**Five (n = 15)**	**P-value**
Age (years)		57 ±8	45 ±18	0.17
Sex	**Males**	4 (80%)	9 (60%)	0.613
	Females	1 (20%)	6 (40%)	
Risk factor		4 (80%)	12 (80%)	1.0
Site	**Proximal humerus**	1 (20%)	4 (26.7%)	0.449
	Mid shaft humerus	3 (60%)	4 (26.7%)	
	Distal humerus	1 (20%)	7 (46.7%)	
Time of presentation	**One-day**	4 (80%)	8 (53.3%)	0.787
	Two-day	1 (20%)	4 (26.7%)	
	Three days	0 (0%)	3 (20%)	
Approach	**Deltopectoral**	3 (60%)	7 (46.7%)	1
	Posterior	2 (40%)	8 (53.3%)	
Method of fixation	**Plate**	3 (60%)	4 (26.7%)	0.33
	Nail	2 (40%)	9 (60%)	
	K-wires	0 (0%)	2 (13.3%)	
Augmentation by cement		2 (40%)	6 (40%)	1
Operation time (min.)		183 ±28	175 ±24	0.549
Blood loss (ml)		900 (400 - 1014)	1000 (200 - 1800)	0.445
Radial nerve injury		0 (0%)	1 (6.7%)	1.0
Mechanical failure		1 (20%)	1 (6.7%)	0.447
Non-union		0 (0%)	5 (33.3%)	0.266
Infection		1 (20%)	3 (20%)	1.0
Hospital stay (days)		9 (2 - 18)	4 (2 - 16)	0.23

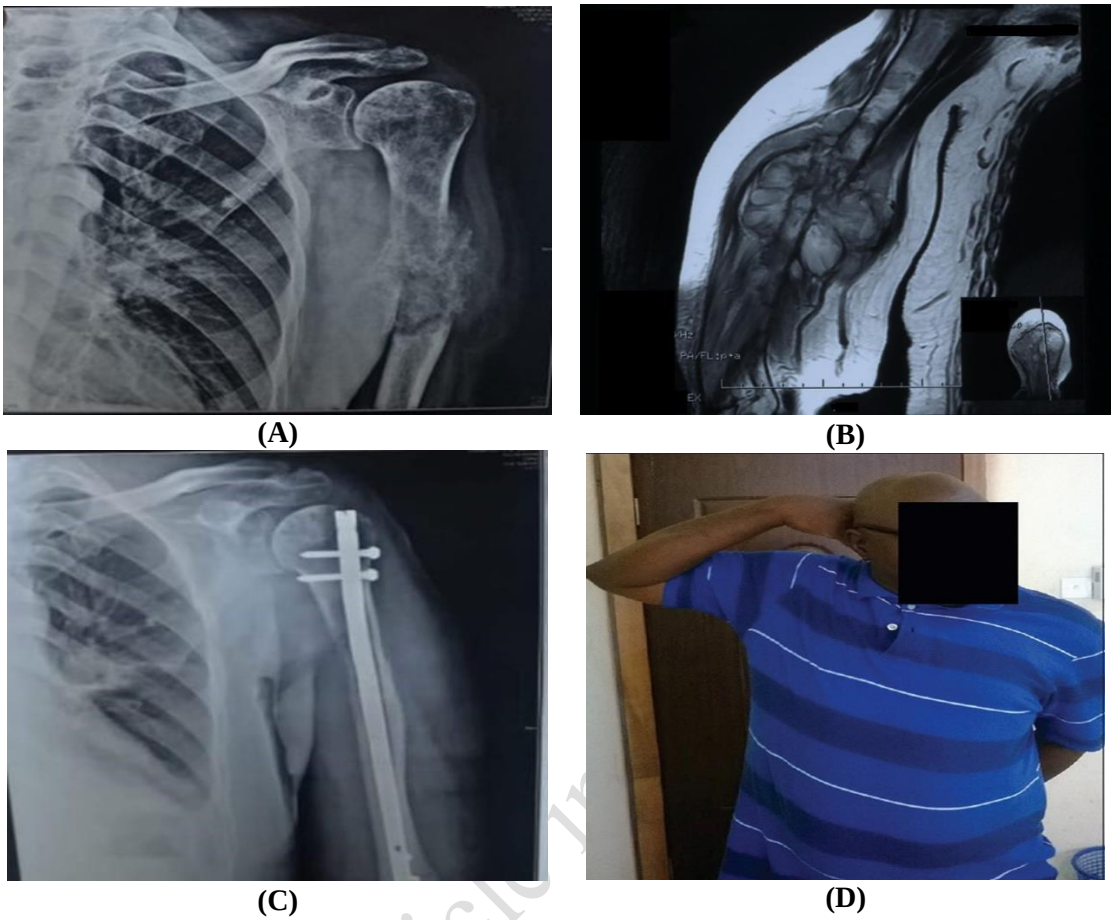

Figure 1: (A) Preoperative X-ray showing pathological humeral fracture, (B) Preoperative MRI showing the tumor, (C) Postoperative X-ray showing united humeral fracture fixed with nail, (D) Follow up clinical photo

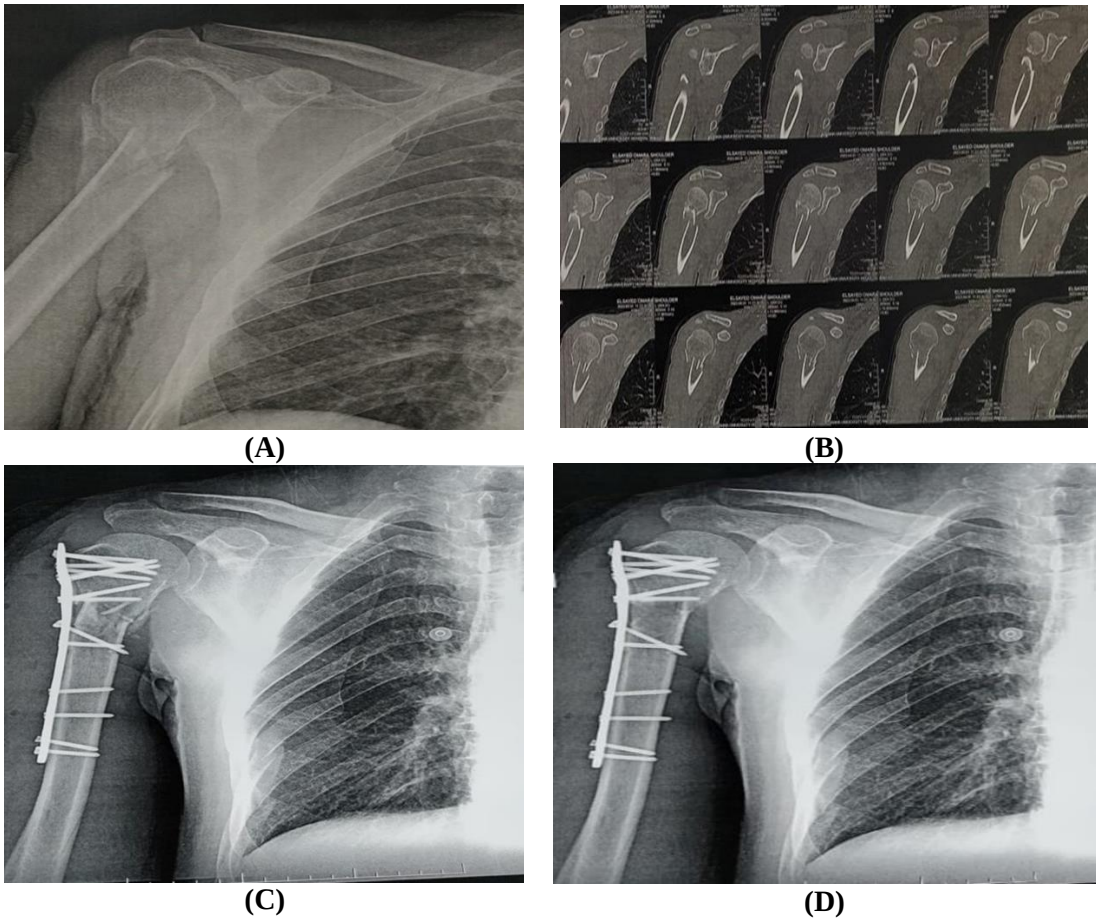

Figure 2: (A) Preoperative x-ray showing pathological humeral fracture on UBC, (B) Preoperative CT showing fallen leaf sign of U, (C) postoperative fixation of humeral fracture due to UBC, (D) Post-operative X-ray shows union of #

Discussion

All the patients who were included in the study were treated by fixation using different methods of fixation techniques. As compared to published studies, we have low percentage of pathological humeral fracture. Our study number of patients: plate fix: 7, intramedullary: 11, k. wires: 2. Less than compared to series of Zhao et al. (7) in their study, where the number of patients: plate fix: 33 and intramedullary nail fix: 16.

In our study, the average age of participants was 48 years, with a standard deviation of 16 years. These

results was matching with Koob et al. (8) retrospective cohort study, in which the average age of patients: plate fix: 64.2, intramedullary nail fix: 64.2

In our study most of the study participants were females (65%), while males constituted 35% of the study population. These results was matching with Ricard et al. (9) prospective cohort

study: in their study gender of patients : 8 (44.4%)

In our study follow up duration 6 months, these results was matching with Casadei et al. (10) retrospective cohort study: in their study, the follow up duration: 22 months.

The end point in our study is 6 months. These results was matching with Janssen et al. (11) retrospective cohort study: in their study end point was implant failure or death. :

In our study complications are radial nerve injury was observed in 5% of the cases. Mechanical failure occurred in 10% of the patients. Non-union was reported in 25% of the cases. Infection was noted in 20% of the patients. Local recurrence rate was 10% These results was matching with Schwabe et al. (12) retrospective cohort study: in their study complications were (fixation failure rate: 1, local recurrence rate: 0, radial n palsy:1, wound complication rate: 0 and chest metastasis: 0) and Janssen et al. (11) retrospective cohort study: in their study complications were (fixation failure rate: 0, local recurrence rate: 1, radial n palsy: 0, wound complication rate: 0 and chest metastasis: 0),

In our study, regarding the method of fixation, nails were the most used technique, accounting for 55% of the cases, followed by plates at 35%, and K-wires being the least utilized at 10%. Additionally, augmentation by cement was applied in 40% of the cases.

Wedin et al. (13) in their study the implant details were PF: Plate without bone cement, INF: Interlocked intramedullary nail. Schwabe et al. (12) in their study the implant details were PF: Locking-compression plate with bone cement and INF: Intramedullary nail

Oncological outcome assessed by detecting local recurrence of the tumor, chest metastasis, and patient survival. Regarding the local recurrence, two patients in our study group developed local recurrence of the tumor (10%). We found in our study non-significant relation between method of fixation and local recurrence.

Our study is similar to Casadei et al. (10) retrospective cohort, their local recurrence was: 1. Ricard et al. (9) prospective cohort study, the local recurrence was : 1

Regarding chest metastasis, only two patients developed lung metastasis (10%). Two patients who had lung metastasis developed local tumor recurrence while we have lower incidence of lung metastasis as compared to Zhao et al. (7) retrospective cohort study, in their study rate of chest metastasis was: 1. In Koob et al. (8) retrospective cohort study, the rate of chest metastasis was: 1

We used the Musculoskeletal tumor society scoring system (MSTS) as assessment tool in functional outcome of our patients. We found in our study that

there was no significant differences were observed between those with MSTS scores below and above five regarding approach, method of fixation, and augmentation by cement. That was matching with other studies like of Zhao et al. (7) and Koob et al. (8)

Conclusion

Both intramedullary nailing and plating are safe and effective surgical methods for treating metastatic lesions in humeral shaft fractures. In this study, there were no significant differences noted in the incidence of fixation failure, local recurrence, wound complication or overall complication. However, the INF group demonstrated a significantly lower incidence of postoperative radial nerve palsy than the PF group. Considering the short life expectancy and complexity of end-stage patients, the choice of surgical method depends on the patient's individual condition, the fracture and lesion patterns and the surgeon's experience. Therefore, comprehensive discussion between surgeons and patients and shared decision-making are essential.

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