Treatment of nonunited fractures of the proximal humerus using locked plate, synthetic and autogenous bone grafting

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Background
Nonunion following fracture of the proximal humerus is not uncommon, particularly in the elderly. Stable internal fixation is essential to obtain healing of a nonunited fracture of the proximal humerus.

Aim
This study aimed at evaluation of the results of open reduction and internal fixation of nonunited fractures of the proximal humerus using the locked plate, synthetic and autogenous bone graft.

Patients and methods
Twelve patients diagnosed with nonunited fracture of the proximal third of the humerus were included in this study conducted between 2009 and 2011 in Suez Canal University. Eight patients were female and four were male. The mean age of the patients was 72.3 years (range, 65–80 years). The time between injury and surgery ranged from 6 to 12 months (mean 8.7 months). Three patients had undergone previous operations for persistent nonunion. The follow-up period lasted for 7–12 months, with a mean of 9.3 months. Radiographic evaluation was carried out with biplane radiographs taken at the time of the most recent follow-up evaluation, to determine the presence of bridging osseous trabeculae, which is suggestive of healing, as well as any loosening or failure of the fixation. The objective results were assessed on the basis of the modified scoring system of Constant and Murley. The subjective results were assessed on the basis of the score derived from the Disabilities of the Arm, Shoulder, and Hand Questionnaire.

Results
Radiological bone healing was documented in 11 of 12 patients. Objective and subjective assessments documented marked functional improvement in patients with healing fractures. The results were classified as good in 11 of 12 patients, and few complications were encountered.

Conclusion
Locked plate used in conjunction with synthetic and autogenous bone grafting is an excellent device for the treatment of proximal humerus nonunions with minimal complications.

Keywords:
locked plate, nonunion, proximal humerus, synthetic bone graft

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Introduction

Two-fifths of fractures of the humerus occur in the proximal part. Elderly patients are subjected to these fractures more than others. The causes of nonunion of these fractures are the comminuted four parts fractures and the use of conservative measures in the treatment (e.g. hanging plaster cast and skeletal traction) [1]. Complications of nonunion include shoulder and elbow joint contractures, marked osteopenia or bone loss, and implant failure [2]. Successful surgical managements require stable internal fixation and early joint motion. Osteoconduction and osteoinduction are needed for sufficient bone healing. Locking plate technology with a fixed-angle relationship between the screws and plate has been developed as a potential solution to the difficulties encountered using conventional plating to treat fractures in osteoporotic bone. To prevent screw toggling, sliding, pulling-out, and diminishing the possibility of primary or secondary loss of reduction, threaded screw heads are locked into the threaded plate holes; thus, the load is transmitted from the bone to the plate through the screw-plate threaded connection. The stability of the fracture depends on the stiffness of the plate and screw constructs [3]. Bone healing is not anticipated without the addition of a potent biologic stimulus. Osteoconductive bone graft substitute is indicated as an extender of an osteoinductive substance in the management of nonunion. Several osteoconductive bone graft substitutes are available for clinical use, including coralline hydroxyapatite, collagen-based matrices, calcium phosphate, calcium sulfate, and tricalcium phosphate. These products vary considerably in their chemical composition, structural strength, and resorption/remodeling rates [4].

This study aimed at radiological and functional evaluation of open reduction and internal fixation of

nonunited fractures of the proximal humerus using locking plate, synthetic and autogenous bone graft.

Patients and methods

Twelve patients diagnosed with nonunited fracture of the proximal third of the humerus were included in this study conducted between 2009 and 2011 in Suez Canal University Hospital. Eight patients were female and four were male. The mean age of the patients was 72.3 years (range, 65–80 years). The time between injury and surgery ranged from 6 to 12 months (mean 8.7 months). Three patients had undergone previous operations for persistent nonunion (Fig. 1). Approval have been taken verbally from the patients.

The follow-up period lasted for 7–12 months, with a mean of 9.3 months (Table 1).

Radiographic evaluation was carried out with biplane radiographs taken at the time of the most recent follow-up evaluation, to determine the presence of bridging osseous trabeculae, which is suggestive of healing, as well as any loosening or failure of the fixation. The Shoulder Outcome Score was used for assessing the objective results based on the modified scoring system of Constant and Murley [5].

A score between 80 and 100 points was considered excellent, between 60 and 79 points was considered good, between 40 and 59 points was considered fair, and between 0 and 39 points was considered poor. The subjective results were assessed on the basis of the Quick DASH scores derived from the Disabilities of the Arm, Shoulder, and Hand Questionnaire [6]. A score between 0 and 20 points was considered excellent, between 21 and 40 points was considered good, between 41 and 60 points was considered fair, and between 61 and 100 points was considered poor.

Surgical technique

The patient was placed in a semiseating position. The deltopectoral approach was preferable to preserve deltoid strength and function. The proximal fragment was found to retain good soft tissue attachments in all patients. The nonunion site was identified and debrided to healthy, bleeding, and viable bone. A sufficient dissection and release was performed to allow correction of any deformity, obtain apposition, and allow proper realignment [7]. Kirschner wires (5–7 mm) were used to recreate intramedullary canal, because it is an excellent source of osteoprogenitor cells, and left intramedullary until union established (Fig. 2).

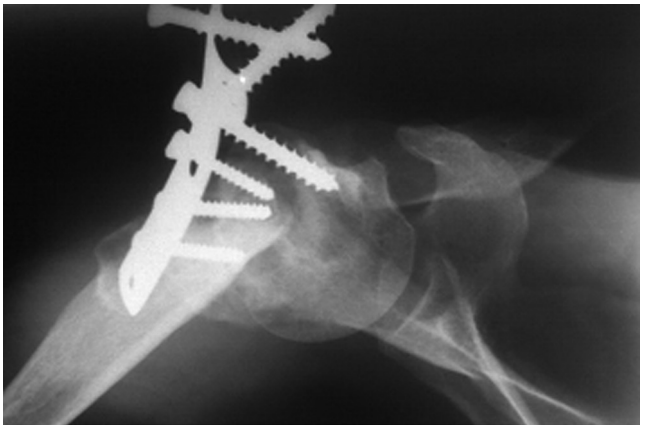
A proximal humerus locking compression plate was locked with different sizes of metaphyseal screws perpendicular to the limb axis to resist bending and torsional forces, starting with two compression screws transfixed distally, and then an indirect reduction was obtained proximally. The obliquity of the fracture was clamped and compressed using a standard reduction

Table 1 Clinical data of 12 patients with nonunited fractures of the proximal humerus treated with locking plates and screws with autologous iliac crest bone and synthetic grafting

Number	Age	Sex	TIS (months)	Follow-up (months)
1	65	Male	8	10
2	70	Male	6	8
3	80	Female	9	7
4	72	Female	12	9
5	73	Female	7	11
6	67	Male	6	12
7	78	Female	7	10
8	73	Female	10	10
9	69	Female	12	8
10	74	Female	12	9
11	78	Male	8	10
12	69	Female	7	8

TIS, time from injury to last surgery.

Figure 1



Preoperative radiograph.

Figure 2

Postoperative radiograph.

clamp, and locking screws were then placed proximally. An interfragmentary screw was then passed across the obliquity of the fracture from the lateral to the medial side [8]. The glenohumeral joint was then examined and found to have significant bursal scarring, which was excised producing a full range of motion. The bony defect was packed with a combination of autologous cancellous bone graft harvested from the ipsilateral iliac crest and synthetic bone granules (Fig. 3).

Results

There were no incidences of wound complications, postoperative neurovascular problems or palsies, and significant donor site morbidities.

Eleven out of 12 nonunited fractures progressed to union. There was no progressive loosening or breakage of fixation device, even in the patient who had radiographic evidences of incomplete union.

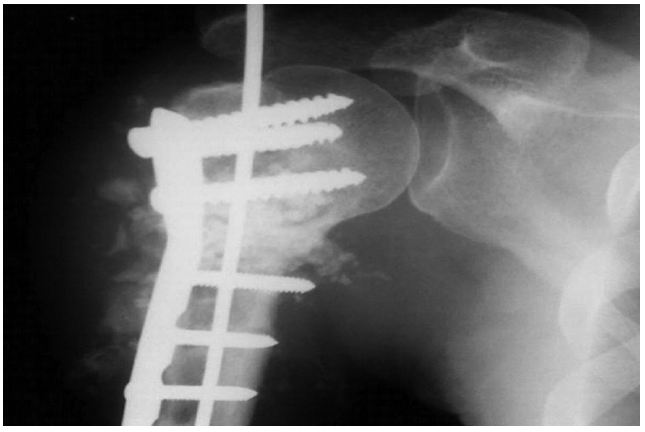
Objective and subjective assessments documented marked functional improvement in patients with healing fractures. The results were acceptable, with few complications encountered. Functional outcome in all except one patient had significant improvements of the functional scores at the most recent follow-up evaluation (Table 2). The mean score based on the modified system of Constant and Murley increased from 17.25 ± 2.56 to 62.58 ± 17.45 (Fig. 4). This difference is considered to be extremely statistically significant (P<0.0001). The mean score based on the Quick Disabilities of the Arm, Shoulder, and Hand Score (DASH) decreased from 72.67 ± 4.33 to 27.00 ± 13.64 (Fig. 5). This difference is considered to be extremely statistically significant (P < 0.0001).

Table 2 Preoperative and postoperative Constant and Murley score and preoperative and postoperative DASH score

Number	Preoperative constant and murley score	Postoperative constant and murley score	Preoperative DASH	Postoperative DASH
1	14	67	79	22
2	17	60	77	25
3	14	10	72	70
4	15	60	68	21
5	18	65	74	22
6	20	69	69	24
7	18	60	76	25
8	22	68	68	21
9	20	70	75	25
10	16	72	68	25
11	15	78	68	21
12	18	72	78	23
Mean ± SD	17.25 ± 2.56	62.58 ± 17.45	72.67 ± 4.33	27.00 ± 13.64

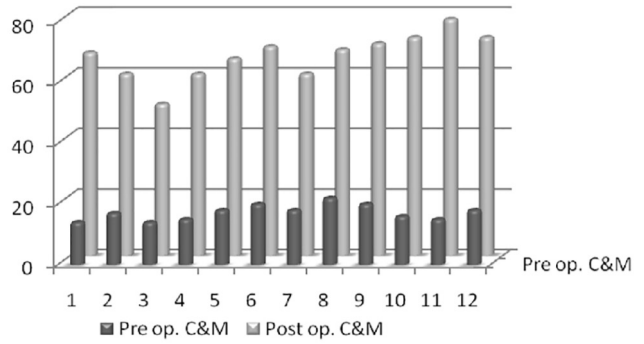
DASH, Disabilities of the arm, shoulder, and hand score.

Figure 3



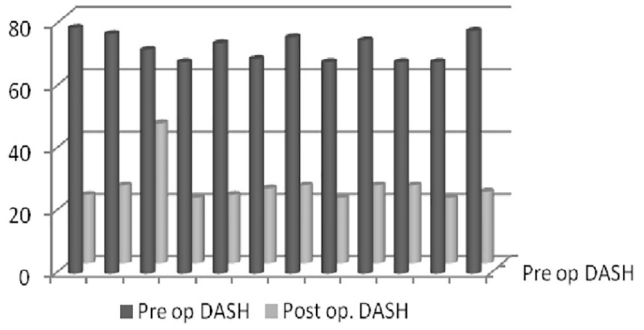
Follow-up radiograph.

Figure 4



Improvement of functional score postoperatively based on the modified scoring system of Constant and Murley (C&M).

Figure 5



Improvement of functional score postoperatively based on the Quick Disabilities of the Arm, Shoulder, and Hand Score (DASH).

Discussion

Nonunited fractures of the proximal humerus are often found in elderly patients with osteoporosis and can be disabling as a result of pain, deformity, and instability. There are relatively few studies published on the treatment of nonunited fractures of the proximal

humerus, and the ideal treatment remains unclear. Internal fixation procedures can be challenging due to poor quality of the bone, shoulder joint stiffness, and pseudoarthrosis. Treatment of nonunited fractures of the proximal humerus including intramedullary roding, rods with tension bands, open reduction and internal fixation, prosthetic replacement, and use of intramedullary cortical bone grafts has been described [9]. Outcomes for the surgical management of proximal humerus nonunion have been reported, with failure rates ranging from 9 to 20% [10]. Techniques of locked plate and screw fixation have emerged as one of the preferred methods for treating nonunited fractures of the proximal third humerus in osteoporotic bone. In this study, all except one patient (11 out of 12 patients) with nonunited fractures of the humerus progressed to union without implant failure (92%). Nonunion persisted in one patient, who developed osteonecrosis of the humeral head and refused shoulder arthroplasty (8%). In this study, because the quantity of available bone graft was insufficient, bone graft substitutes were used in a granular form as bone graft extenders. The low bone quantity can be explained by the high mean age of the patients (72.3 years). Kirschner wires were used to recreate the medullary canal and left intramedullary and subcutaneous until union was established clinically and radiologically.

The results are comparable to the study of Walch *et al.* [11], who reported 96% union with plate fixation and a low complication rate when combined with intramedullary bone peg insertion with cancellous bone grafting. Hamilton and Baird [12] reported that 100% of ununited fractures progressed to union with migration of a single proximal locking screw in two patients. Relatively higher complications were reported by Sturzenegger *et al.* [13] in patients with recent fracture treated with *t*-plate fixation (34%), although this may have been due to the severity of the fracture and extensive soft tissue stripping. Functional evaluation in this study showed that all patients included in the study had poor ranking on the Constant and Murley score preoperatively, with a mean of 17.25 ± 2.56 (range 14–22), whereas 11 of them had good scores and only one patient had poor score postoperatively, with a mean of 62.58 ± 17.45 (range 10–78). In contrast, assessment based on the DASH score showed that all patients had poor score preoperatively, with a mean of 72.67 ± 4.33 (range 68–79), whereas 11 patients had good score and one patient had poor score postoperatively, with a mean of 27.00 ± 13.64 (range 21–70). These results were comparable to that reported in the study by Hamilton and Baird, in which the mean Constant score was 63 (range, 54–81), and also to a study by Walch and colleagues based on Constant's score, in which the results obtained averaged 81.2%. Subjectively, 65% of patients were very satisfied, 30% were satisfied, and 5% were disappointed. The use of these techniques, implants, autogenous and synthetic bone grafting led to a high rate of union in the patients included in the present study. The fixation by locking plate and screws was sufficiently rigid to prevent progressive loosening or breakage of the implants. It is the functional objectives and subjective results, however, which are most encouraging and promising factors in managing elderly patients' disabilities.

Conclusion

Locked plate used in conjunction with synthetic and autogenous bone grafting is an excellent device for the treatment of proximal humerus nonunions with minimal complications.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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