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RESEARCH ARTICLE

MANAGEMENT OF NON UNIONS OF FRACTURE SHAFT OF HUMERUS WITH COMPRESSION PLATING

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ABSTRACT

Introduction: Most of fractures of the shaft of the humeral shaft heal well when treated nonoperatively, nonunion is not a rare complication. The prevalence of nonunion as a complication of both nonoperative and operative treatment has been reported to be as high as 13%. Open reduction and plate fixation combined with autologous bone grafting can result in reliable healing of these humeral nonunions with excellent functional outcome.

Material and Methods: Between 2009 and 2014, 30 nonunion cases of the humeral shaft were treated with open reduction and internal fixation by a plating. The series included 10 female patients and 20 male patients with an average age of 40years (range 20–60 years). The patients were followed up for an average of 18 months. The time from diagnosis of nonunion to our treatment of the nonunion averaged 9 months (range 6–24 months).

Result: According to the Stewart and Hundley Criteria, the functional postoperative result was excellent or good in 22 (73%) cases and fair in eight (27%) cases. One year after surgery, all patients had an essentially normal range of motion of the ipsilateral elbow and shoulder.

Conclusion: Surgical compression plating and autologous bone grafting of humeral diaphyseal nonunions resulted in 100% union rate and mostly excellent or good functional results without significant morbidity.

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INTRODUCTION

Most of the fractures of the shaft of the humeral shaft heal uneventually when treated nonoperatively (Bosch *et al*., 1999), nonunion may also occur. The prevalence of nonunion as a complication of both nonoperative and operative treatment has been reported to be as high as 13% (Epps, 1988; Foulk, 1995; Healy *et al*., 1987). Although plate fixation remains one of the most valid techniques for the treatment of these fractures cases, poor bone quality or a deficient plate technique may lead to nonunion (Foster *et al*., 1985; Henley *et al*., 1991; Muller, 1965; Murray *et al*., 1964; Ring *et al*., 2000; Stewart, 1955; Wu, 1992). Delayed union or nonunion of fracture of the humerus is a debilitating complication, but open reduction and internal fixation combined with autologous bone grafting can result in reliable healing of these nonunion cases; however, not without morbidity at graft site (Arrington *et al*., 1996; Goulet *et al*., 1997). There are little reports in the literature on the outcome of humeral shaft nonunion treatment using a uniform surgical technique (Gupta *et al*., 1985; Wu, 1996).

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Compression plating of the humeral shaft nonunion, especially after previous surgery, is often associated with a high risk for radial nerve injury (Ring *et al*., 1999). The aim of this article was to report on the results of compression plating of nonunion cases both radiologically and functionally.

MATERIALS AND METHODS

Between 2009 and 2014, 30 consecutive cases of humeral shaft nonunion were treated with open reduction and internal fixation with 4.5 mm locking compression plate or 4.5 mm anatomically precontoured lateral plate (for distal fractures) along with autogenous iliac crest bone grafting. All the patients with radiologically and clinically established non unions in which nine months have elapsed since fracture were included in study. Medically unfit patients and infected non unions were excluded. Patients were retrospectively reviewed for mechanism of injury, associated injuries, previous treatment modalities, current surgical data, and complications, and the functional outcome was evaluated using the Stewart and Hundley Criteria (Stewart, 1955) presented in Table 1, the right and left shoulders are assessed separately.

Radiographs were reviewed to assess nonunion preoperatively for displacement, shortening, angulation, and final union. The series included 30 patients (10 women and 20 men) with an average age of 40 years (range 20–60 years) who were followed up for an average of 18 months. The original injury was caused by a raod traffic accident in 22 cases and by fall in eight. The right arm was involved in 18 patients and the left in 12. The time from initial injury to our surgical intervention for the nonunion averaged 8 months (range 5–36 months). The initial fracture treatment was no operative in 17cases, with a hanging cast, and operative in 13 cases. All nonunions demonstrated gross instability and no radiological signs of healing at presentation. All patients also had a degree of shortening measured clinically, ranging from 5 to 34 mm with an average of 8.5 mm. All the patients underwent standard compression plating and autogenous iliac crest bone grafting after appropriate preparation of bone ends. Anteriolateral approach was used in 22 patients and posterior in 8 patients. All patients reported functional disability of the involved upper extremity due to pain and instability at the nonunited fracture site. Details of surgical treatment. Prophylactic cefuroxime 1.5 gm was administered preoperatively to all patients who were generally anesthetized in the supine position. The limb with nonunited fractures was prepared and draped in a standard manner. Surgical fixation was carried out through a standard Henry anterolateral approach [Henry, 1966] with the radial nerve identified between the brachialis and brachioradialis muscles distally and protected throughout the case. Thereafter, subsequent neurolysis was carried out.

Fractutre ends were trimmed upto the bleeding bone and shingling of the ends was done with preservation of soft tissues to avoid bone devascularization. Thereafter, reduction was achieved by gentle impaction of the proximal and distal ends at the fracture site or by using a reduction clamp. Generally shortening of .5 to 2 cms had to be done. Autogenous cancellous bone graft obtained from the patient's anterior iliac crest was used in all cases. Hardware was selected on the basis of previous operative intervention, quality of bone, and presence of bone segment loss. The use of intramedullary nailing was excluded as all patients had atrophic nonunion and they needed debridement and bone grafting. The nonunion was fixed with a 4.5-mm narrow dynamic compression plate and screws, with at least eight cortices engaged on both sides of the nonunion for 25 cases. This plate was secured in compression mode. In remaining cases which were distal, a precontoured lateral plate was used (Fig 1,2,3). The average operative time was 110 min (range 90–175 min) in all patients. The average blood loss was 180 ml (range 110–350 ml).

Postoperatively the patients were encouraged to perform active range of motion exercises of the shoulder and elbow while avoiding resisted activities until healing occurred. After healing of the nonunion, passive range of motion exercises were started. Outcome measurement included a clinical evaluation of morbidity, pain, and recovery of functional level of activity. Functional outcome scores of the Stewart and Hundley Criteria (Stewart, 1955), in addition to the scoring system of Constant and Murley (table2), were also utilized. Radiographic evaluation included assessment of alignment, loosening of the devices, and the presence of a bridging callus across the nonunion site. Healing was assessed clinically and radiographically and was defined as the absence of tenderness on the site of the un-united fracture and the presence of a bridging callus across the fracture site in at least three cortices on two orthogonal radiographic views

RESULTS

Table 3 lists the preoperative patient data including sex, age, limb involved, number of previous surgeries, and interval from injury to index operation. Of the patients, 13 (43%) had undergone previous surgeries and 17 (57%) patients had been treated conservatively with a hanging cast or functional brace. 9 out of 13 cases had undergone surgical plating, four were internally fixed with an intramedullary nail. Table 3 summarizes the preoperative and postoperative patient data including the type and number of plates used and time to radiographic union.

Table 1. Stewart and Hundley Criteria

Score.	Pain.	Limitation of motion	Angulation.
Good	No	<20 degree	<10 degree
Fair	After work	20-40 degree	>10 degree
Poor.	Permanent.	>40 degree	Radiological non union.

Table 2. Scoring system of Constant and Murley

PAIN	
Severe	0
Moderate	5
Mild	10
None	15
Activity of daily living	
Full work	
Severe	0
Moderate	2
No	4
Full recreation/sport	
Severe	0
Moderate	2
No	4
Affected sleep	
Yes	0
Sometimes	1
No.	2
Use of arm in painless activity	
Waist	2
Xyphoid	4
Neck	6
Head	8
Full range	10
Range of motion	
Flexion	10
Abduction	10
External rotation	10
Internal rotation	10
STRENGTH	25

All patients were followed up for a mean period of 26 months (range 12–56 months). No patient required return to the operating room for a second operation or regrafting. The average time to radiographic union was 16 weeks (range 14–22 weeks) for all cases. Functional results according to the Stewart and Hundley Criteria (Stewart, 1995), the functional preoperative results were poor in 26 (87%) cases and fair in four (13%) cases , whereas the postoperative results were excellent or good in 24 (73%) cases and fair in six (27%) cases .One year after surgery, all patients had an essentially normal range of motion of the ipsilateral elbow and shoulder. According to the scoring system of Constant and Murley the preoperative average score was 80 (range 74–87) and the postoperative average score was 90 (range 88–96). All patients were doing well at the final interview and had regained their functional activity before the initial trauma.

Table 3. Preoperative and post operative data and functional evaluation

Cases	Age	Sex	Limb	Implant in place	Time since injury (months)	Type of implant	Time to union (weeks)	Functional (s & h)# score	Functional (c & m)$ score
1.	55	M	L	Y	11	4.5 MM LCP	16	Excellent	91
2	48	M	L	N	11	"	19	Excellent	92
3	46	M	R	N	6	"	16	Excellent	91
4	55	FF	L	Y	10	"	19	Fair	88
5	70	M	L	N	24	"	18	Excellent	91
6	69	F	R	Y	11	"	20	Excellent	92
7	43	M	R	Y	17	"	15	Excellent	91
8	45	F	R	N	9	"	16	Fair	88
9	63	M	L	N	13	"	18	Excellent	89
10	77	M	L	Y	21	"	17	Excellent	90
11	48	M	L	N	8	"	21	Excellent	91
12	41	M	L	N	14	"	22	Excellent	89
13	47	M	R	Y	22	"	19	Fair	88
14	36	F	R	N	12	"	20	Excellent	92
15	61	F	L	N	14	"	22	Fair	91
16	48	M	L	Y	15	"	21	Excellent	90
17	49	M	L	Y	9	"	25	Excellent	90
18	60	M	L	N	8	"	16	Excellent	89
19	51	F	R	Y	9	"	19	Excellent	91
20	46	F	L	N	11	"	17	Excellent	94
21	45	F	L	Y	16	"	15	Fair	88
22	23	M	R	N	18	"	17	Excellent	93
23	80	M	R	Y	33	"	18	fair	88
24	56	M	L	N	10	"	19	Excellent	91
25	34	M	L	Y	11	"	20	Excellent	92
26	23	F	L	N	10	"	21	Excellent	89
27	65	M	R	N	108	"	22	Excellent	90
28	34	M	R	N	16	"	15	Excellent	92
29	46	M	L	N	15	"	14	Excellent	92
30	55	F	L	Y	16	"	22	Excellent	91

"= SAME (4.5 MM LCP)
#= Stewart and Hundley Criteria
$= Scoring system of Constant and Murley

No patient developed wound infection, osteomyelitis, neurovascular injury, and all achieved solid union.

Fig 1- non union humerus 9 years old

DISCUSSION

Most humeral fractures can be treated by conservative methods unless they had been caused by high-energy trauma and needs surgical fixation to obtain adequate reduction and good functional outcome.

However, Ostermann *et al*. (1993-1994) reported a nonunion rate of 2%, whereas other authors reported a nonunion rate up to 13%, which can be severely disabling (Epps, 1988; Foulk, 1995; Healy *et al*., 1987). Plate fixation in combination with bone grafting appears to be more reliable in the treatment of nonunions of the humeral shaft even in the presence of poor bone quality due to osteopenia or loss of cortical integrity (Ring, 2000; Jupiter, 1990).

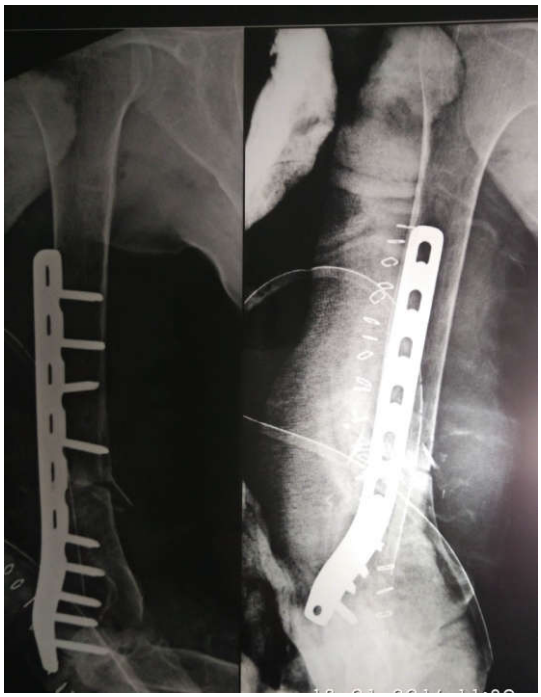

Fig. 2. Fixation with anatomical 4.5 mm lcp with bone grafting

Fig 3. Solid union at 5 months followup.

Healy *et al*. (1987) concluded that plate fixation is the most reliable treatment for humeral nonunion. They pointed out that the main factor for success was a stable plate achieved by securing fixation of at least six cortices proximal and distal to the nonunion site, whereas other authors recommended eight cortices proximal and distal to the fracture site (Heim *et al*., 1993). Although plate fixation remains one of the most valid techniques for the treatment of these nonunions, poor bone quality or a deficient plate technique may lead to nonunion (Foster *et al*., 1985; Henley *et al*., 1991; Muller, 1965; Murray *et al*., 1964; Ring *et al*., 2000; Stewart, 1955; Wu, 1992). Foster *et al*. (1985) reported a 96% rate of union in their study on fixation of both fractures and nonunions. They used both single-plate and dual-plate constructs either with or without lag screws. The treatment of nonunion differs from that of acute fractures (Ring, 1997). A nonunion usually requires thorough debridement of the sclerotic bone, synovial tissue, and fibrous tissue to obtain a well-vascularized bone bed and optimize placement of a bone graft in the nonunion site.

We reported successful open reduction and internal fixation of atrophic nonunion augmented with autologous iliac crest grafting of the humerus. The surgical approach and plate fixation technique are of immense importance to avoid radial nerve injuries and achieve a high degree of absolute stability. This was accomplished with compression and rigid plate fixation, which provided a stable construct and an ideal biomechanical environment required for successful bone healing. After freshening of the fracture site by radical debridement, enhancement of the local biology was accomplished using autologous bone grafting. We have found it mandatory to perform resection of the nonunion and remove all fibrous tissue to ensure a new vascularized bed at the fracture site, which in turn enhances migration of osteogenic cells and prepares the host environment for successful graft integration. We successfully used rigid internal fixation with bone grafting to achieve union with a high success rate and excellent functional outcome. In our experience, we found that humeral diaphyseal nonunion treated with surgical plating and autologous bone grafted yielded a 100% union rate with no radial nerve injury or wound infection. The functional outcome of our cases based on two functional scores showed outstanding results.

Conclusion

Humeral nonunion is a debilitating condition that can result in long-term sequelae and loss of function, which can be successfully treated by surgical plating and autologous bone grafting to have the best postoperative functional results.

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