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Is Compressive Intramedullary Nailing an Effective Method in Aseptic Humerus Nonunions without Bone Defects?

Je kompresní nitrodřeňové hřebování efektivní metodou u aseptického pakloubu humeru s kostním defektem?

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ABSTRACT

PURPOSE OF THE STUDY

Treatment of nonunion of humerus continues to be a matter of debate. For this purpose, many treatment methods have been reported. The aim of this retrospective cohort study is to evaluate the results of patients who underwent revision surgery with compressive intramedullary nailing implemented a single type of surgical technique in aseptic humeral nonunions without bone defects.

MATERIAL AND METHODS

Data of 15 patients with humerus nonunion, all were treated with compressive intramedullary nailing between 2000 and 2019 were retrospectively evaluated. Three patients were hypertrophic and 12 were atrophic types. The mean ages of patients at the surgery was 47.3±18 years. In all cases, maximal bone contact was created between the proximal and distal bone fragments after reaming and debridement, and fixation was performed with compressive intramedullary nailing. Radiological assessment of union was performed based on the RUSHU criteria, and functional outcomes were assessed according to Constant-Murley scoring criteria.

RESULTS

The ten out of 15 patients were male. The radiological union was achieved at a mean duration of 16.6±2.3 weeks in 14 patients. The average time of follow-up after nonunion treatment was 25.2±8.8 months. Twelve out of 15 patients implemented bone grafting taken form iliac bone with spongiosa obtained via reaming. The functional results were made according to the Constant-Murley score and excellent functional results were obtained in nine patients, good in four patients and poor functional results in one patient. Implant failure was not observed. One patient has had post-operative transient ulnar nerve palsy and another patient developed transient radial nerve palsy.

CONCLUSIONS

Compressive intramedullary nailing is a useful method that provides excellent union in the surgical treatment of aseptic non-union of the humerus, without bone defects.

Key words: intramedullary compressive humeral nail, nonunion, failed intramedullary nailing humerus fracture, fracture fixation, autologous bone grafting.

INTRODUCTION

Humerus fractures can be successfully treated conservatively or surgically. However, the incidence of nonunion in conservatively treated fractures is 8%, while it is reported between 0% and 13% after surgical treatment (27, 15). Union time varies between 12 and 16 weeks. If there are no signs of the union after six months, nonunion should be considered (5).

Initial trauma severity, transverse fracture pattern, soft tissue interposition, conservative follow-up in unstable fractures are known to be provoking factors in nonunion. Besides, systemic diseases, use of drugs that delay union, smoking and alcohol consumption, and local factors such as infection and circulatory disorders negatively impact the union. These factors should be considered in planning treatment (13).

The type of nonunion is extremely important in surgical planning. Among the different classifications proposed for nonunion, the Weber and Cech classification is used more, which is orientated on the surgical treatment of nonunions (23).

Since hypertrophic nonunion with extensive callus formation has a high chance of union, and stable osteosynthesis will be the best treatment choice (14). Atrophic nonunions are characterized with a low amount of callus formation, circulatory insufficiency of the bone, and low chance for recovery. This type of nonunion requires debridement of the necrotic tissue, stable fixation and additional biological stimulation (6, 14).

Many fixation methods have been recommended for nonunion of the humeral shaft, including single or dual plates fixation augmented with autologous bone graft, the intramedullary device with bone morphogenetic proteins, cortical augmentation with the fibular strut, and fixation with Ilizarov apparatus (6, 11, 14, 20, 26).

In the literature, we did not find the results related to the humeral nonunion cases treated with a compressive intramedullary nail. This retrospective study aimed to describe our treatment concepts for this entity and present the results of patients treated for nonunion of the humerus in our hospital.

MATERIAL AND METHODS

The study protocol was approved by the Antalya Training and Research Hospital Ethics Committee (IRB:2020-129:8/13). The data of 15 patients who developed nonunion without bone defects and were treated between 2000 and 2019 were retrospectively reviewed. The mean age of the patients included in the study was 47.3±18 years. Ten of the patients were male and five were female. Hypertrophic nonunion was seen in three patients and atrophic nonunion in twelve patients. As the primary treatment, conservative treatment was performed in four patients, open reduction and fixation with the locking plating in five patients, and intramedullary nail fixation in six patients. All of the patients had a closed fracture and were non-infected and nondefective. The primary cause of fracture was a traffic accident in five patients and fall in ten patients. The average time of follow-up after nonunion treatment was 24.1±16.4 months. In all cases, the intramedullary nail was implemented on following the nonunion area were debrided, and a good bone contact was established. The autogenous iliac bone cancellous graft and spongiosa taken via reaming was placed in all atrophic nonunion cases. Direct X-ray images were assessed according to the RUSHU criteria (18), and functional evaluation was performed according to the Constant-Murley scoring system, in which 100–80 points are evaluated as a very good functional result, 80–60 as good, 60–40 as moderate, 40–20 as poor and 20–0 as very poor (7). Written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki. C75 locking compressive humerus nail was used in all patients (Hipokrat, Izmir, Turkey).

Surgical techniques

Under general anesthesia, the patient was placed in the beach-chair position. After sterile closure and draping, in patients who underwent surgery, the old incision site, and in patients treated conservatively anterolateral incision were used for the exposure of the nonunion area. The pseudoarthrosis area was exposed and the bone ends were debrided. A four cm longitudinal skin incision from the anterio-lateral point of the acromion was performed, centered over the tip of the greater tuberosity. Attention should be paid not to extend the incision more than 4 to 5 cm in the deltoid muscle to avoid damaging the axillary nerve. The rotator sheath was reached after passing through the deltoid fibers. A small longitudinal split incision was created in the insertion of the supraspinatus muscle. With an awl, the entrance hole was opened. Following the reaming, the fragment reduction was provided under appropriate length and thickness of the nails to be used were determined and it was gently inserted with a nail holder. Distal locking was applied without fluoroscopy according to the technique we described before (1).Then a grooved tipped screw was placed in the head from the oval hole. As the compression device contacted lock screw, 1 mm compression was applied. The mean stress was approximately 50 MPa (3, 8). Following the full threaded cortical screw was placed bicortical, the end cup put into place and the procedure was completed. The rotator cuff area was repaired at the nail insertion area, a graft was taken from the iliac bone for atrophic nonunions and the surgical area was closed by the anatomy. Prophylactic antibiotics were given as 4x1 g of cefazolin sodium iv for 24 hours. Postoperative arm sling was performed. In the first week, passive exercises were initiated, and in the second week,

Fig. 1. a–d. 41-year-old man, fracture of the proximal third of the right humerus. Preoperative radiography shows the spiral-oblique fracture pattern (a). Nonunion following 6 months after plate osteosynthesis (b). Computer Tomography evaluation of atrophic nonunion (c). Union three month after new surgical treatment with compressive intramedullary nailing (d).

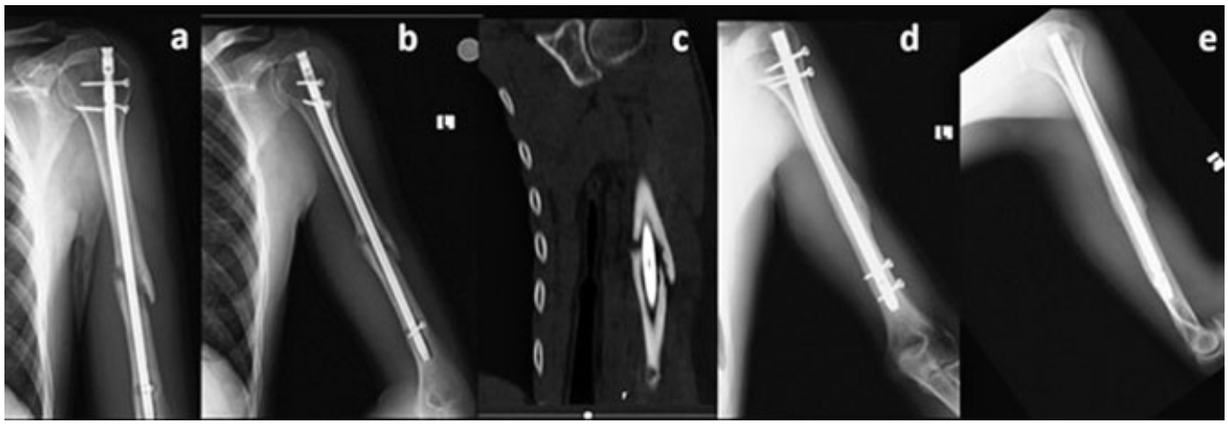

Fig. 2. a–e. A 22-year-old man, fracture of the humeral diaphyses. Six months after locked intramedullary nailing, evidencing radiographic lack of callus formation, and loosening of the IM nail (a, b). CT view shows atrophic nonunion (c). Five-month follow-up showing radiographic bony union (d, e).

active exercises were performed as tolerated. Patients were not allowed to lift any weight before the radiological union was seen.

RESULTS

Of the patients surgically treated for humeral nonunion, five were female and ten were male. Mean age was 47.3±18 years. Mean follow-up was 25.2±8.8 month. We lost to follow-up of three patients after 24 months. Diabetes, Hypertension, and Hypothyroidism were the most common in comorbidity analysis. There were no signs of comorbidity in three patients. Five of the twelve atrophic nonunion cases were initially fixed with locking plating (Fig. 1). The five patients were fixed with an intramedullary nail (Fig. 2) and two patient were treated conservatively (Fig. 3) (Table 1). One of the hypertrophic nonunions were initially stabilized with an intramedullary nail and two patients were treated conservatively. Union was considered clinically as the absence of any pain, and present of trabecular continuity of more than two cortexes. Complete consolidation was achieved in 14 out of 15 patients in an average of 16.6±2.3 weeks. One patient had nonunion and at the same time, transient radial nerve palsy was observed in this patient. One patient was developed transient ulnar nerve palsy. Twelve of 15 patients were grafted with autograft taken from the iliac bone and spongiosa to aid union.

The outcome scores of patients were measured at every follow-up. Median Constant score for a shoulder of twelve patients was 76.7±25.5. The follow-up of three patients was lost after 24-month control. The Constant score was 88±1.6 at last control in these patients. There were no reported cases of infection and implant-related problems in these patients. All patients had complete shoulder and elbow function at last follow-up

DISCUSSION

Nonunion seen after conservative or surgical treatment of humeral fractures is a serious condition. There are many biological and mechanical factors on the basis of healing and achieving a good functional result in humerus nonunions. Avoiding unnecessary surgical procedures, performed appropriate surgical technique, and

Fig. 3. a–d. A 40-year-old man with a fracture of the distal third of the right humerus. Failure of orthopaedic treatment by immobilization in a U-shaped sling at 3-month follow-up (a). Painful function impotence with gross mobility at the nonunion site (b). Union 3 months after surgical treatment with compressive intramedullary nailing (c, d).

Table 1. Demographic and surgical variables of patients patients underwent revision surgery with compressive intramedullary nailing

Patients	Age	Gender	Type of nonunion	Initial treatment	Union (time)	Substitude	Complication	Follow up	Constant-Murley score
1	41	E	Atrophic	Plating	16	Iliac crest, spongiosa	None	35	92
2	76	K	Atrophic	IMN	20	Iliac crest, spongiosa	None	25	43
3	40	E	Hypertrophic	Conservative	16	Spongiosa only	None	24	95
4	47	K	Atrophic	IMN	16	Iliac crest, spongiosa	None	24	88
5	27	E	Hypertrophic	Conservative	20	Spongiosa only	None	27	82
6	22	E	Hypertrophic	IMN	14	Spongiosa only	None	32	100
7	60	E	Atrophic	Plating	18	Iliac crest, spongiosa	None	35	95
8	76	K	Atrophic	conservative	20	Iliac crest, spongiosa	None	26	45
9	66	K	Atrophic	Plating	18	Iliac crest, spongiosa	None	28	58
10	66	E	Atrophic	Conservative	None	Iliac crest, spongiosa	Transient ulnar nerve palsy	34	18
11	28	E	Atrophic	IMN	14	Iliac crest, spongiosa	None	24	86
12	22	E	Atrophic	Plating	14	Iliac crest, spongiosa	None	32	92
13	56	K	Atrophic	Plating	16	Iliac crest, spongiosa	Transient radial nerve palsy	24	90
14	38	E	Atrophic	IMN	16	Iliac crest, spongiosa	None	28	88
15	44	K	Atrophic	IMN	14	Iliac crest, spongiosa	None	25	95

IMN: intramedulllary nailing

appropriate implant selection will reduce the incidence of nonunions. There are many studies in the literature related to the development of nonunion based on inadequate surgical indication, implant selection and surgical technique (2, 9). Reed et al reported that the underlying cause of atrophic nonunion might be found in a lack of osteogenic cells and growth factors at the fracture site, caused by reduced vascularity at the defect gap (22). Extensive soft-tissue stripping by the initial injury or subsequent to surgery is lead to cause osteonecrosis. Therefore, non-viable, atrophic fragments and fibrous scar tissue in the fracture gap should be removed radically. Giannoudis et al. also emphasized the need for adequate circulation support in combination with mechanical stability and osteoconductive agents in fracture healing (10). Therefore, surgical intervention should be planned to restore stability. This can be performed by replacing the nail and plate, as well as debridement of the interposed tissues and providing spongiosis support. No significant difference was reported between IMN and plating in terms of the incidence of nonunion in the literature. However, if nonunion has occurred, there are studies indicating that using a locking compression plate is advantageous in terms of union (17).

Although humeral fractures can be successfully treated conservatively, nonunion rates of approximately 17% have been reported (24). The four cases we revised, were nonunion after conservative treatment. Two of these cases were hypertrophic and two were atrophic nonunion. Hypertrophic nonunion was successfully treated with compressive nailing and grafting only with spongiosa achieved from intramedullary reaming. While one of the patients with atrophic nonunion who was performed the same treatment method recovered successfully, in the other patient with high comorbidity, the union could not be achieved. The external fixator is preferred in nonunion treatment because it provides good reduction and compression. However, the emergence of risks such as re-fracture occurrence, development of pin tract infection, septic arthritis and nerve damage has limited the use of this method, especially in nonunions without soft tissue loss (19, 21).

In the treatment of nonunions, fixation with plate may be more preferred in terms of providing good compression, correcting axial plane and stimulating osteogenesis. With this method, about 90% of the union can be achieved (16, 25). In the study of Barquet et al., reported union in 24 out of 25 patients treated with wide DCP and autologous graft (4). Disadvantages such as the need for wide dissection, iatrogenic radial nerve damage (5–12%) and inadequate fixation in osteopenic patients are well known (12).

We revised five patients whose primary treatment was a fixation with plate and who developed nonunion. The plate was broken in three of them, screws in the proximal fragment were broken in one case, and the insufficient reduction was found in one case. All of the cases were atrophic nonunion.

Intramedullary nailing is a less invasive method compared to open reduction and plating. However, although it is a locked implant, nonunion rates of up to 29% have been shown due to the axial and rotational instability that still needs a solution (20). There are also publications reporting good results in the literatüre (20).

In our six cases, the intramedullary nail was implemented previously, and in two cases sufficient reduction

(gap) could not be achieved, in three cases had a thin nail and locking screws were not appropriately placed, one case had no locking screw, and these are accepted as a technically inadequate condition. Five of these patients had atrophic and one developed hypertrophic nonunion. Previous nails were removed, the nonunion line was debrided and the ends were refreshed. After reaming, the intramedullary compressive nail was placed, the obtained spongiosa obtained with intramedullary reaming, as well as autogenous iliac graft were placed in the field. It was observed that there was sufficient consolidation in their follow-up.

So far, we have not encountered studies reporting the results of compressive intramedullary nails in nonunion treatment. We suppose that, providing adequate compression and eliminating the need for wide dissection contribute to preserving the biology of bone. We accept with manual reduction and reaming the biology is affected, but there is no periosteal stripping is involved.

The small number of the patient included in the study was the limitation of our study. However to our knowledge, there is no more study in the literature, to evaluate the radiological and functional outcomes of a locked compressive intramedullary nail in adult humerus nonunion.

CONCLUSIONS

The treatment of humerus nonunion poses a great challenge. Patients must be evaluated in detail based on their comorbidities, the drugs they use, and types of nonunion also primary treatment should be taken into consideration.

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