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ORIGINAL ARTICLE

Implementation of locking compression plate together with intramedullary fibular graft in atrophic type humeral nonunions

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Abstract
Objective This study aims to report the results of locking compression plate along with intramedullary fibular graft that was implemented in patients with the diagnosis of nonunion of humerus diaphysis.
Materials and methods Five patients, operated between 2000 and 2009 for atrophic type nonunion of humeral diaphysis, were included in this study. Two patients were women (40%) and three were men (60%). The mean age was 49.2 years. Nonunion was found to be on the right humerus of 3 patients and on the left side of 2 patients. Causes of fractures were traffic accident in 2 cases, simple fall in 2 cases, and fall from height in 1 case. Mean duration after the elementary fracture was 70 months. Nonunion was diagnosed at 1/3 proximal humeral diaphysis in 2 patients, 1/3 distal humeral diaphysis in 2 patients, and 1/3 middle humeral diaphysis in one patient. Initially, conservative treatment was chosen for 3 cases and plate-screw osteosynthesis for 2 cases.
Results Complete union was obtained in all cases radiologically. Mean union time was 20.1 weeks. With a mean of 1.78 cm, shortening was detected in comparative radiographies of both humeri. Mean range of motion at the elbow was 118° in flexion–extension arch of patients. The mean Constant-Murley score was 88 points. There was no complication regarding the operation and graft donor sites.
Conclusion The management of atrophic type humeral nonunions is difficult. The method that we practice in such patients is a reliable treatment option with its stabile fixation and high union rates.

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Keywords Humerus fracture · Nonunion · Surgical treatment · Fibular allograft · Plate osteosynthesis

Introduction

The nonunion rates of diaphysial fractures of humerus were reported as 1–13% in the literature [1–3]. Complaints such as pain and movement in fracture site may lead to serious functional limitations. Fracture pattern, severity of the trauma, possible soft tissue interposition, and patient-related factors, such as alcoholism and obesity, are determinants of fracture union. Insufficient fixation, impairment of bone nutrition, or postoperative infections can lead to nonunion. Nonunions are divided into subgroups according to facient mechanisms, such as infected/noninfected or atrophic/hypertrophic types [3, 4].

Intramedullary nailing, external fixation with grafting, and plate-screw fixation following the revival of the fracture ends by open reduction are options for the treatment of diaphysial nonunions of humerus [1, 6]. The purpose of this study is to report the results of locking compression plate fixation along with intramedullary fibular grafting in the treatment of atrophic type humeral diaphysial nonunion.

Materials and method

Five patients operated between 2000 and 2009, for atrophic type nonunion in humeral diaphysis, were retrospectively evaluated [2 women (40%), 3 men (60%), and mean age 49.2 years (Range: 37–60)]. Nonunion was present on the right humerus of 3 patients and on the left humerus of 2 patients. Causes of fractures were traffic accident in 2 cases, simple fall in 2 cases, and fall from height in 1 case. Mean

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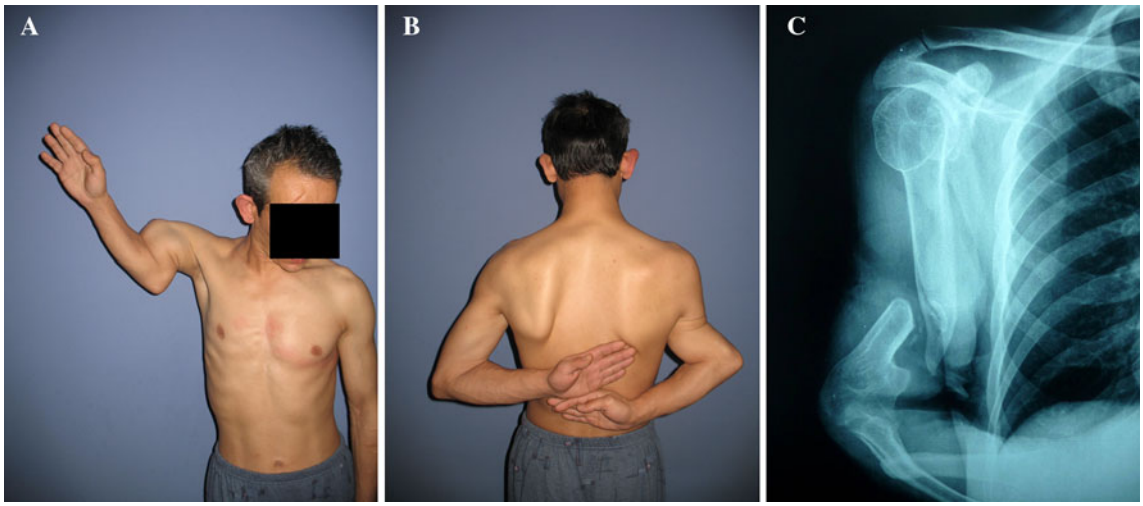

Fig. 1 **a–c** Preoperative clinical situation and radiographs of the patient

duration after the elementary fracture was 70 months (range: 24–128). Nonunion was diagnosed at proximal 1/3 of humeral diaphysis in 2 patients, 1/3 distal humeral diaphysis in 2 patients, and 1/3 middle humeral diaphysis in 1 patient. Conservative treatment was chosen in 3 cases initially. In one case, plate-screw osteosynthesis was applied as an initial treatment, and sixth months later, grafting was performed due to delayed union. Implants were removed after the emergence of an infection in the eighth month. In last case, fracture was treated with plate-screw fixation, but implant failure occured. Radial nerve lesion was detected in one case. In a patient who was treated conservatively, additional ipsilateral forearm pseudoarthrosis was present. Movement was detected at nonunion region in all cases (Fig. 1a, b, and c). Three patients were smokers, but any comorbidity was not detected in none of the patients.

In all cases, first-generation cephalosporin (Cefazolin sodium, Sefazol®, Mustafa Nevzat) was used intravenously for prophylaxis in the dosage of 4 × 1 gram for 48 h after the operation. All patients were followed up with 6-week intervals for the first 6 months and then once in 6 months in an outpatient base. Evaluation of union was performed radiographically. Range of motion of shoulder and elbow was functionally evaluated. In the evaluation of shoulder functions, Constant-Murley scoring system was used [7]. Shortening of extremity was checked with comparative radiographs of controlateral humerus. Mean follow-up duration was 22.8 months (Range: 12–36).

Surgical technique

In all cases, anterolateral incision was preferred. Radial nerve exploration was applied routinely. Previously implanted hardwares were removed in 2 cases. Fibrotic tissues within the fracture sites were removed and the contiguity of fracture ends was provided. Ipsilateral fibular graft was taken as 6 cm long. Proximal and distal portions of fracture sites were excavated according to the diameter of the graft. Fibular autograft was placed intramedullary. Osteosynthesis was ensured by the application of locking compression plate (Fig. 2). A rehabilitation program including active elbow and shoulder exercises was practiced beginning at the postoperative second day.

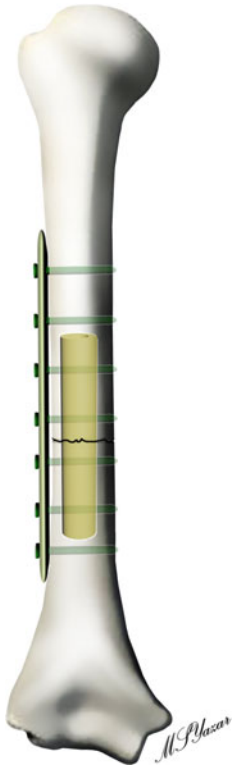

Fig. 2 Illustration of the plate and the graft

Results

Three-quarters cortical consolidation in anteroposterior and lateral radiographs was accepted as union and ensured in all patients (Fig. 3a, b, and c). Mean union duration was 20.1 weeks (Range: 16–22). With a mean of 1.78 (Range: 1.2–2.4) cm, shortening was detected in comparative radiographies of both humerus. Mean range of motion at the elbow was 118° (Range: 100–130) in flexion–extension arch of patients. Mean Constant-Murley score was 88 points (Range: 80–95). There was no complication regarding the operation and graft donor sites of patients. Tendon transfer procedures were applied to the patient with radial nerve palsy after fracture union. Mean follow-up duration was 22.8 months (Range: 12–36).

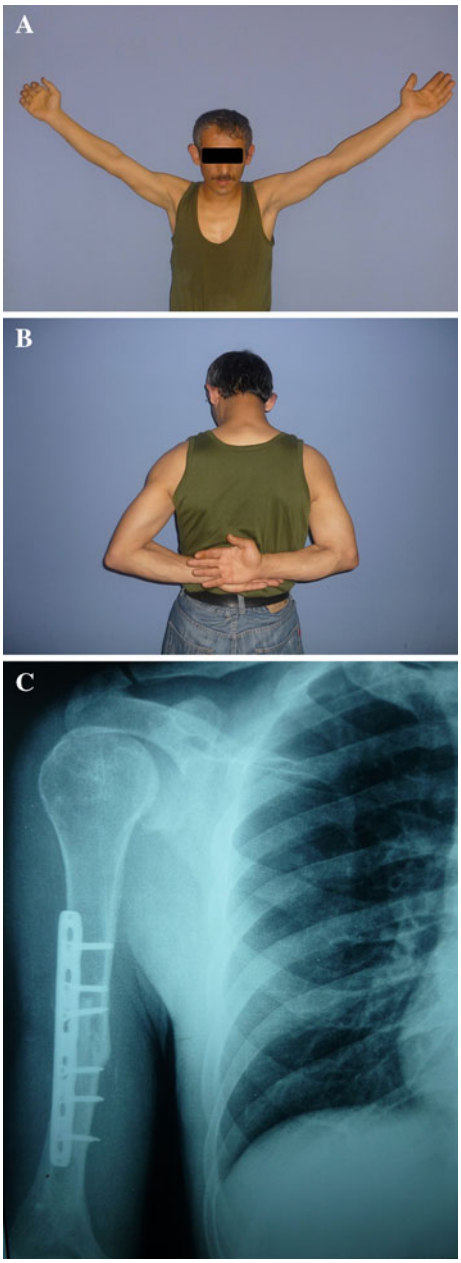

Fig. 3 **a–c** Postoperative clinical situation and radiographs of the patient

Discussion

Fractures of humeral diaphysis represent approximately 3% of all fractures. Goals of treatment are fracture healing in acceptable positions and satisfactory functional outcomes by permitting early exercises. Conservative methods such as functional brace or surgical treatment can be used to achieve these goals [8, 9]. Lack of union in fracture site within 24 months is accepted as nonunion [10]. The nonunion rates for conservative and surgical treatment of humeral diaphyseal fractures were reported as 1–13% [1, 3].

Inappropriate blood supply to fracture site and insufficient immobilization are frequent reasons of nonunion. Soft tissue interposition between fracture ends, stabilization of the fracture with excessive distraction, metabolic abnormalities, and infections are other possible causes. Severity of trauma and type of fracture pattern can affect results. Insufficient stabilization with appropriate blood supply causes hypertrophic type nonunion. The opposite condition or bone defects may cause atrophic type nonunion [3, 11]. All patients in this series had atrophic type nonunion.

Plate and screw fixation, intramedullary nailing or external fixation following open reduction, and revival of fracture ends are treatment options for humeral nonunions [1, 6]. Perioperative bone grafting is recommended to attain more reliable union [1, 11–13]. Plate fixation has superior outcomes in humeral nonunions. Dynamic compression plates (DCP) are preferred by many authors [5, 6, 12, 14]. Particularly, in patients with good-quality bones, it is possible to provide a low cost and stable fixation. Healing rates of 90–100% with plate fixation are reported in the literature [13, 15, 16]. In this study, mean duration between the first trauma and nonunion treatment is 70 months. This long period would cause decrement of bone quality due to osteoporosis; therefore, locking compression plates have been preferred in spite of their higher costs. Locking compression plates provide superior mechanical stability on the fracture line due to its provision of angular stability [17]. The use of locking compression plates in osteoporotic humeral diaphysial nonunion has also been supported by Ring and Kloen [2]. Major complications of plate fixations are screw back-outs, radial nerve palsy, and infection [11]. In this study, no complication was seen.

Unreamed locking intramedullary nailing has similar results as plate fixation for the treatment of humeral nonunions [17, 18]. External fixation is recommended

particularly in infected cases, osteoporotic patients, distal fractures, and in conditions where the usage of plate is unfavorable such as long spiral or wide-segmented fractures [6, 19]. Atalar et al. compared patients treated with plate fixation and unilateral/circular external fixation and claimed that they had similar results [3, 6]. However, bacterial contamination risk, particularly due to long-term usage, and less patient comfort are disadvantages of external fixation [5].

Selection of the graft to be used in humeral nonunion is controversial. Autogenic grafts are preferential due to more osteoinductive features, ease of attainability, and lower costs. Frequently used autografts are iliac pterygoidal and fibular autografts. Fibular graft contributes to the mechanical stability with its osteoinductive and osteoconductive features along with its cortical structure and integrity. Its donor site morbidity is lower compared with iliac pterygoidal graft [11]. Additionally, we did not meet any complication concerning donor graft area in none of the patients. In the study of Wright et al. [20], being interested in intramedullary use of fibular graft in humeral pseudoarthrosis, it is stated that four-cortex fixation ensures a more stable fixation than two-cortex fixation. Vidyadhara et al. [11] listed advantages of intramedullary fibular graft as increased stability of osteosynthesis and cortical adherence of screws, helping bone growth and osteointegration. It must be kept in mind that excavation performed before the intramedullary application also helps the union via increasing blood supply. Vascularized fibular graft is an option selected particularly in defective cases. We suggest that this is not necessary to use routinely, because it requires microsurgery experience.

Limitations in elbow and shoulder movements occur particularly in ignored humeral pseudoarthrosis [3, 6]. Fixation of the fracture as stable as possible is important in terms of relieving these complaints by starting early exercises. The method we applied provides a more stable fixation than other methods with the advantages of locking compression plate and cortical support of graft. To our knowledge, no other research in the literature discusses intramedullary fibular graft usage accompanied by locking compression plate. Although number of patients is limited, complete union is ensured in all cases and any complication related to plate or graft applications did not occur. We show that this method combines advantages of intramedullary fixation and compression plates. It is a preferable method with its effect on mechanical stability and fracture union, besides its ease of application particularly in osteoporotic atrophic humeral pseudoarthrosis.

Conflict of interest No funds were received in support of this study. The author(s) of this manuscript has/have chosen not to furnish *Ejost* and its readers with information regarding any relationship that might exist between a commercial party and material contained in this manuscript that might represent a potential conflict of interest. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

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