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Treatment of the Refractory Atrophic Humeral Nonunion with Autogenous Block Iliac Crest Graft and Spongioplasty: a Retrospective Study

Léčení refrakterního pakloubu humeru s použitím autologního kostního štěpu z hřebene kosti kyčelní a spongioplastiky: retrospektivní studie

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ABSTRACT

PURPOSE OF THE STUDY

Most humeral nonunions can be successfully treated with a single procedure, but some are more difficult to heal. Humeral nonunions which have two or more surgical procedures were defined as refractory humeral nonunions, and this condition is a very challenging condition. The aim of the study is to show the results of atrophic refractory humeral nonunion treated with open reduction and internal fixation and autogenous block iliac crest graft and spongioplasty.

MATERIAL AND METHODS

Refractory humeral nonunions treated with open reduction and internal fixation and autogenous block iliac crest graft and spongioplasty from January 2010 to March 2019 were included this study retrospectively. Patient baseline information, number of previous surgeries, comorbidities, follow-up time, fracture union time, and complications were recorded. The functional outcome was evaluated with the Constant scores and Mayo scores at the end of the first year. The primary outcome variable was mentioned as bony union.

RESULTS

A total of 13 refractory humeral nonunions included this study. The average age of the patients was 50.92±15.55 years (range, 26–78 years), and 8 of them were female. Preoperative and postoperative mean Mayo scores were; 56.54±17.84, and 85.38±7.49 respectively ($p<0.001$). Preoperative and postoperative mean Constant scores were; 45±11.71, and 80.62±5.38 respectively ($p<0.001$).

DISCUSSION

The strict application of basic nonunion principles can result in successful salvage of refractory humeral nonunions. But this concept may not provide sufficient solution for each situation. On the other hand, we also applied the basic nonunion principles. Compression plating and autogenous bone grafting and spongioplasty have been considered as the gold standard in the management of humeral shaft nonunion.

CONCLUSIONS

Open reduction and internal fixation and autogenous block iliac crest graft and spongioplasty should be considered as an alternative for the treatment of refractory atrophic humeral nonunions, whose treatment is a very challenging condition for surgeons.

Key words: block graft, bone grafting, nonunion, refractory humeral nonunion, spongioplasty.

INTRODUCTION

The nonunion rates of humeral shaft fractures treated nonoperative range from 0% to 13%, with the incidence increasing to 15–30% for operatively treated fractures (10). Instability, reduced vascularity, infection, or fracture displacement may result in nonunion (6, 10).

Bone union is usually achieved after revision open reduction and internal fixation (ORIF) and autogenous grafting (9, 10). Although most humeral nonunion are successfully treated with a single procedure, some are more difficult to heal and require multiple procedures (8). Humeral nonunion which have two or more surgical procedures were defined as refractory humeral nonunions (2). Refractory humeral nonunion is a very challenging condition (2, 15). There is insufficient information in the literature regarding the treatment of refractory humeral nonunion.

The aim of the study is to show the results of refractory humeral nonunion treated with ORIF and autogenous block iliac crest graft and spongioplasty.

MATERIAL AND METHODS

In this retrospective study, refractory humeral nonunion treated with ORIF and autogenous block iliac crest graft

and spongioplasty between January 2010 to March 2019 were included. The ethics committee approval was obtained (E2-22-01). The clinical and baseline information were extracted from the hospital database records. Informed consent forms were obtained from all patients in the study. Humeral nonunion which have two or more prior surgical procedures were defined as refractory humeral nonunion. The previous operations of the patients were not performed by us and they were the patients referred to us because we are the reference center.

Inclusion criteria were defined as ORIF with plate-screw and autogenous block iliac crest graft and spongioplasty for the treatment of refractory humeral nonunion, atrophic nonunion, age >18 years and a minimum of 1-year follow-up. Patients were excluded from the study if they operated with different surgical techniques, hypertrophic nonunions, oligotrophic nonunions, pathological fracture, and infected nonunion. A total of 13 atrophic refractory humeral nonunion were met inclusion criteria for study analysis.

All operations were performed with the patients placed in supine position. Previous skin incisions were used. First, the nonunion site was exposed and then the implants were removed. The fracture site was cleared of fibrous tissue, and the necrotic stump was resected with rounger. Approximately 2cm shortening was made until viable bone was reached. Meanwhile, the radial nerve was exposed and protected till the end of the surgery. Second, 4.5 LCP plate and screws were used for fixation. Minimum three screws proximally and three screws distally of the refractory humeral nonunion were used for fixation. Third, tricortical autogenous block

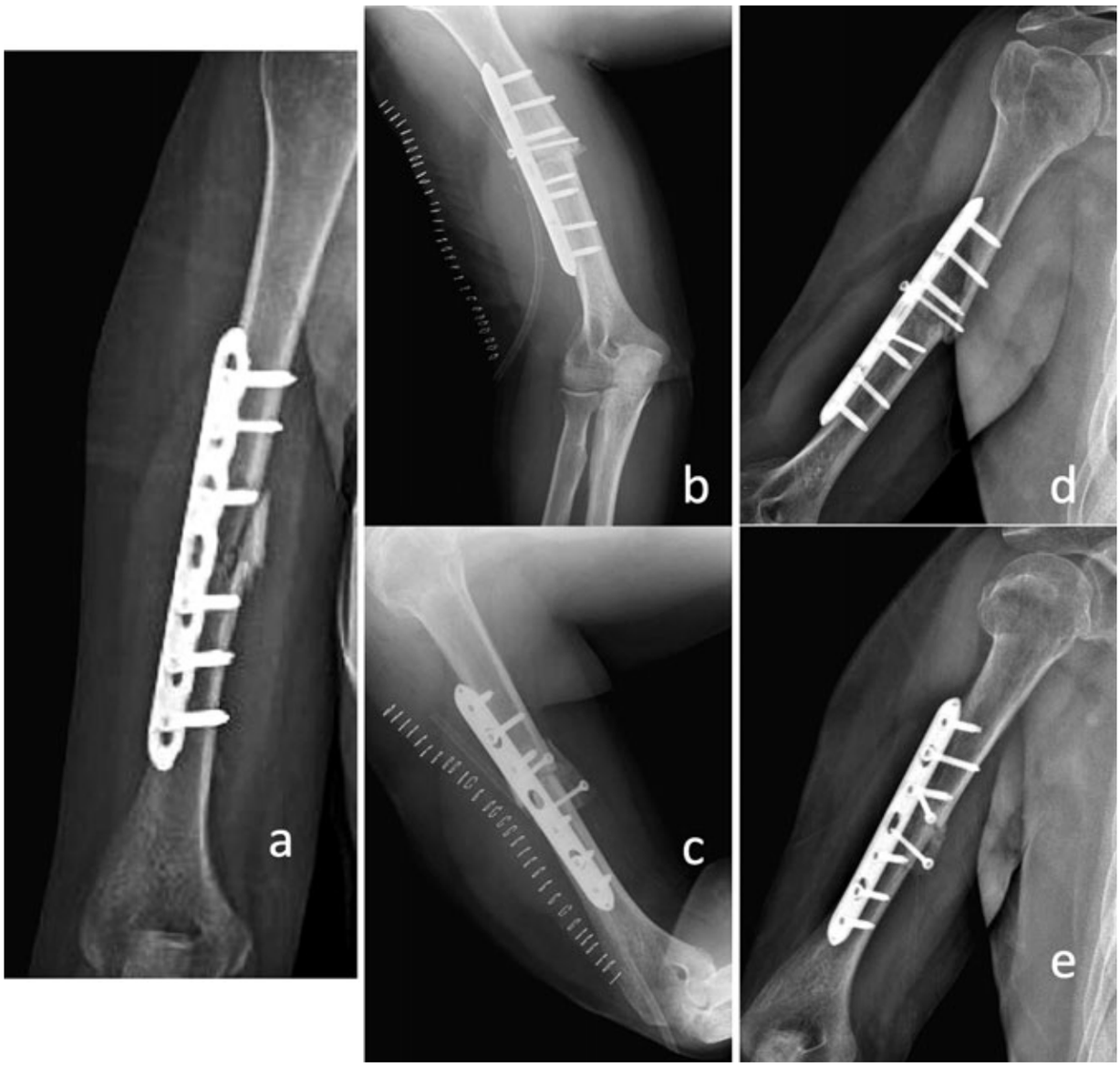

Fig. 1. A 64-year-old male patient with atrophic refractory nonunion of the right humerus that was operated ORIF and autogenous block iliac crest graft: a – preoperative image, b – postoperative AP image, c – postoperative lateral image, d – postoperative 4th month AP image, and e – postoperative 4th month lateral image.

graft was harvested from anterior iliac crest. The length of this block graft was planned as being longer than the fracture side and enough for the fixation with screws; this length was about 4 to 5 cm. The graft was fixed with two screws from the proximal and distal sides. Also, the original fracture side was bone grafted with spongious bone graft which was harvested from the iliac crest. Finally, the reduction and fixation were checked by X-ray (Figs. 1 and 2). Following placement of the drain in the wound, the soft tissue and skin were closed layer by layer.

In all cases, 3x1 g cefazolin sodium was used intravenously as prophylaxis for 24 hours postoperatively. Postoperatively, sling was used one month postoperatively. Early active assisted shoulder and elbow range of motion exercises were started within two weeks of surgery. Full range of motion was achieved after postoperative 6th week. Patients were allowed normal daily activities after radiologically proven bone union. Forced activities were allowed after the 6th month. Healing was defined as the presence of a bridging callus in at least three cortices on two radiographic views. On the autogenous block iliac crest graft side, observation of the cortical fusion and continuity of the bone with graft was based on. The patients' follow-up was performed every two weeks for the first month and every month after that, till the third month. The follow-up intervals changed to every three months afterwards.

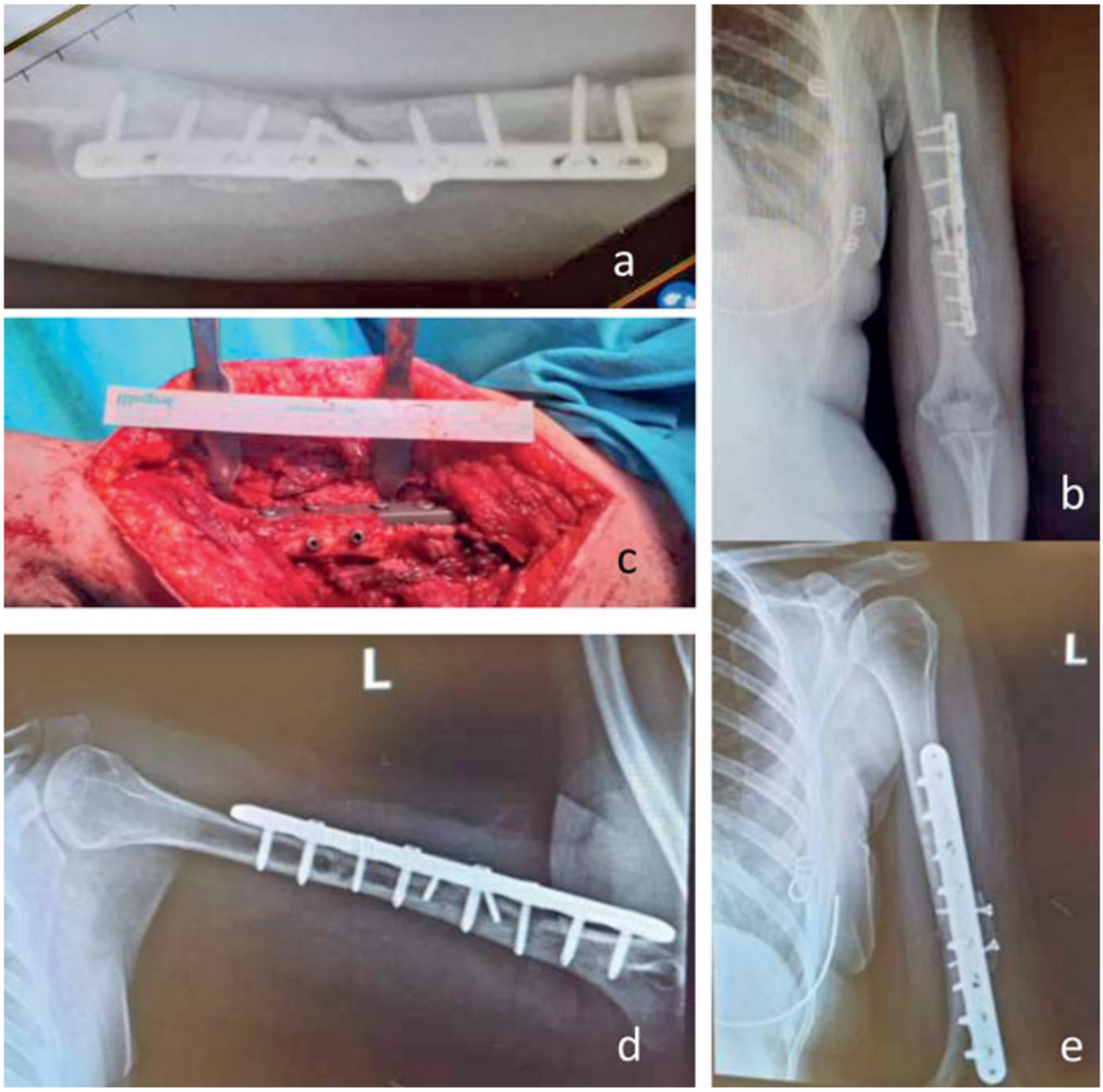

Fig. 2. A 45-year-old female patient with atrophic refractory nonunion of the left humerus that was operated ORIF and autogenous block iliac crest graft: a – preoperative lateral image, b– preoperative AP image, c – intraoperative image, d – postoperative 1st year lateral image, and e – postoperative 1st year AP image.

Patient baseline information, number of previous surgeries, comorbidities, follow-up time, fracture union time, and complications were recorded. The functional outcome was evaluated with the Constant score (3) and Mayo score (14) at the end of the first year. In the current study, primary outcome variable was mentioned as bony union.

All the patients undergoing revision surgery underwent standard laboratory serologies and intraoperative cultures to evaluate for the presence of infection. All positive cultures were treated with antibiotics under the care of an infectious disease specialist. Also, these infected cases were excluded from the study.

Statistical analysis was performed using IBM SPSS® Statistics for Windows 23.0 (IBM Corp., Armonk, New York, USA). Data that were normally distributed were described using means, minimum and maximum values, and SDs, where appropriate. Nonparametric data were described using medians, minimum and maximum values, and interquartile ranges, as appropriate. Differences in pre- and postoperative data were identified using paired Student t tests for normally distributed data and Wilcoxon test for nonparametric data. A result was considered to be statistically significant with p value <0.05.

RESULTS

A total of 13 refractory humeral nonunion were met inclusion criteria for study analysis. The mean age of the patients was 50.92±15.55 years (range, 26–78 years), and eight of them were female. Patient baseline information's are listed in Table 1. It was determined that the patients included in the study had undergone mean of 2.54±0.66 operations before (Table 2).

Radial nerve palsy (RNP) was observed in 4 cases and 3 of them were resolved spontaneously. We only gave the patients range of motion exercises and radial nerve orthosis. The other one was permanent RNP (7.69%), and tendon transfer was performed (Table 2). No donor site complications were observed in the patients in our study.

Full healing was obtained in all the refractory humeral nonunion in this study. Preoperative and postoperative mean Mayo scores were; 56.54±17.84, and 85.38±7.49 respectively (p<0.001). Preoperative and postoperative mean Constant scores were; 45±11.71, and 80.62±5.38 respectively (p< 0.001) (Table 2).

Table 1. Patient baseline information, comorbidities, and pseudoarthrosis times

		Atrophic refractory humerus nonunions (n=13)
Gender	male female	5 (38.46%) 8 (61.53%)
Age (years)		50.92±15.55 (range, 26–78)
Side	right left	7 (53.84%) 6 (46.15%)
Comorbidities	DM smoking none	 1 2 10
Pseudoarthrosis time (years)		2.62±0.77 (range 2–4)

(DM = Diabetes mellitus)
(Pseudoarthrosis time = time interval between fracture time and final surgery)

Table 2. Complications, Constant scores, Mayo scores, follow-up times, and fracture union times

	Atrophic refractory humerus nonunions (n=13)	P-value
Complications temporary radial nerve palsy (neuropraxia) permanent radial nerve palsy (neurotmesis) none	 3 1 9	–
Constant score preoperative postoperative	 45±11.71 (range, 21–59) 80.62±5.38 (range, 74–86)	P<0.001
Mayo score preoperative postoperative	 56.54±17.84 (range, 15–80) 85.38±7.49 (range, 70–95)	P<0.001
Follow-up time (year)	2.46±2.30 (range, 1–8)	–
Number of previous surgeries	2.54±0.66 (range, 2–4)	–
Fracture union time (month)	3.92±0.49 (range, 3–5)	–

DISCUSSION

The literature is mostly concerned with the first humeral nonunion. Refractory humeral nonunion is a very challenging condition. Hornicek et al., described the use of cortical allograft bone plates or struts in conjunction with internal fixation by metal plates in 6 patients with refractory nonunion following two failed surgical procedures (7). On the other hand, lack of osteoinductive capabilities and the risk of transmitting infections are limitations of allografts. The mainstay of surgical treatment for nonunion with impaired biology is autologous bone grafting (14). In the present study we used the autogenous block iliac crest graft. Patel et al., described Ilizarov external fixator in patients with refractory humeral nonunion. However, pin-site infections, nerve injuries, and frame impingements are the potential complications (16). Borus et al., concluded that strict application of basic nonunion principles can result in successful salvage of refractory humeral nonunions (2). But this concept may not provide sufficient solution for each situation. On the other hand, we also applied the basic nonunion principles.

Various treatment strategies for nonunion of humeral diaphyseal fractures have been reported (11, 17). Al-

though an evidence-based consensus regarding the optimal treatment of humeral shaft nonunion has not been reached yet (8). Treatment with intramedullary nailing has its own problems, such as need of large diameter locked nails for maintaining stability, difficulty in achieving compression at the nonunion site, and rotator cuff damage (5, 12). Treatment with external fixator is another option (16, 19). However, pin-site infections, nerve injuries, and frame impingements are the potential complications (16). Compression plating and autogenous bone grafting have been considered as the gold standard in the management of humeral shaft nonunion (6, 20).

Placement of a second plate or an on-lay cortical bone graft has been reported to enhance stability at the nonunion site. A double plate construct was found to be significantly stiffer than a single plate construct as per the biomechanical and clinical study by Rubel et al. (18). Dhar et al., used a combination of an intramedullary fibula with a locking plate in 5 cases with nonunion of the humerus in a severely osteoporotic bone (4). De Boer et al. stated that, on-lay grafts and double plating entail more extensive soft tissue stripping and devascularization of the humerus, vascularized fibular grafts increase the complexity and cost of the osteosynthesis procedure (1).

There are some limitations in the present study, retrospective design, lack of control group and limited number of patients. However, its strength was that it was an article that examined the effect of a tricortical autogenous iliac crest graft on refractory humeral nonunion using a different technique. In addition, only atrophic refractory humeral nonunions were evaluated in the study.

CONCLUSIONS

Improvement in functional scores and bone union in refractory atrophic humeral nonunion could be achieved with ORIF and autogenous block iliac crest graft and spongioplasty. This method should be considered as an alternative for the treatment of refractory atrophic humeral nonunions, whose treatment is a very challenging condition for surgeons.

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