Treatment of Surgical Neck Nonunions of the Humerus with Locked Plate and Autologous Fibular Strut Graft

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Key Words

Proximal humeral nonunion • Locked plate • Bone graft

Abstract

Objectives: To determine whether using a fixed-angle locked plate plus a fibular strut autograft to treat humeral surgical neck nonunions can result in improved union. **Patients and Methods:** The study cohort included 5 females and 2 males with an average age of 58.4 years (range 45–76) who presented with atrophic nonunion of the surgical neck of the humerus. All patients underwent revision surgery with locked plating plus a nonvascularized autologous fibular strut bone graft. Clinical and radiological union was documented in all patients. **Results:** The mean time from initial trauma to last revision surgery was 20.1 ± 12.6 months (range 12–48). The average time between revision surgery and the date of union was 6.1 months (range 5–8). The average active forward flexion was 124° (range 70–160) at final follow-up. The Constant-Murley score increased from an average of 25.7 points preoperatively to 77.7 points postoperatively ($p < 0.001$). The average analog scale of pain decreased from 7.57 points (range 6–10) preoperatively to 0.57 points (range 0–2) postoperatively ($p < 0.001$). **Conclusions:** Locked plate fixation and autologous fibular strut bone graft facilitated the successful treatment of humeral surgical neck nonunions.

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Introduction

Surgical neck nonunion is difficult to treat because the proximal fragment is small and difficult to secure, especially when the condition is long-standing nonunion [1]. In addition, neck nonunion is often associated with poor bone quality and compromised soft tissue due to multiple previous surgeries. These factors complicate treatment and pose a significant challenge to surgeons who treat this condition.

Although many treatment options have been described, outcomes have been variable and no definitive surgical solution has been identified [2–7]. The purpose of this retrospective study was to assess the outcomes of locked plating fixation and an autologous nonvascularized fibular strut graft to humeral surgical neck nonunions.

Patients and Methods

Between January 2006 and March 2010, 7 patients (table 1) with aseptic humeral surgical neck nonunions were treated at our trauma center; the same team supplemented internal fixation with a nonvascularized fibular strut bone graft. All cases were graded as atrophic nonunions according to Weber and Cech's classification [8]. All cases presented with varying degrees of humeral head varus malpositioning.

Fig. 1. a ‘Interdigitated’ fibular graft placement with reduction of the humeral head on the shaft. **b** Final fixation with fixed-angled locked plate and passage of screws through the graft.

Table 1. Patient characteristics

Patient No.	Age/sex	Mechanism	Dominant arm	Previous treatment	Comorbidities	Delay from injury to operation, months
1	46/F	fall	no	common plate and locked plate	none	48
2	53/M	fall	yes	K-wires and staple	smoker	20
3	57/F	traffic accident	yes	clover plate	none	12
4	72/F	fall	no	sling	osteoporosis, hypertension	16
5	76/F	fall	no	sling	diabetes, hypertension, osteoporosis	12
6	44/M	traffic accident	yes	cloverleaf plate	none	18
7	61/F	fall	no	cloverleaf plate	none	15

The 7 patients comprised 5 females and 2 males with an average age of 58.4 years (range 45–76). The right dominant arm was affected in 3 cases and the left non-dominant arm in 4 cases. All nonunions resulted from traumatic fractures. The initial fractures were secondary to falls from a standing height in 5 cases and car accidents in 2 cases. The time from initial fracture to repair of the nonunion with internal fixation and fibular strut graft ranged from 10 to 48 months with an average of 20 months (table 1).

Operative Techniques

The patients were operated on in the beach chair position while under general anesthesia. The shoulders and ipsilateral legs were prepared and draped at the same time. A standard deltopectoral approach was used to expose the nonunion site of the surgical neck of the humerus. The implants were removed from 5 patients who had failure of hardware. Then the interposing scar and fibrous tissue were meticulously debrided and tissue samples were collected for culture to exclude any occult infections. The humeral head varus deformity was corrected in all patients and the locations of the bone defects were noted. In each patient, a 5–6 cm fibula was harvested from the ipsilateral leg through osteotomy and was applied on the medial cortex of the humerus. The cephalad portion of the graft was impacted into the cancellous bone of the head (fig. 1a). An internal fixation with humeral proximal locked plate (Synthes) was applied to all patients. The fibula graft was fixed with at least two screws at the caudal portion, leaving an approximately 1–2 cm cephalad part onto which the humeral head was impacted (fig. 1b). No attempt was made to pass the proximal screws through the fibular graft.

Postoperative Management

In all cases, patients' shoulders were immobilized postoperatively for 6 weeks using a sling. Therapists initiated a passive range of movement exercises on the first operative day and started a progressive range of movements at 3 weeks. Follow-up reviews were made monthly at the outpatient clinic until the fracture had healed. Radiological union was defined as bridging bone trabecula across the fracture site and incorporating the fibula graft into the humeral shaft. Each patient was assessed for pain, shoulder mobility, and strength at each follow-up using the Constant-Murley score and a visual analog scale (VAS). To test for differences between the preoperative and postoperative Constant-Murley score and the analog pain scale, a statistical analysis was performed with Fisher's test using SPSS 11.0 statistical software (Chicago, Ill., USA). A *p* value <0.05 was considered statistically significant.

Results

The mean length of follow-up was 22.7 ± 6.5 months (range 15–36). All patients achieved clinical and radiological union and none required any additional procedures (fig. 2a–f). The mean time from revision surgery to union was 6.1 ± 1.3 months (range 5–8).

The average active forward flexion was 124° (range 70–160), average active abduction was 119° (range 70–160),

Fig. 2. Case example of a patient with recalcitrant nonunion of the surgical neck of the humerus. **a** Nonunion of the surgical neck of the humerus developed 18 months after surgery. **b** Revision surgery with cloverleaf plate fixation and autologous cancellous bone graft. **c** 18 months after the revision surgery, X-ray showed plate breakage and head varus deformity. **d** Second revision surgery with locked plate fixation and autologous cancellous bone graft. **e** X-ray showed

a persistent nonunion with breakage of the locked plate 5 months after the second revision surgery. **f** Nonunion healed 7 months after the third revision surgery with locked plate fixation and autologous fibula strut graft at the medial calcar of the humerus. The humeral head had been distorted while head necrosis was not observed. **g** Clinical photographs demonstrating restoration of the range of motion and return to normal activities of daily living.

and active external rotation averaged 32° (range 10–80). The active internal rotation averaged at the 12th thoracic vertebra (range buttock to 4th thoracic vertebra) (fig. 2g).

The average Constant-Murley score increased from 25.7 points (range 15–35) preoperatively to 77.7 points (range 60–90) postoperatively ($p < 0.001$). The VAS score decreased from 7.57 points (range 6–10) preoperatively to 0.57 points (range 0–2) postoperatively ($p < 0.001$) (table 2). All patients reported significant pain relief.

None of the patients had any postoperative infection and none of the plates or screws broke. One patient suffered partial superficial peroneal nerve palsy in the donor leg and recovered completely within 4 months. Another patient developed radial nerve palsy, which resolved within 3 months. At the final follow-up, no humeral head avascular necrosis or arthritis was observed.

Table 2. Results

Patient No.	Preoperative function	Postoperative function	Preoperative pain (VAS)	Postoperative pain (VAS)
1	15	90	10	0
2	20	87	7	0
3	40	82	8	0
4	35	70	8	1
5	15	60	7	2
6	35	75	6	1
7	20	80	7	0

Discussion

The ideal treatment for subcapital humerus fracture nonunion is still a matter of debate. In this paper we describe an alternative technique for dealing with this nonunion.

Contemporary options for surgical neck nonunions include nailing, plating, and arthroplasty. The nailing procedure may cause a mechanical impingement and usually requires a second procedure to remove the rods [9–11]. Shoulder arthroplasty is only indicated in selected old patients or as a salvage procedure because it is important to preserve the native humeral head in young patients with relatively good bone stock [3, 5, 7, 12]. The most viable fixation technique at present involves using an angle-stable device. Surgeons have achieved good results using blade plates to heal surgical neck nonunions [1, 4, 13]. Despite these results, the procedure is technically demanding, as placing a blade part inadequately in the humeral head could produce an impingement between the plate and the acromion [13].

In our study, we used the precontoured locked plate. The plate allowed us to insert a greater number of multidirectional screws into a small, poor-quality cancellous bony segment, which is often present in humeral surgical neck nonunion. Additionally, the low profile design minimized the incidence of subacromial impingement.

When nonunion of the surgical neck of the humerus occurs, the head fragment is usually in a varus malposi-

tion as a result of the tension of the supraspinatus muscle [1]. In addition, an incomplete reduction at the medial hinge in association with insufficient fixation of the egg-shell articular fragment often leads the head varus to slip and become impacted. Recent data suggest that locked plates cannot support the humeral head alone from a lateral position and that the integrity of the medial column is the key factor for predicting loss of fixation [14]. In the present study, we used a strut graft to reconstruct the medial calcar of the humerus. We postulate that the fibular strut may provide medial metaphyseal support, preventing varus collapse of a head.

We used autograft instead of allograft. Bone autograft is the only graft material that has osteogenic, osteoinductive and osteoconductive properties, which makes it an ideal graft material [15]. An allograft risks transmitting disease and lowers the graft's osteogenic and osteoinductive potential [16, 17]. Regardless, surgeons should be aware that while a fibular graft may provide ideal structural support medially, it cannot restore compromised vascularization of the humeral head. Therefore, they should make great efforts to preserve the residual head vascularity intraoperatively, especially in regard to the muscular attachments to tuberosities and the posterior articular capsule. In the case described here, although the humeral head had been distorted due to multiple previous surgeries, head necrosis had not developed at last follow-up (fig. 2f).

This study is limited by the small cohort of patients, the retrospective nature of this review and the lack of a control group. It is possible, even probable, that some of them may have arthritic change developing in the affected shoulders with time. Despite these relative weaknesses, we think that this series provides important data and guidance to treat this difficult clinical problem.

Conclusion

Locked plating in combination with autologous non-vascularized fibula graft could be a simple and reliable method to treat surgical neck nonunions of the humerus.

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