



Original article

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TREATMENT OF THE HUMERAL SHAFT NONUNION

SUMMARY

The incidence of nonunion after humeral shaft fractures is reported as low because of the favorable results of conservative treatment. The treatment of humeral shaft nonunion is challenging, often requiring one or more surgical interventions. Different surgical methods were described for humeral shaft nonunion with complication such as radial nerve palsy or joint stiffness.

Retrospectively, we reviewed 33 patients with aseptic humeral shaft nonunion treated by different methods. Patients were followed for a mean of 42.9 months (range, 36 to 66 months). The inclusion criteria was aseptic shaft nonunion without bone defects more than two centimeters. Six patients had hypertrophic and twenty-seven patients had atrophic nonunion.

Solid union, as documented on plain radiographic views, was obtained in thirty-three (100%) patients. Overall, the average healing time was 4.5 months (range, three to nine months). According to Constant and Murlay score, 23 (69.7%) patients had excellent outcome and 10 (30.3%) patients had good outcome. Excellent results were achieved using Mitkovic selfdynamisable internal fixator in four patients, Mitkovic external fixator in seven, plate in eleven, and intramedullary nail in one patient.

In this retrospective study, the selfdynamisable internal fixator and unilateral external fixator - both with less invasive surgical technique tended to yield equally favorable treatment results as did plate and intramedullary nail fixation. In our series, all used methods led to a high percentage of nonunion healing with good functional results and minimal complications.

Key words: humeral shaft, nonunion, Mitkovic selfdynamisable internal fixator, Mitkovic unilateral external fixator, plate, intramedullary nail, bone graft

INTRODUCTION

Fractures of the humeral shaft generally heal within 12 to 16 weeks. Nonunion is defined as a lack of union 24 to 32 weeks after the injury (1, 2). A conservative management for isolated humeral shaft fracture is recommended and generally provides good results (3). However, the nonunion rate after conservative treatment ranges from 0 to 39% in the literature (4, 5). Predictive factors for nonunion of the

humeral shaft include the location of the fracture, fracture pattern, comminution and osteoporosis, chronic alcoholic use and obesity (6). With operative management, nonunion rate was reported between 13-14% (7,8). The most common risk factor is inadequate internal fixation with lack of stability (3, 9-12).

Several operative methods have been used in the treatment of humeral shaft nonunions, which included open plating (10,11,13), intramedullary

nauling (14, 15) and external fixator (16-18).

AIMS

The aim of the study was to review the clinical and radiological results of humeral shaft nonunion treatment and compare the well-known methods as plate and intramedullary nail with Mitkovic unilateral external fixator (19,20) and Mitkovic selfdynamisable internal fixator (SIF) (21).

MATERIALS AND METHODS

Between January 1998 and December 2002, thirty-three patients were treated because of humeral shaft nonunion. According to Weber and Cech (22), avital humeral nonunion was diagnosed in twenty-seven (81.2%) patients and vital humeral nonunion was diagnosed in six (18.8%) patients.

There were 16 men and 17 women with an average age of 60 years (range, 32 - 81 years). The medical records and preoperative and postoperative radiographs were collected and reviewed by independent surgeons.

Inclusion criteria of this study was nonunion of the humeral middle shaft which did not show any progress in healing over 6 months following initial treatment.

Diagnosis for nonunion was made based on clinical examination that included local tenderness or false motion, and plain radiographs in all patients.

Previous treatment was conservative in all

patients. Failure of nonunion treatment was recorded in three patients and they underwent the next surgical procedure.

Patients were operated on a mean of 9.8 months (range, 6 - 14 months) following their initial treatment. Radial nerve deficit was not present in any patient.

Autologous cancellous bone graft was used in 28 (84.6%) patients: in 16 patients with plate osteosynthesis, in two patients with intramedullary nail, in 8 patients with Mitkovic unilateral external fixator; and in two patients with Mitkovic SIF. In five (15.4%) patients bone graft was not used (Table 1).

In patients treated with plate and intramedullary fixation, the upper extremity was immobilized in a long arm splint, with an extension to the shoulder, for three weeks postoperatively. The long arm splint was replaced with a functional Sarmiento's brace (3) and active exercises were allowed at the end of the 3rd week postoperatively. The functional Sarmiento's brace was used until union was achieved.

Patients treated with SIF and external fixator were encouraged to perform active mobilization of the shoulder and elbow from the first postoperative day and continued active mobilization at home after being discharged. Physiotherapy and rehabilitation gradually increased 3 weeks after the operation when all active exercises were allowed.

All patients were followed up at the clinic and plain radiographs were taken. Constant and Murley score (16) for shoulder was used for clinical and functional evaluation.

Table 1. Applied methods in the humeral shaft nonunion treatment

| Methods of the treatment | | Number of patients | % |
|--|---|--------------------|------|
| With autologous cancellous bone graft | AO plate osteosynthesis | 16 | 48.4 |
| | Intramedullary nail osteosynthesis | 2 | 6 |
| | Mitkovic unilateral external fixator | 8 | 24.2 |
| | Mitkovic selfdynamisable internal fixator | 2 | 6 |
| | All | 28 | 84.6 |
| Without autologous cancellous bone graft | AO plate osteosynthesis | 1 | 3.1 |
| | Intramedullary nail osteosynthesis | 1 | 3.1 |
| | Mitkovic unilateral external fixator | 1 | 3.1 |
| | Mitkovic selfdynamisable internal fixator | 2 | 6.1 |
| | All | 5 | 15.4 |
| All | | 33 | 100 |

RESULTS

Patients were followed for a mean of 38.9 months (range, 36 to 66 months). The mean age for union was 4.5 months (range, 3 to 9 months).

At the end of the follow-up, according to Constant and Murlay score, excellent results were recorded in 23 (69.8%) patients and good results in 10 (30.2%) patients (Table 2).

(Figure 2) and patients treated with intramedullary nail (IP95%: 13.3% to 120%)

Complications

Pin track infection around the Schanz pins was recorded in two (6%) patients. Oral antibiotics and daily dressing for one week resolved this superficial infection in both patients. Complications

Table 2. Functional results at the end of follow-up according to Constant and Murlay criteria (23)

| Methods of the treatment | Results | | | | All | |
|---|--------------------|------|--------------------|------|--------------------|-----|
| | Excellent | | Good | | Number of patients | % |
| | Number of patients | % | Number of patients | % | | |
| AO plate osteosynthesis | 11 | 64.7 | 6 | 35.3 | 17 | 100 |
| Intramedullary nail osteosynthesis | 1 | 33.3 | 2 | 66.7 | 3 | 100 |
| Mitkovic unilateral external fixator | 7 | 77.8 | 2 | 22.2 | 9 | 100 |
| Mitkovic selfdynamisable internal fixator | 4 | 100* | - | - | 4 | 100 |
| All | 23 | 69.8 | 10 | 30.2 | 33 | 100 |

*p0,05 - Interval confidence for difference ratio (see results)

Excellent result were achieved in all (four) patients treated with SIF, in 7 patients treated with Mitkovic unilateral external fixator (Figure 1), in 11 patients treated with plate and in one patient treated with intramedullary nail.



Figure 1. Distal-shaft fracture of the humerus sustained after a fall. Initial treatment was carried out with plaster cast.

A. An anteroposterior radiograph taken seven months after the fracture shows atrophic nonunion.

B. Four months after fixation with Mitkovic unilateral external fixator, radiograph shows healing of the fracture.

Interval confidence for difference ratio showed statistically significantly higher percent of excellent results in patients treated with SIF than in patients treated with plate (IP 95%: 12.6% to 58%)

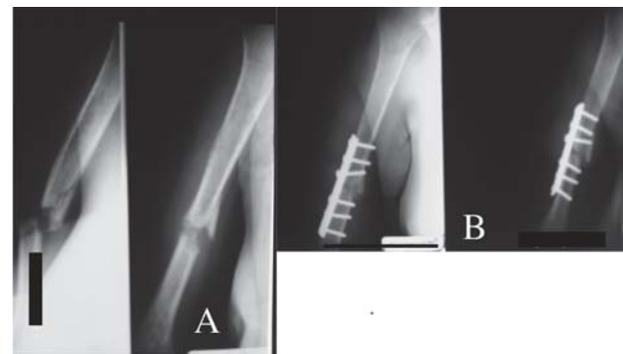


Figure 2. A transverse humeral mid-shaft fracture sustained after a fall. Initial treatment was carried out with plaster cast.

A. Eight months after the fracture, radiograph shows atrophic nonunion

B. Subsequent nonunion was treated with plate and autogenous cancellous bone graft

such as deep infection or permanent nerve damage were not observed in any patient.

DISCUSSION

The treatment of nonunion of humeral shaft is challenging, often requiring one or more surgical interventions with high complication rates such as radial nerve palsy or joint stiffness (14 - 16, 24).

Decortication, cancellous bone graft and rigid fixation have been advocated in surgical management (9 - 11, 13)

Treatment of humeral shaft nonunion using cancellous bone graft and unilateral external fixator was described by Martinez et al. (18). In all patients union was achieved for a mean of 4.5 months. In five patients superficial pin infections were recorded. One patient had excellent results and three patients had good results. In two patients satisfactory and poor results were recorded because of functional limitation of shoulder and elbow.

Many authors described application of Ilizarov circular external fixator (8, 17).

Kocaoglu et al. (16) used Ilizarov external fixator and autologous cortico-spongius bone graft for the humeral nonunion treatment in 35 patients. In all patients except one, the union was achieved with a mean of 5.5 months (range, three to 10 months). A superficial pin track infection was observed in three patients, after which the fixator was removed.

External fixation as the minimally invasive method provides enough stability on the nonunion site to allow early joint motion (17, 18). However, the risk of joint stiffness, patient's discomfort and pin tract infections remain concern to orthopaedic surgeons (16 - 18).

The plate and bone graft are well-known method in humeral nonunion treatment (9 - 13). Ring and Jupiter described humeral nonunion treatment with plate and autologous spongius graft in 22 patients (10). Union was achieved in 20 (91%) patients. Nine (41%) patients had excellent results at the end of treatment, four good, two satisfactory and two patients had poor results. Regional abscess and transitory radial nerve palsy were observed in one patient.

Rubel et al. (25) used two plate with bone graft in humeral nonunion treatment. Attained results showed no difference in the union time between the groups treated with one plate or two plates.

Kumar et Sadiq treated 40 patients with dynamic compression plate (26). In 31 (91%) patients, the union was achieved with a mean of 4.5 months (range, three to 9 months). Transitory radial nerve palsy was observed in two patients and deep infection in one.

Advantages of the plate are good stability on the nonunion site and comfortability for a patient (9 - 13, 24).

Using intramedullary nail and bone graft Ilzas and Younge (27) and Kesemenli et al. (28) achieved excellent results in more than 85% of the patients treated due to the humeral shaft nonunion. However, intramedullary nailing does not provide sufficient rotational stability, which may require additional augmentation fixation (12, 16).

Our study showed similar results as the studies of other authors. The higher percent of excellent results after application of the selfdynamisable internal fixator, the unilateral external fixator is not statistically significant ($p > 0.001$).

The use of the Mitkovic selfdynamisable internal fixator presents a new method in the humeral nonunion treatment. Preliminary results are encouraging, but prospective randomized study is necessary.

The treatment of humeral shaft nonunion in the future will depend upon a surgeons' affinity and several options will be available and usable.

CONCLUSION

In this retrospective study of the humeral shaft nonunion, SIF and unilateral external fixator with less invasive surgical technique tended to yield equally favorable treatment results as did plate and intramedullary nail fixation. In our series, all used methods led to a high percentage of nonunion healing, with good functional results and minimal complications.

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LEČENJE NEZARASLIH PRELOMA DIJAFIZE HUMERUSA

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SAŽETAK

U literaturi se opisuje niska učestalost nezarastanja nakon dijafizarnih preloma humerusa, uglavnom zbog povoljnih rezultata konzervativnog lečenja. Tretman nezaraslih preloma dijafize humerusa predstavlja izazov i često zahteva više hirurških intervencija. Opisane su različite hirurške metode u lečenju nezaraslih dijafizarnih preloma humerusa.

Praćeno je 33 pacijenta sa aseptičnim nezaraslim prelomom dijafize, lečenih različitim metodama. Period praćenja prosečno je iznosio 42,9 meseci (36 - 66). U studiju su uključeni pacijenti sa aseptičnim nezaraslim prelomom dijafize humerusa sa koštanim defektom manjim od 2 cm. Hipertrofični tip nezaraslog preloma dijagnostikovao je kod 6 pacijenata, a atrofični tip kod 27 pacijenata.

Zarastanje preloma, dokumentovano na radiografskim snimcima, postignuto je kod svih pacijenata. Prosečno vreme zarastanja iznosilo je 4,5 meseci (3 - 9). Na osnovu Constant and Murlay bodovnog sistema, 23 (69,7%) pacijenta imalo je odličan rezultat i 10 (30,3%) pacijenata dobar rezultat. Odličan rezultat postignut je kod 4 pacijenta kod kojih je primenjen samodinizirajući unutrašnji fiksator, kod 7 pacijenata kod kojih je primenjen Mitković spoljašnji fiksator, kod 11 pacijenata kod kojih je primenjena ploča i kod jednog pacijenta kod koga je primenjen intramedularni klin.

U prikazanoj retrospektivnoj studiji, primenom samodinizirajućeg unutrašnjeg fiksatora i unilateralnog spoljašnjeg fiksatora minimalno invazivnom hirurškom tehnikom, postignuti su jednako povoljni rezultati kao i primenom ploče i intramedularnog klina. U našoj seriji, primenom svake metode, postignut je visok stepen zarastanja uz dobar funkcionalni rezultat i uz minimalne komplikacije.

Ključne reči: dijafiza humerusa, nezarastanje, Mitković samodinizirajući unutrašnji fiksator, Mitković unilateralni spoljašnji fiksator, ploča, intramedularni klin, koštani graft