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ASSESSMENT OF THE TREATMENT EFFICACY OF LOCKING COMPRESSION PLATES IN HUMERUS SHAFT FRACTURES

Humerus Cisim Kırıklarının Kilitli Kompresyon Plakları ile Tedavi Etkinliğinin Değerlendirmesi

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ABSTRACT

Introduction: In this study, we evaluated the efficacy of osteosynthesis by using locking plate in the treatment of humerus shaft fractures.

Material and Methods: The mean age of 30 patients (19 male, 11 female) operated for humerus shaft fractures was 36.2 (23-66) years. A 3.5 locking compression plate was applied to all patients. We found radial nerve damage in 4 patients preoperatively. These lesions were considered neuropraxia and a dynamic splint was applied in order to keep wrist and fingers in extension after operation. Functional evaluation based on Stewart-Hundley criteria. The mean follow up period was 32 months (12-60 months).

Results: Except 1 patient, all patients showed radiological healing in 14 weeks on average (10 week-24 week). Two patients showed union retardation, and the mean union time of these patients was 21 weeks. These were class C1 fractures with larger soft tissue damage and multifragments. One patient developed pseudoarthrosis. Besides primary surgery, this patient underwent a pseudoarthrosis surgery with plate-screw and iliac grafting. Radiological union was achieved at the 18th week. Four patients with preoperative radial nerve damage underwent early radial nerve exploration and plate-screw fixation. Then, dynamic wrist splint was applied. All of them healed in 4 months. Based on Stewart-Hundley criteria, the result was good in 27 (90%) cases, moderate in 2 (6.6%) patients, and bad in 1 (3.3%) patient. Radial nerve damage due to surgery occurred in 1 patient who achieved full recovery 3 months after surgery. A superficial skin infection was developed in 1 patient and it was managed with oral antibiotic therapy. None of the patients developed deep soft tissue infection which requires removal of the implant.

Conclusion: In the treatment of humerus shaft fractures, osteosynthesis with locking plate may result in satisfactory radiologic and functional outcomes providing sufficient fixation and early mobilization when used with correct technique in adequate patient.

Keywords: *Locking plate, humerus fracture, fracture fixation*

ÖZ

Giriş: Bu çalışmamızda, humerus cisim kırıklarının tedavisinde uyguladığımız kilitli plak ile osteosentezin etkinliğini değerlendirdik.

Gereç ve Yöntem: Humerus cisim kırığı nedeniyle opere edilen 30 hastanın (19 erkek, 11 kadın) ortalama yaşı 36,2 yıl (23-66 yıl) idi. Tüm hastalara 3,5'luk kilitli kompresyon plağı ile osteosentez uygulandı. 4 hastamızda preop radial sinir arazı saptandı. Nöropraksi olarak değerlendirilen bu lezyonlara cerrahi bir işlem yapılmayıp postoperatif el bileği ve parmakları ekstansiyonda tutan dinamik splint uygulandı. Fonksiyonel sonuçlar Stewart-Hundley ölçütlerine göre değerlendirildi. Hastaların ortalama takip süresi ortalama 32 ay (12-60 ay) idi.

Bulgular: Bir hasta dışında tüm hastalarımızda ortalama 14 haftada (10-24 hafta) radyolojik iyileşme sağlandı. İki hastamızda kaynama gecikmesi saptandı, bu hastaların ortalama kaynama süresi 21 hafta olarak tespit edildi, AO sınıflamasına göre parçalı ve yumuşak doku hasarının fazla olduğu C1 sınıfı kırıklar idi. Bir hastamızda psödoartoz gelişti. Bu hastaya primer cerrahi dışında iliak kanattan alınan greft ile beraber plak-vida ile psödoartroz cerrahisi yapıldı. 18. haftada radyolojik olarak kaynama sağlandı. Preop radial sinir arazı olan 4 olguya erken radial sinir eksprolasyonu ve plak vida ile fiksasyon yapıldıktan sonra dinamik el bileği splinti uygulandı ve tüm hastalarda 4 ay içinde tam düzelme sağlandı. Stewart-Hundley ölçütlerine göre 27 olguda (%90) iyi, 2'sinde (%6,6) orta, 1'inde (%3,3) kötü sonuç elde edildi. Bir olgumuzda cerrahi operasyona bağlı olarak radial sinir arazı gelişti ve cerrahi sonrası üçüncü ayda tam düzelme sağlandı. Bir olguda oral antibiyotik tedavisi ile düzelen yüzeyel cilt enfeksiyonu gelişti. Hiç bir olgumuzda implant çıkarmayı gerektirecek derin yumuşak doku enfeksiyonuna rastlanmadı.

Sonuç: Humerus cisim kırıklarının tedavisinde kilitli plak osteosentez ile uygun hasta ve doğru teknik kullanıldığında, yeterli fiksasyon ve erken hareket sağlanmakta, tatmin edici radyolojik ve fonksiyonel sonuç alınmaktadır.

Anahtar Kelimeler: *Kilitli plak, humerus kırığı, kırık tespiti*

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INTRODUCTION

Humerus shaft fractures account for 3% to 5% of all fractures (1, 2). Those fractures, in general, result from axial compression, bending or torsional forces. The treatment should be effective against these forces (3). Various treatment methods were defined in humeral diaphysis fractures. Among these, conservative and surgical methods can be listed. Today, conservative method with a functional brace has been the most common method for treatment of humerus shaft fractures. However, there are some disadvantages such as the risk of non-union, frequent night pains, limitation of self-care, long-term use in some cases. Despite all these disadvantageous factors, the conservative method is still popular due to success rates higher than 90% (4). Surgery is inevitable for a good functional outcome in humerus fractures resulting from high energy trauma. In addition, surgery should be the first choice in open fractures, pathological fractures, bilateral humeral fractures, ipsilateral multi-site upper extremity fractures, in polytrauma patients, in patients with humerus diaphysis fractures together with thoracic or head trauma, and in patients with vessel injury (5-7). Postoperative complications such as infection, non-union, radial nerve injury have orthopedic surgeon to choose conservative treatment (5). The most important drawback in conservative treatment is limitation in mobility of elbow and shoulder joints due to immobilization. Today, Sarmiento brace enables early mobilization and protects joint range of motion. In surgery, the most common fixation materials are plate screw, elastic intramedullary nail, locking intramedullary nail and external fixators (6, 7). However, superiority of each material to others is controversial and there has been no ideal fixation method yet.

In this study, radiologic, clinical and functional outcomes of 30 patients treated with locking related complications were also recorded.

PATIENTS AND METHOD

Thirty patients (19 male, 11 female) who were operated due to humerus diaphyseal fracture between February 2005 and June 2009 were included to the study. The mean age was 36.2 (23-66) years. In the fixation of humerus shaft fractures, number 3.5 locking compression AO plates were used. The included fractures were between 5 cm distal to surgical neck and 5 cm proximal to olecranon fossa. Patients under 18 years of age, patients with pathological fracture, and patients who had pseudoarthrosis treatment were excluded.

The fracture was on the right side in 18 (60%) patients and on the left side in 12 (40%) patients. The reason was motor vehicle traffic collision in most of the cases. Twelve patients (40%) were in the car whereas 8 (26.6%) were out of the car. Other reasons included falls in 7 (23.3%) patients and workplace accidents in 3 (10%) patients. According to Gustillo – Anderson classification, 3 (10%) patients had Type 1 and 1 (3.3%) patient had Type 2 open fracture. According to AO/ASIF classification, 3 (10%) patients had A1, 6 (20%) patients had A2, 13 (43.3%) patients had A3, 2 (6.6%) patients had B1, 1 (3.3%) patient had B2, 2 (6.6%) patients had B3, and 3 (10%) patients had C1 fracture.

4 (13.3%) patients had 1/3 proximal, 21 (70%) patients had 1/3 middle, and 5 (16.6%) patients had 1/3 distal fracture localization. When the fracture line is taken into account, 13 (43.3%) transverse, 6 (20%) oblique, 8 (26.6%) spiral and 3 (10%) multifragmentary fracture were determined.

Four (13.3%) of the patients had preoperative radial nerve damage. These patients had dynamic wrist splint which kept wrist and fingers in extension. None of the patients had vessel injury related with fracture.

All of the 30 patients underwent open reduction and fixation by using 3.5 nr titanium locking compression AO plates. Of these, 7 (23.3%) patients had

conservative treatment which failed to provide sufficient reduction or resulted in loss of reduction during follow up period. Another common indication for surgery was surgery for other reasons and early mobilization in 7 (23.3%) patients.

Surgical incision was anterolateral in all patients. Plates had at least 6 holes and maximum 10 holes. Minimum 6 cortical screws were placed to proximal and distal parts of the fracture line. Long arm splint was applied to reduce postoperative movement-related pain and fixation was ended on the 15th day after removal of sutures. All patients received first generation cephalosporin (3x1 g/day) for 5 days. On the postoperative 15th day, passive movements of hand, wrist, elbow and shoulder were started. Active elbow and shoulder movements until pain threshold were started. Patients were followed up by monthly x-ray imaging.

The mean follow up period was 32 (range, 12-60) months. Radiological and functional evaluations were performed during follow up period. Steward-Hundley criteria were used for functional evaluation (Table 1).

Table 1. Functional evaluation based on Steward-Hundley criteria

Result	**Pain**	**Limitation of elbow and shoulder motion**	**Angulations**
Good	None	<20º	<10º
Moderate	following fatigue or an effort	20º-40º	>10º
Bad	Continuous	>40º	Radiologic non-union

RESULTS

Thirty patients who had osteosynthesis with plate-screw were included. The mean follow up period was 32 (12-60) months. Union time, shoulder and elbow joint functions, and postoperative complications were evaluated.

Steward-Hundley criteria were used for functional evaluation. Accordingly, 1 patient had shoulder movement limitation less than 20°, other 2 patients had elbow joint movement limitation between 20º-40º. In one of these patients, external fixation was used in addition to long-term internal fixation because of fixation safety. Another patient started physical therapy program later due to retardation of union. None of the patients showed angular deformity higher than 10º, and shortness more than 1 cm.

The mean fracture union time was 14 (10-24) weeks. Two patients showed retarded union and the mean fracture union time was 21 weeks in these two patients. These 2 patients had C1 fracture of AO classification which includes extensive soft tissue damage and multifragmentation. One patient developed pseudoarthrosis and had revision and grafting with iliac wing corticospongios bone and plate-screw. Radiologic healing was obtained in 18 weeks.

One patient had superficial skin infection and cured by oral antibiotic therapy. None of the patients developed deep soft tissue infection and osteomyelitis. None of the patients had scarring which required revision.

Four patients (13.3%) had preoperative radial nerve injury. These patients underwent early radial nerve exploration together with locking plate-screw fixation. None of the patients showed radial nerve cut and the lesions were accepted as neuropraxia. Postoperative dynamic wrist splint was applied in order to keep extension position of the wrist. All of the patients achieved full recovery in 4 months. Besides those 4 patients, 1 (3.3%) patient developed iatrogenic radial

nerve injury due to operation and this patient was followed up by dynamic wrist splint and achieved full recovery in 3 months.

The mean recovery time in our patients other than the patient with osteoarthrosis was 14 (10-24) weeks. Based on Steward-Hundley criteria, functional outcome was good in 27 (90%) patients, moderate in 2 (6.6%) patients and bad in 1 (3.3%) patient.

DISCUSSION

Diaphyseal humerus fractures account for 3% to 5% of all fractures (1, 2). The most common mechanism for injury is blow directly to arm and especially motor vehicle collision. Another factor is to fall down (2, 8). In our series, the reason was motor vehicle collision in 20 patients (66.6%). The second reason was falls in 7 (23.3%) patients. The reason for diaphyseal humerus fractures in young people is mostly high energy trauma whereas it may be simple falls in osteoporotic elderly after 7th decade (9). Among our 30 patients, 20 (66.6%) were between 18 to 40 years of age.

Diaphyseal humerus fractures do not show gender tendency. The left arm is affected more than the other side (10). In this study, of the patients, 63.3% were male whereas 36.6% were female. The fracture was on the right in 18 (60%) patients and on the left in 12 (40%) patients. Literature suggest that middle diaphyseal region is involved more than the others and the fracture line is mostly transverse (11, 12). Our study group was in accordance with literature. Of the fractures, 70% was in the middle 1/3 and 43.3% was transverse.

The most commonly preferred treatment method for diaphyseal humerus fractures is conservative. Conservative treatment methods include functional brace, U splint and hanging cast. U splint and functional brace are preferred especially in mid-diaphyseal spiral-oblique fractures (13). Besides successful results with conservative treatment, the risk of radial nerve injury after injury, and complications such as pseudoarthrosis, and infection made the conservative treatment the first line of the treatment (8, 10, 14).

In 2000, Sarmiento et al., published a study of 620 diaphyseal humerus fractures treated by functional brace. They found 3% nonunion and the mean fracture union time was 11.5 weeks. They also stated that conservative treatment was cheaper than surgical treatment and it does not require hospitalization (15). In 1988, Zagorski et al., performed conservative treatment in 170 humerus shaft fractures and 3 patients developed nonunion. The mean angle was 5º (12). In literature, successful results with conservative treatment were reported by McMaster (elbow hinged cast brace), Winfield (using hanging cast), and Clenermann (using U splint) (16, 17). Steward and Hundley used U splint and reported the mean union time to be 10 weeks. The Union rate was 94% (17, 18). We also use conservative treatment in humerus shaft fractures as the primary treatment.

Conservative treatment can be performed in many cases. However, surgery is necessary in patients with extensive soft tissue damage, multiple trauma, in patients with loss of reduction or irreducible fracture, non-union and pathological fractures (5). In addition, surgery should be preferred in patients with vascular injury, radial nerve injury after reduction, multifragmentary fractures, or floating elbow (7, 19).

Of the studied 30 patients, 7 were (23, 3%) initially treated with conservative methods. But, during control visits, loss of reduction, extensive distraction, and insufficient patient compliance led to surgery. Most of the fractures were transverse. Although conservative treatment is recommended in transverse fractures, surgery should be considered when the patient is incompliant or in distraction of fracture line due to heavy casting. According to Klenerman, primary surgical treatment in mid-diaphyseal transverse fractures may increase the risk of non-union (17, 20).

In this study, among the surgery indications, the first line was loss of position following a conservative treatment in 7 (23.3%) patients. Other reasons include multitrauma, intolerance to conservative treatment and failure of reduction and retardation of bone union.

Osteosynthesis with plate-screw, intramedullary nail and external fixator are used in surgical treatment (4, 5, 21, 22). External fixator is preferred in open fractures. Disadvantages consist of lesser patient comfort, pin bottom infections, failure to provide rigid fixation and nonunion (10).

Intramedullary nailing technique has advantages of minimal incision and close fracture line and disadvantages of shoulder movement limitation, rotator cuff lesions and nonunion due to rotational stability loss. The rate of non-union was reported 22% by Flink et al., 23% by Robinson et al., 13% by Stern et al. On the other hand, Riemer et al., reported union in all their patients (22-25). Intramedullary nailing in the right indication with flawless technique may significantly reduce the rate of non-union (4, 7, 21).

Bell achieved bone union in 33 of 34 polytrauma patients with an average 19 weeks (26). Foster achieved bone union in 91% of the patients by using compression plate (5). Kesemenli et al. found 97% union rate in 3.5 months in 27 patients by using locking plate (21). In our study, radiologic recovery was achieved in 14 (10-24) weeks in 29 of 30 patients (96.6%) with 3.5 nr locking plate. One patient developed pseudoarthrosis, and underwent grafting and a second fixation with locking plate. He achieved radiologic union in 18th week.

In classical plate-screw osteosynthesis, the stability of fracture fixation is directly related with friction between the bone surface and screw hold. Stability is related with holding resistance of cortical screws to cortical bone. Bending resistance of screws and prevention of movement between plate and screw seem to increase stability. In locking compression plate-screws, the bond between screw head and hole is designed grooved in order to provide angular stability and contact of bone and implant. These plates affect biology of periosteum lesser than LC-DCP plates and apply lesser pressure onto the bone. As the screw is locked to plate, it leads lesser bone necrosis and periosteum corruption. As these plates have conventional screw hole, axial compression is possible on the fracture line (3, 22, 27-29). None of our patients showed nonunion due to implant failure.

Fine fixation of osteoporotic bone is difficult. The holding power of screw is positively correlated with bone mineral density (27, 29, 30). Two (6.6%) of the patients were above 65 years of age and their mean union time was 5 months. These patients mobilized in early period and no implant failure was observed. Therefore, we think that osteosynthesis with locking plate is a good internal fixation material in osteoporotic humerus shaft fractures.

Iatrogenic radial nerve injury can be seen at the rate of 3-29% in plate-screw osteosynthesis of diaphyseal humerus fractures (12, 17). This rate is between 0-3% in intramedullary nailing (4, 21). In our study, only 1 patient (3.3%) had postoperative radial nerve lesion. There was no sensory deficit but motor deficit developed. Extensor dynamic wrist splint was used and full recovery was achieved in 3 months. We think that radial nerve injury was due to excess traction or neuropraxia during release. Persistent nerve injury due to total radial nerve rupture was observed in none of the patients.

Conservative treatment is still the first choice in diaphyseal humerus fractures in selected patients. However, when conservative treatment is no possible, locking compression plates can be applied according to fundamental AO rules. These plates should be screwed distal and proximal ends of the fracture passing at least 6 cortices. Besides, we think that surgery with minimum soft tissue and radial nerve damage is an effective and safe treatment method.

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