



Treatment of humeral pseudarthroses by open reduction and internal fixation

Humerus psödoartrozlarının açık redüksiyon ve internal tespit ile tedavisi

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Amaç: Humerus psödoartrozlarının tedavisinde otojen greftleme ile birlikte uygulanan açık redüksiyon ve plak ile internal tespitin etkinliği değerlendirildi.

Çalışma planı: Yirmi dört hasta (16 erkek, 8 kadın; ort. yaş 44; dağılım 28-64) humerus psödoartrozu nedeniyle ameliyat edildi. Ameliyat öncesinde, 16 hasta cerrahi, sekizi de konservatif tedavi görmüştü. Hastalar başlangıç tedavilerini takiben ortalama 10.8 ay (dağılım 7-21 ay) içinde ameliyat edildi. Ameliyat öncesinde hiçbir olguda enfekte kaynamama, 4 cm üzerinde kemik defekti ve radial sinir yaralanması yoktu. Tüm hastalara açık redüksiyon ve psödoartroz hattının proksimalinde ve distalinde en az dörder vida (8'er korteks) ile tutturulan plak tespiti ve otojen greftleme uygulandı. Hastalar ortalama 40 ay (dağılım 28-60 ay) süreyle izlendi. Son kontrollerde hastalar eklem hareket açıklığı açısından Rommens ve ark.nın, fonksiyonel olarak da Stewart ve Hundley'in ölçütlerine göre değerlendirildi.

Sonuçlar: Ortalama 19 hafta (dağılım 14-26 hafta) sonunda tüm hastalarda kaynama elde edildi. Omuz hareketleri tüm hastalarda mükemmel; dirsek hareketleri 22 hastada mükemmel, iki hastada orta olarak değerlendirildi. Fonksiyonel olarak 20 hastada mükemmel, dört hastada iyi sonuç elde edildi. Hiçbir hastada derin enfeksiyon, kaynamama, kötü kaynama, implant yetersizliği ve kalıcı sinir hasarı gibi komplikasyonlar görülmedi. İki hastada gelişen radial sinir felci kendiliğinden iyileşti.

Çıkarımlar: Özellikle enfekte olmayan, defektsiz ve deformite düzeltilmesi gerektirmeyen humerus psödoartrozlarının tedavisinde otojen greftleme ile birlikte uygulanan açık redüksiyon ve plak vida tespiti güvenilir ve etkin bir yöntemdir.

Anahtar sözcükler: Kemik plağı; kırık, kaynamamış/cerrahi; humerus kırığı/cerrahi/komplikasyon; psödoartroz/etioloji/cerrahi.

Objectives: The effectiveness of open reduction and plate fixation combined with autogenous bone grafting was assessed in the treatment of humeral diaphysis pseudarthrosis.

Methods: Twenty-four patients (16 men, 8 women; mean age 44 years; range 28 to 64 years) were operated on for humeral pseudarthrosis. Of these, 16 patients and eight patients had had previous surgical and conservative treatments, respectively. Surgery was performed after a mean of 10.8 months (range 7 to 21 months) following the initial treatments. Preoperatively, none of the patients had infected nonunion, a bone defect greater than 4 cm, and radial nerve injury. Treatment included open reduction and plate fixation combined with autogenous bone grafting. The plate was secured with at least four screws (8 cortices) both proximally and distally, The mean follow-up was 40 months (range 28 to 60 months). The range of motion of the shoulder and elbow was evaluated according to the criteria by Rommens et al. Functional evaluations were made according to the criteria by Stewart and Hundley.

Results: Union was achieved in all the patients after a mean of 19 weeks (range 14 to 26 weeks). Shoulder range of motion was excellent in all the patients. Elbow range of motion was excellent in 22 patients and moderate in two patients. Functional results were excellent in 20 patients and good in four patients. Deep infection, nonunion, malunion, implant failure, or permanent nerve injury did not occur in any of the patients. Two patients had transient radial nerve palsy.

Conclusion: Treatment with open reduction and plate fixation combined with autogenous bone grafting is a safe and effective option in humeral pseudarthroses, particularly in cases without infection, bony defect, and deformity requiring correction.

Key words: Bone plates; fractures, ununited/surgery; humeral fractures/surgery/complications; pseudarthrosis/etiology/surgery.

Although many humeral fractures heal uneventfully, nonunion is not an uncommon problem.^[1-3] Lack of union in 4 to 8 months following primary treatment is accepted as pseudarthroses.^[4, 5] Pain and loss of function are common problems in humeral pseudarthroses. An arm which is not well stabilized causes difficulties in daily activities of the patients. Various methods are used for the treatment of humeral pseudarthroses.^[6-9] The aim of this study is to assess the results of open reduction and plate fixation with autogenous grafting in the treatment of humeral pseudarthroses.

Patients and method

Between the years 1996 and 2001 24 (16 men, 8 women, mean age 44 years, range 28-64 years) patients were operated on for humeral pseudarthrosis. Sixteen patients had surgical and 8 patients had non-surgical treatments prior to operation. Fractures which did not heal in 6 months following the initial treatment were considered as pseudarthrosis. Diagnosis for pseudarthrosis was made by clinical examination and on direct x-rays in all patients. Seven patients had hypertrophic and 17 patients had atrophic or oligotrophic pseudarthroses. Patients were operated on a mean of 10.8 (7-21) months following their initial treatment. Neither of the pseudarthroses were infected, nor did any of them have bone defects more than 4 cms. Etiology of pseudarthroses were identified as soft tissue interposition in 2 cases, soft tissue interposition and smoking in 4 cases, distraction of fracture site and smoking in 2 cases, segmental fractures in 2 cases, inadequate fixation and smoking in 10 cases, inadequate fixation in 3 cases and noncompliance of the patient in 1 case. Radial nerve deficit was not present in any patient. Previous incisions were used in patients with previous surgeries and anterolateral incisions were used in patients with previous non-surgical treatments. Fixation was performed with 4.5 mm broad dynamic compression plates with 4 cortical screws (8 cortices) on each fragment following the

exposure of radial nerve. Grafting with autogeneous bone was performed in all patients. In 1 patient the autogenous bone was mixed with allograft due to the insufficient amount of harvested autogenous bone.

Upper extremity was immobilized in a long arm cast splint with an extension to the shoulder for 3 weeks postoperatively. Long arm cast splint was replaced with a functional brace of Sarmiento and active exercises were started by the end of 3rd week. Functional brace of Sarmiento was used until the union was achieved. Patients were followed for a mean of 40 (28-60) months. At latest follow-up, range of motions in shoulder and elbow were assessed according to Rommens et al^[10] and functional results were assessed according to Stewart and Hundley.^[11] (Tables 1 and 2)

Results

Union was achieved in all patients in a mean of 19 (14-26) months. (Figures 1a, 1b, 1c, 1d and 1e). Shoulder range of motion was excellent in all patients according to Rommens et al¹⁰. Elbow range of motion was excellent in 22 (91.7%) and moderate in 2 (8.3%) patients. (Figures 2 a and b). Functional results were excellent in 20 (83.3%) and good in 4 (16.7%) patients. Complications like deep infection, nonunion, malunion, implant failure and permanent nerve damage were not observed in any patients. Radial nerve palsy which occurred in 2 patients resolved spontaneously in both patients.

Table 1. Assessment of range of motion in shoulder and elbow joint.^[10]

| | Excellent | Moderate | Poor |
|-------------------------------------|-----------|----------|------|
| Restriction in shoulder motion <10° | | 10°-30° | >30° |
| Restriction in elbow motion <10° | | 10°-30° | >30° |

Table 2. Functional assesement.^[11]

| |
|--|
| Excellent |
| No pain |
| Full range of motion |
| Proper alignment |
| Good |
| Occasional pain |
| Less than 20° restriction in any adjacent joint motion |
| Angulation less than 10° |
| Fair |
| Pain following effort |
| 20°-40° restriction in any adjacent joint motion |
| Angulation more than 10° |
| Poor |
| Continuous pain |
| More than 40° restriction in any adjacent joint motion |
| Nonunion or iatrogenic nerve damage |

Discussion

Ten percent of long bones fractures are humeral fractures and 10% of humeral fractures are diaphyseal fractures.^[12] Although majority of humeral shaft fractures heal uneventfully, nonunion is not an uncommon problem. The rate of nonunion is reported to be 2 to 10% in nonsurgically treated, and 10 to 15% in surgically treated humeral shaft fractures.^[1-4,12,15] The causes of nonunion in humeral shaft fractures can be mentioned as the severity of initial injury, transverse fracture pattern, distraction of fracture, soft tissue interposition, inadequate immobilization, obesity, alcohol abuse, smoking and inadequate treatment. Nonunion of humeral shaft fractures should be treated surgically in order to avoid problems like instability, pain and loss of function.^[16,17]

Pseudarthroses of humeral shafts may be treated with plate fixation, intramedullary nailing, cortical onlay grafts and external fixators.^[3,6-9,13,18]

Union is usually not possible with Siedel nails and there is need for secondary surgical interventions in 34 to 58% of cases.^[19,20] Failure with Siedel nails was attributed to inability of the nails to achieve distal rotational stability and efforts were made to solve the problem by application of staples cancellous bon grafting at the fracture site in all

cases.^[21,22] Despite the successful results with ante-grade nailing, this type of treatment may lead to loss of function in the shoulder joint.^[23,24] Martinez et al^[8] treated 21 patients with retrograde unreamed nails and cancellous autograft in order to avoid the risk of loss of function in shoulder joint. They achieved union in all cases but observed over 10° loss in shoulder and elbow motion in 33% of their cases. They also observed varus and valgus malunions of 5° in 2 patients. They had difficulties in locking the nail tip in 5 cases. Rommens et al^[25] as well, reported complications like difficulties in locking the nail tip, fissure or avulsion of entry point and secondary radial nerve palsy with retrograde nailing.

Ilizarov method may provide some advantages in the treatment of humeral pseudarthroses. These advantages may be mentioned as the lack of need for bone grafting and the possibility to treat infected nonunions. Besides, the technique allows immediate postoperative motion. But the patients may experience discomfort caused by the frame and treatment may result with some severe complications. Lammens et al^[9] achieved union in 28 of 30 patients treated with Ilizarov external fixation. Pin tract infections which needed oral antibiotic treatment were present in all patients. They observed temporary neurological problems in 3 patients and another patient had to be treated with arthroscopic lavage

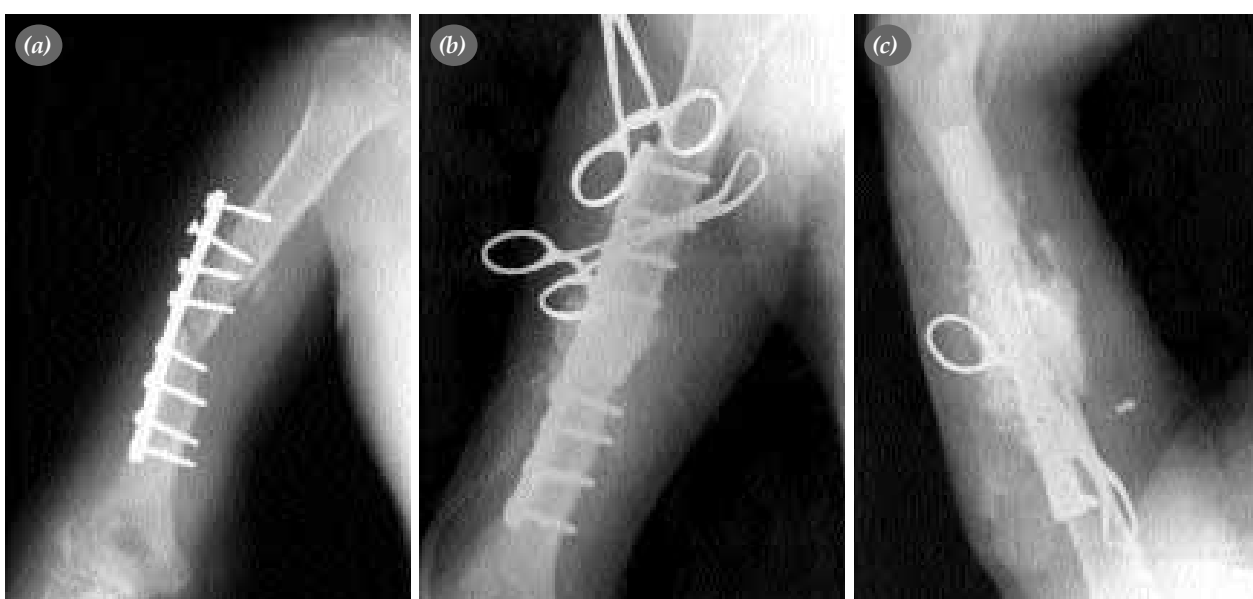
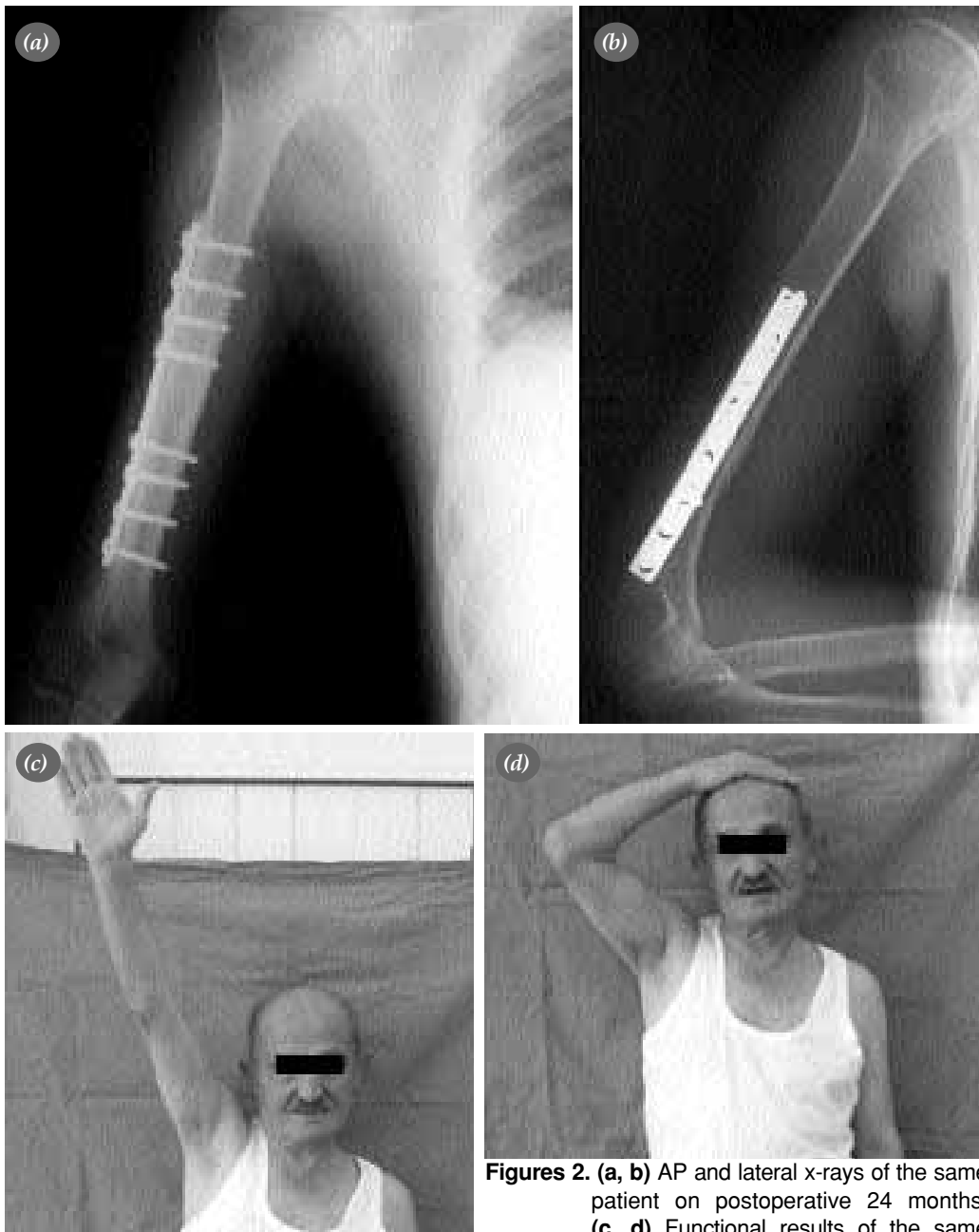


Figure 1. (a) Implant failure and pseudoarthrosis of humeral diaphysis. (b, c) Intraoperative AP and lateral x-rays of the patient who was treated with

due to septic arthritis of the elbow joint. They also encountered problems which required exchange of pins or the whole frame. Kocaoglu et al^[26] treated 35 patients with the method of Ilizarov and achieved union in 97.14% of cases in a mean of 5.5 months. They did not observe loss of motion in any cases but had improvements in ranges of motion. They observed nerve problems in 4 patients and resulted with permanent radial nerve damage despite the exploration of radial nerve in previously operated

patients with distal one-third fractures.

Healy et al⁶ reported plate fixation to be the most successful treatment method in humeral nonunions. Stable plating achieved by fixation of 6 cortices on both fragments was reported to be the most important factor for a successful result by the authors. On the other hand, obtaining a bone bed with a good blood supply and grafting the nonunion site can only be possible with adequate debridement of bone and soft tissues.^[27-29] Achieving an absolute cortical contact



Figures 2. (a, b) AP and lateral x-rays of the same patient on postoperative 24 months. (c, d) Functional results of the same patient on postoperative 24 months.

between fragments also influences healing in both acute fractures and nonunions.^[17]

Rubel et al^[7] achieved union in 34 (92%) of 37 patients with humeral pseudarthroses performing open reduction and internal fixation. They observed hypoesthesia without loss of motor function in the area of radial nerve distribution in 1 patient. Authors of the study looked for micromovement with manual stress at the pseudarthrosis site following plate application with fixation of 8 cortices on both fragments. They performed an additional fixation with 3.5 mm reconstruction plate in patients (18 cases) with micromovement at pseudarthrosis site. Two of 3 nonunions in this series were observed in cases with double plate application.

We achieved union in all patients using 4.5 mm broad plating with fixation of 8 cortices on both fragments combined with autogeneous grafting. Successful results in our series may be attributed to lack of open fractures or infected pseudarthroses and good quality of bone without osteoporosis which was observed in all patients. We did not observe any complications like radial nerve injury and deep infection which are the major disadvantages of plate-screw application. As a conclusion we advocate open reduction and plate fixation combined with autogenous grafting in humeral pseudarthroses without infection, bony defects and deformities requiring correction.

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