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The results of open reduction and internal fixation of radial head fractures

Radius başı kırıklarında açık redüksiyon ve internal tespit sonuçları

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Amaç: Radius başı kırıklarında uyguladığımız açık redüksiyon ve internal fiksasyon sonuçları değerlendirildi.

Çalışma planı: Çalışmaya, radius başı kırığı nedeniyle açık redüksiyon ve internal fiksasyonla tedavi edilen 15 hasta (9 erkek, 6 kadın; ort. yaş 38; dağılım 23-46) alındı. Mason sınıflandırmasına göre yedi hastada tip II, beş hastada tip III, üç hastada tip IV kırık vardı. Radius başı kırığına, bir olguda olekranon ve koronoid proçes kırığı, bir olguda skafoid ve koronoid proçes kırığı, bir olguda lunatum çıkığı ve skafoid kırığı, bir olguda kapitellum kırığı, bir olguda kolles kırığı, üç olguda koronoid proçes kırığı eşlik etmekteydi. Dokuz olguda AO mini plak, altı olguda vida ile osteosentez yapıldı. Beş olguda radius distalinden alınan greft kullanıldı. Klinik ve radyografik değerlendirmeler modifiye Morrey fonksiyonel derecelendirme indeksi kullanılarak yapıldı. Hastalar ortalama 26.4 ay (dağılım 14-53 ay) süreyle izlendi.

Sonuçlar: Modifiye Morrey fonksiyonel derecelendirme indeksine göre 15 dirseğin altısında mükemmel, üçünde iyi, üçünde orta sonuç alındı. Üç olguda radius başında psödoartroz gelişti. On iki olguda anatomik, ikisinde iyi, birinde kötü redüksiyon sağlandı.

Çıkarımlar: Radius başı kırıklarında, dirsek biyomekaniğinin korunması amacıyla radius başının anatomik bütünlüğü sağlanmalıdır. Dikkatli bir planlamayı takiben, lateral ligament yapının anatomisi korunarak, pronasyon ve supinasyonu kısıtlamayacak şekilde güvenli bölgede uygulanan osteosentez ve stabil bir dirsekle radius başı kırıklarında iyi sonuçlar elde edilmektedir.

Anahtar sözcükler: Kemik çivileri; kemik plakları; dirsek eklemi/cerrahi/yaralanma/radyografi; kırık fiksasyonu, internal/yöntem; kırık, parçalı/cerrahi/radyografi; radius kırıkları/cerrahi/radyografi; hareket açıklığı, artiküler.

Objectives: We evaluated the results of radial head fractures treated with open reduction and internal fixation.

Methods: Fifteen patients (9 men, 6 women; mean age 38 years; range 23 to 46 years) underwent open reduction and internal fixation for radial head fractures. According to the Mason classification system, the fractures were type II in seven patients, type III in five patients, and type IV in three patients. Accompanying fractures involved the coronoid process (n=3), olecranon and coronoid process (n=1), scaphoid and coronoid process (n=1), scaphoid with perilunate dislocation (n=1), and the capitellum (n=1). One patient had a Colles' fracture. Osteosynthesis was performed with an AO small plate in nine patients and with a screw in six patients. Bone grafts taken from the distal part of the radius were used in five patients. Clinical and radiographic evaluations were made with the use of a modified Morrey functional evaluation index. The mean follow-up period was 26.4 months (range 14 to 53 months).

Results: Functional results were excellent in six elbows, good in three elbows, and moderate in three elbows. Pseudoarthrosis of the radius head was encountered in three patients. Reductions were assessed as anatomic in 12 patients, good in two patients, and poor in one patient.

Conclusion: In the treatment of radial head fractures, the anatomic integrity of the radius head should be preserved in order to maintain the biomechanics of the elbow. Following a meticulous treatment plan and with preservation of the lateral ligament anatomy, osteosynthesis performed in a safe zone and achievement of a stable elbow may provide successful results in the treatment of radial head fractures.

Key words: Bone nails; bone plates; elbow joint/surgery/injuries/radiography; fracture fixation, internal/methods; fractures, comminuted/surgery/radiography; radius fractures/surgery/radiography; range of motion, articular.

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With the recognition of the importance of the radial head in the elbow and forearm biomechanics and the development of surgical techniques and plate-screw systems, surgical reconstruction has gained more importance in radial head fractures. When the medial colatteral ligament itself gets injured or together with the interosseous membrane, the radial head acts as the main stabilizer against longitudinal compressive forces and valgus stress on elbow. In such patients in whom radial head excision is not recommended, the anatomic integrity of the radius should be preserved by surgical restoration or replacement. Radial head fractures may be accompanied by injury of the distal radioulnar joint, the interossseous ligament or the medial colatteral ligament; olecranon and coronoid process fractures, as well as the hand wrist, corpal region fractures and dislocations on the same side.

Until the 1980s, while treatment for nondislocated radial head fractures was observation and a start of early movements, for the deplaced and comminuted fractures, it was limited to radial head resection. However, surgical reconstruction which started in the 1950s has been used till now by very few surgeons. Complications such as pain, instability, vulgas deformation, loss in the range of motion were reported after resection performed within an early or late period. Following an early or late resection complications such as pain, instability, valgus deformity, loss in the joint's range of movement, osteoarthritis, proximal radial migration were reported. However, today, suggestions are as follows: short time immobilization and early movement for nondeplaced fractures; open reduction and internal fixation for deplaced fractures ; resection or use of prothesis for multiple comminuted fractures.

In this study, the patients treated with open reduction and internal fixation due to deplaced radial head fractures were assessed in terms of indication, treatment approach, and factors affecting the results.

Patients and methods

Between the dates 1998 and 2002, fifteen adult patients (9 men, 6 women; mean age 38 years; range 23 to 46 years), one of whom had Essex-Lopresti lesion, underwent open reduction and internal fixation for radial head fractures. Of the patients 6 were workers, 3 housewives, 2 civil servants, 4 were liberal professionals. Radial head fractures in 8 patients were the result of a fall on the elbow and in 7 patients they were caused by a fall on an outstretched hand that causes hyperextension of the elbow. In 7 patients (47%), the fractures were on the right; in 8 patients (53%) on the left. 10 patients underwent surgical treatment between the first

On admission, each patient's hand wrist, forearm and elbow were evaluated and fracture type was determined by direct radiography. Instability was assessed with the use of axillar and vulgas stress tests. According to the Mason classification system, fractures with more than 2-mm dislocation in the radial head and those whose remaining portion of the radial head was more than 30% were classified as type II (7 patients), those with comminuted fractures type III (5 patients), and those accompanied by elbow dislocation as type IV (3 patients). The radial head fractures were accompanied in one patient by olecranon and type III coronoid process fractures; in one patient by scaphoid and type III coronoid process fracture, in one patient by lunatum dislocation and scafoid fracture, in one patient by capitellum fracture, in one patient by colles fracture, and in one patient by type I, and in two patients by type II coronoid process fracture (Table 1).

Surgical technique

No standard protocol was used as surgical treatments were carried out by different surgeons. Lateral approach was used in all patients. After the fracture was seen, firstly anatomic reduction was secured on the joint surface. Upon the temporary fixation of the fragments with the Kirschner wires, for permanent fixation T or Y-shaped AO small plates were used in 9 patients (Figure 1a, b), in five patients 3.5- mm screws, and in one patient 2- mm screw were used respectively. Implants were placed in the safe area of 90 degrees which was between the radius stiloid and the lister tubercle in the hand wrist and was not participating in joint movements in the radial head. Anterolateral zone was selected in nuetral rotation in order to prevent pressure in the radioulnar joint. In communited or impact fractures, grafts taken from the distal part of the radius were placed along the fracture line and in the defective area. The annular ligament and the lateral capsular complex were repaired properly. For olecranon fractures accompanying radial head fractures, a plate was placed, a Herbert screw was placed to the scafoid fracture, and for the capitellum fracture osteossynthesis was done with a screw. And for the cronoid fracture in two patients fixation was carried out. Varying degrees of capitellum cartilage damage was observed in four patients .

Three patients with elbow dislocation and type IV radial head fracture were admitted to hospital after their

reductions were performed. During operation, in two patients the ulna and the humerus were fixed with a Kirschner wire. In one patient type III coronoid process fracture was fixed with an anchor. Above - elbow circular cast was performed in three patients. Grafts were used in five patients, of whom three had type II, one had type III and another one had type IV fracture. (As the operations were done by different surgeons, different attitudes were shown regarding the grafts).

After surgery, above-elbow cast was performed for 4 weeks in 7 patients, one of whom had distal radioulnar joint pain. Splints were not used in four patients who had AO small plates. In other patients rest-splints were used for a period of 3-4 weeks which allowed active and passive motions. In recent patients early motion was started in shoulder-arm braces. The mean follow-up period was 26.4 months (range 14 to 53 months).

In the assessment of the results the modified Morrey functional evaluation index was used. Motion range of the joints, strength of grip, clinical and radiological stability, and subjective pain complaints were scored (Table 2). For stability assessment history, radiography (AP stress graphies) and physical examination methods were used. Range of motion of the operated elbow was compared with the healthy side (Figure 1c, d). in terms of flexion, extension, pronation and supination. Patients were assessed with AP and lateral graphies involving both the elbows and wrists. Ulnar variance was used in the assessment of proximal radial migration. Diaphyiseal ulnohumeral angle (CE angle) was comparatively assessed in both AP radiographies.

Results

According to the modified Morrey functional grading system, results were excellent in six patients, good in

Table 1: The results of patients with a fracture of radial head

Tip	Case no	Age	Mechanism of injury	Fractured side/ dominant side	Mason classification	Associated lesions	Time for surgery (day)	Fixation materials	Follow-up (month)	
Tip II	1	(E)	Fall on an outstretched hand	Right/Right	2	Lunate luxation, fracture of the scaphoid fracture of the scaphoid	1	3.5 mm screw	53	++++
	2	(E)	Fall on the elbow	Left/Right	2	fractures of the capitellum	3	3.5 mm screw	44	++++
	3	(E)	Fall on an outstretched hand	Left/Right	2		1	3.5 mm screw	30	++++
	4	(E)	Fall on an outstretched hand	Right/Right	2		3	2.0 mm screw	27	++++
	5	(K)	Fall on the elbow	Left/Right	2		1	AO mini plate, graft	23	++++
	6	(E)	Fall on the elbow	Right/Right	2		5	AO mini plate, graft	21	+++
	7	(K)	Fall on the elbow	Left/Right	2		2	AO mini plate, graft	16	++++
Tip III	1	(K)	Fall on the elbow	Right/Right	3		2	AO mini plate	23	+++
	2	(E)	Fall on an outstretched hand	Left/Right	3		3	AO mini plate	18	+
	3	(K)	Fall on an outstretched hand	Right/Righ	3	Essex-Lopresti, type I coronoidal fracture	7	AO mini plate	18	++
	4	(K)	Fall on the elbow	Left/Right	3	Fracture of the olecranon, Type III fracture of the coronoid process	4	AO mini plate, anchor	16	+
	5	(K)	Fall on the elbow	Left/Right	3		5	AO mini plate, graft	12	+
Tip IV	1	(E)	Fall on the elbow	Right/Right	4	Type II fracture of the coronoid process (6)	3	3,5 mm screw, K wire fixation for the elbow	47	++
	2	(E)	Fall on an outstretched hand	Left/Left	4	Fracture of the scaphoid and Type III fracture of the coronoid process	9	AO mini plate, graft and anchor	20	++
	3	(E)	Fall on an outstretched hand	Right/Right	4	Colles fracture and Type II fracture of the	1	3,5 mm screw, K wire fixation for the elbow coronoid process	14	+++

(++++) excellent; (+++) good; (++) moderate; (+) poor, pseudoarthrosis. (6) According to Regan-Morrey classification

three patients, and moderate in three patients. In three patients pseudoarthritis was encountered (Table 1). Approximately 12-degree flexion loss was observed in the range of motion in the elbow joint. It was observed that in six patients there was a partial limitation in the extention not affecting functions , and in five patients there was loss of rotation. The mean pronation loss was 8.3 degrees, supination loss was 9.6 degrees. There were complaints of pain during daily work, slight in three patients, moderate in three patients and severe in another three patients. In one patient, especially during the forearm rotation movements, crepitation was observed. It was determined that in one patient, who had been treated for Essex-Lopresty lesion with a plate, the pain in the wrist and forearm which existed before surgery was still going on less severely. There was slight loss of stregth in five patients, and moderate in one patient. Proximal radial migration was not observed in any patients in the AP graphies.

Radioulnar index was normal in all patients. In stress graphies no noticeable changes were observed especially regarding mediolateral joint stability. In one patient there was a little loss of stability. The increase in the CE angle of the AP graphies was found approximately 5.2 degrees (range 3-100) in comparison with the other side. Instability was not observed neither subjectively nor objectively in spite of the increase in the carrying angle. Complications such as neuroproxy, infection, reflex sympathic dystrophy, valgus-varus instability, degenerative changes were not encountered. In three patients, one of whom had impingement syndrome, the plates were removed. There was crepitation in one patient, and in another one there was sensitiveness in the radial head. It was observed that these symptoms did not affect the functions of the elbow.

Pseudoarthrosis was encountered in three patients with type III fractures whose radial head had more than three pieces. Two patients underwent radial head resection. The plate was broken in the first patient who had resection while pulling the horizantal bar to restore elbow range of motions. In the other patient, it was found that there was looseness in the plate removed and that synovial tissue reaction had occurred around it. In the third patient whose radial head fracture was accompanied by olecranon and coronoid fracture elbow functions were normal in spite of the loosenessness in the plate (Figure 2a-d).

Discussion

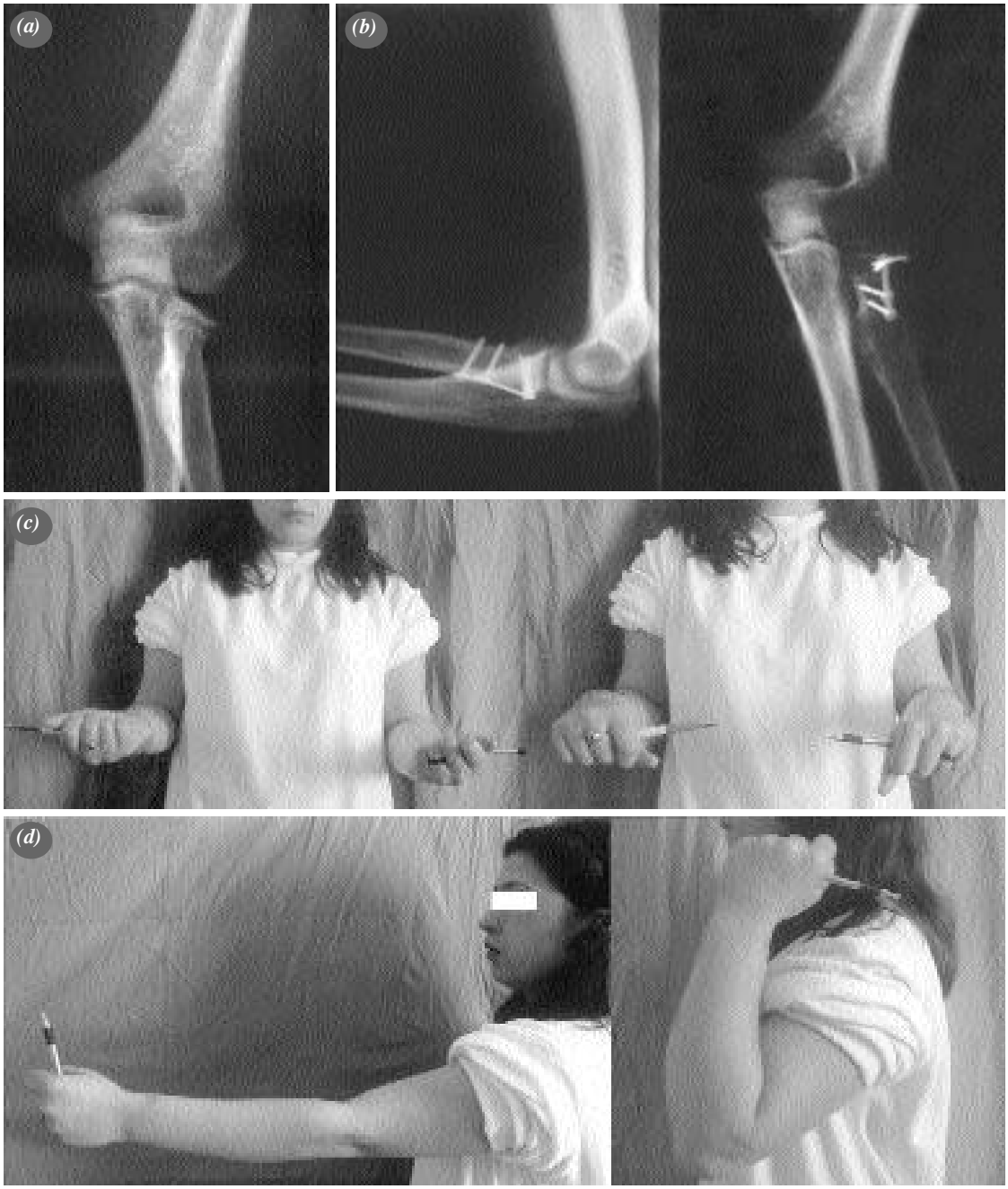
Radial head fracture is caused by either direct or indi-

Table 2: Modified Morrey functional evaluation index [7]

Functional status		Score
Motion	Flexion, ideal 150º	30
(score=0,2_arc)	Extension, ideal 10º	2
	Pronation, ideal 80º	16
	Supination, ideal 80º	16
Grip strength	Normal	12
	Minimal loss (80% of the other extremity)	8
	Moderate loss (50 % of the other extremity)	4
	Advance loss (complains in daily activities)	0
Stability	Normal	12
	Slight loss	6
	Instable	0
Pain	None	12
	Slight (normal activity, no medication)	8
	Moderate (with activity)	4
	Severe (during the rest, all time medication)	0
Results	Excellent	90-100
	Good	80-90
	Moderate	70-80
	Poor	<70

rect travma. Fractures often occur as a result of the axial pressure on the forearm in pronation or supination when the radial head is pressed like a piston into the capitellum . Deplaced, impacted, comminuted radial head fractures are encountered in such injuries. Radial head fractures may be seen in backward falls on the forearm in extension and supination position or in direct falls on the elbow.

Previously in the osteosynthesis of radial head fractures Kirschner wires were used. Starting from 1990s thin and biomechanically strong AO small plates and screw systems, Herbert screws, fibrin adezit adhesives and intramedular fixation methods have been used. Open reduction and internal fixation performed for mono-piece deplaced fractures of the radius head has been extended so as to include impact or comminuted fractures as well

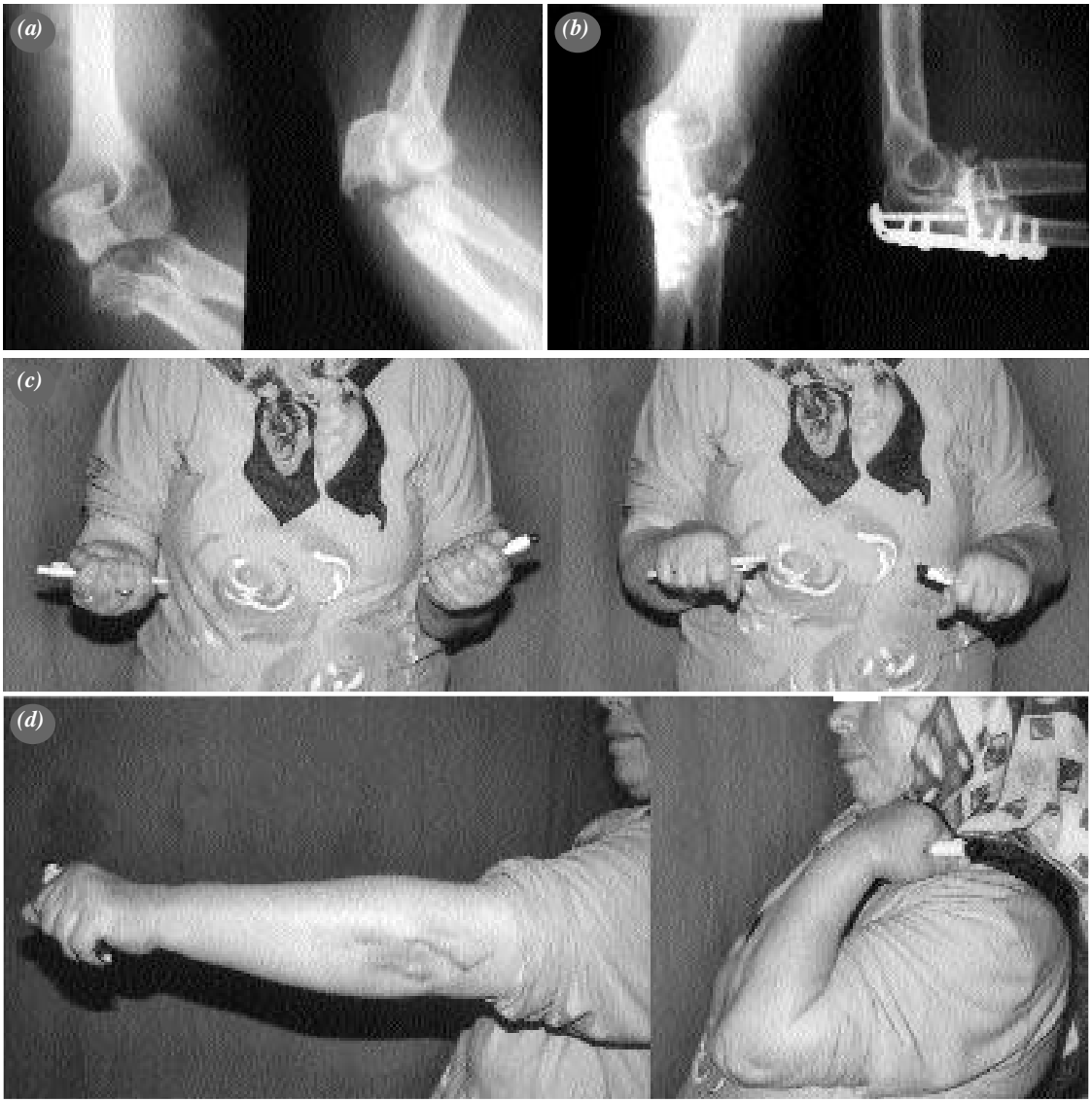


Picture 1. **(a)** displaced and impacted fracture of the radial head. **(b)** a mini-plate and graft was applied, but pseudoarthrosis of the radial head was developed

as those which can be seen together with elbow dislocations. In our patients AO small plate systems were preferred as far as possible in order to be able to start stabilization and early motion.

In cases when the radial headwas not comminuted, osteosynthesis was performed with an AO small plate. Open reduction and internal fixation were used in patients in whom more than one-third of the radial head joint surface was affected and 2-mm and more deplacement or 2-3 -mm joint compression occurred, and in those with accompanying fractures around the elbow, Essex-Lopresti lesion or damage in the ulnar collateral ligament. The best results are obtained in mono-comminuted radial head type II fractures. Results were excellent in six patients, and good in one patient with radial head type II fractures. No limitation was observed in the patients' elbow and forearm movements. Starting early motion upon stable osteosynthesis for type II fractures is preventing restriction in the elbow and forearm motions, and making rehabilitation easier.

The rate of good and perfect results in type III radial head fractures is lower. For this reason, for type III radial head fractures determined either by radiography or during operation as multi-comminuted, it is suggested that internal fixation methods should not be employed and that anthroplasty or resection alternatives should be eval-



Picture 2.(a) displaced fracture of the olecranon and comminuted fracture of the radial head. **(b)** Pseudoarthrosis of the radial head fracture and loosening of the mini-plate. Postoperative **(c)** supination and pronation and **(d)** flexion and extension of the elbow joint.

uated. Ikeda and et al. reported that the results were perfect in one patient and good in two patients who had been treated with cancellous graft and double plates. The results in five patients with radial head type III fractures were as follows: good in one, moderate in one, bad in three. In patients with bad results there were more than three fragments in the radial head. Grafting and double plate insertion as suggested by Ikeda et al should be considered in patients with more than three fragments of the radial head, or resection or replacement should be conducted depending on instability.

In patients, in whom the interosseous ligament has been damaged, the importance of anatomical integrity of the radial head is becoming more vital as it provides longitudinal stability. In the prevention of proximal radial migration, the repair of the radial head or the preservation of the length of the radius through prothesis replacement makes it possible to share the forces exerted on the elbow. In cases accompanied by medial collateral ligament injury, fractures in the radial head, which is the secondary stabilizer against valgus forces, should be fixed to supply stability in the elbow and the forearm. In patients in whom medial collateral ligament injury was thought and unition was obtained, valgus and axial instability was not observed as radial head was protected in spite of the fact that any ligament repair was not done. Proximal radial migration was not encountered in the AP graphies of any patients. In one patient, who pre-surgery had complaints of pain in the wrist and the forearm, and was thought to have Essex-Lopresti lesion, an above-elbow cast was performed after plate osteosynthesis. Moderate result was obtained in the patient with no complaints of pain. As with Essex Leprosti lesions, for radial head fractures accompanying acute forearm dislocation surgical reconstruction should be performed.

In our patients with type IV comminuted dislocation in their radial heads, we got a good result in one, and moderate in two. In two patients, who had also coronoid process fracture and had given good and moderate results, the ulna and the humerus were fixed with a Kirschner wire. Joint fixation is no longer applied in our clinic. In patients in whom ligament repair was not performed there was no apparent instability. Posterior elbow dislocation and coronoid process fracture accompanying radial head fracture are called as the terrible triad of the elbow. In instable cases, for the restoration of stability the provision of radiocapitellar contact through radial head osteosynthesis or replacement of radial head, repair of radiocollateral ligament, and internal fixation of the coronoid process fracture is advocated. In our cases we showed great care for repair of the lesions which were the cause of instability. In one patient with a type III coronoid process fracture fixation was performed with an anchor to prevent instability of the elbow. Ikeda and et al reported the results as excellent in one patient, good in four, and moderate in one, in whom they had used double plates and grafts for type IV fractures.

The same authors applied a cast in patients with type III and IV fractures which permitted supination and pronation, and allowed the elbow to be fixed at 900 of flexion for a period of 2-3 weeks; and after the cast was removed they used an articulated brace allowing flexion and extension at the elbow for 4-6 weeks; thus, results they got were excellent in three patients, good in six it was limited toit was limited tosand moderate in one. In our patients, circular casts were used in initial cases for 3-4 weeks, and then early motion was started in the shoulder-arm sling. As Ikeda and et al recommended early movement can be started with an articulated brace.

Much loss of function and strength was not observed in our patients who were treated with open reduction and internal fixation. Complications such as arthritis, compression on the joint surface, narrowing in the joint opening were not encountered. No patients who had pain complained of movement restriction. As Ring et al pointed out, in one of our patients, whose plate was removed, it was observed that the deformed radial head restricted supination and pronation by rubbing against the capitellum.

In patients with impaction or metaphyseal defection on the fracture line, use of humerus lateral epicondyle or grafting from olecranonin is recommended. Unition was obtained in four patients who were treated with radial distal point grafts. Pseudo arthrosis was encountered in one patient with a type III fracture.

Good results can be achieved in deplaced type II fractures of the radial head through osteosynthesis together with the support of graft when necessary, and with early motion of the elbow. Treatment of multiple-comminuted type III radial head fractures, which have ligament damage in the forearm or the elbow, or have small fragments of joint surface, is still a problem today. In such casas, if it is possible to to get anatomical lining along the joint surface with reduction of the fracture, a plate should be used together with the support of a graft when nessary, and early movement should be allowed. In cases where

stability stability or anatomical restoration on the joint surface cannot be obtained in type III radial head fractures, forced internal fixation should be avoided, and if there is ligament injury in the forearm or the elbow, a radius head prothesis should be used; otherwise radius head resection should be carried out.

Following a meticulous treament plan and with preservation of the ligament anatomy, osteosynthesis performed in a safe zone so as not to restrict pronation and supination, and achievement of a stable elbow may provide successful results in the treatment of radial head fractures.

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