Open reduction and internal fixation of radial head fractures

Radius başı kırıklarında açık redüksiyon ve internal tespit uygulamaları

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BACKGROUND
We evaluated the radiologic and functional outcomes of patients with radial head fractures managed with open reduction and internal fixation.

METHODS
Between 1998-2003, 15 patients (7 males, 8 females; mean age 34.1; range 18 to 49 years) with radial head fracture were treated with open reduction and internal fixation. Follow-up time was 54.6 months (42-78). Three fractures were Mason type II, 8 were III and 4 were IV. They were evaluated by anteroposterior and lateral radiographs and functionally by Broberg and Morrey criteria.

RESULTS
All the fractures except in 1 patient with Mason type III had united. The mean range of motion of the elbow was 20° to 145° with 71.9° of pronation and 83.2° of supination. According to Broberg and Morrey criteria, the outcome was excellent in 8, good in 4, fair in 1 and bad in 2. Excision and prosthetic replacement were performed in 1 patient because of implant failure.

CONCLUSION
We suggest open reduction and internal fixation even in comminuted cases because it gives satisfactory elbow function and avoids radial shortening, loss of motion and wrist joint dysfunction as a result of radial head excision. When it fails, excision and prosthetic replacement can be done later.

Key Words: Elbow; Kirschner wire; open reduction and internal fixation; radial head fracture.

AMAÇ
Açık redüksiyon ve internal tespit uygulanan radius başı kırıklı olguların radyolojik ve fonksiyonel sonuçları değerlendirildi.

GEREÇ VE YÖNTEM
1998-2003 yılları arasında radius başı kırığı ile başvuran ve açık redüksiyon ve internal tespit uygulanan 15 olgu (7 erkek-8 kadın; ortalama yaş 34,1; dağılım 18-49) değerlendirildi. Takip süresi 54,6 (dağılım 42-78) aydı. Mason sınıflandırmasına göre olguların 3'ü tip II, 8'i tip III ve 4'ü tip IV idi. Radyolojik değerlendirme arka-ön ve yan radyografilerle, fonksiyonel değerlendirme Broberg ve Morrey ölçütlerine göre yapıldı.

BULGULAR
Kaynamama tespit edilen tip III kırıklı olgu dışında tüm kırıklarda kaynama saptandı. Dirsek eklemi fleksiyonu 20°-145° arasında saptandı. Ortalama pronasyon 71,9° ve supinasyon 83,2° idi. Sekiz olguda mükemmel, 4 olguda iyi, 1 olguda orta ve 2 olguda kötü sonuç alındı. İmplant yetersizliği nedeni ile 1 olguda radius başı eksizyonu ve protez uygulaması yapıldı.

SONUÇ
Radius başı kırıklarında açık redüksiyon ve internal tespit uygulamasını dirsek fonksiyonlarında tatmin edici sonuçlar elde edilmesi ve ayrıca radius başı eksizyonu sonrası oluşan radius kısalığının, el bileği eklemi disfonksiyonunun ve hareket kısıtlılığının önlenmesi nedeniyle parçalanma miktarının fazla olduğu durumlarda bile önermekteyiz. Ayrıca, kötü sonuç elde edildiğinde eksizyon ve protez uygulaması daha sonra yapılabilir.

Anahtar Sözcükler: Dirsek; Kirschner teli; açık redüksiyon ve internal tespit; radius başı kırığı.

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It is now known that excision of the radial head due to fractures without replacement leads to instability of both the distal radioulnar and elbow joints as well as disabling pain interfering with daily activities. Additionally, some limitations in range of motion of joints, cubitus valgus, dysfunction of ulnar nerve, posttraumatic osteoarthritis, proximal radial migration, and inferior radioulnar joint subluxation have been reported as early and long-term complications after excision of the radial head.[1-5] Those serious problems have led researchers to perform biomechanical studies to increase our understanding of the functions of the radial head not only for the elbow joint but also the forearm and wrist joints.[6-8] After injury to the medial collateral ligament itself or with interosseous membrane, the only primary stabilizing segment of the elbow against compressive forces and valgus stress is the radial head. As a result, authors have begun to do open reduction and internal fixation with AO mini-plates with screws, Herbert screws and other forms of fixation even in comminuted fractures of the radial head in conjunction with the progress in fixation materials.[9-16] In fractures not amenable to open reduction and internal fixation, replacement with prosthesis may be decided.

In this study, we aimed to evaluate patients with radial head fractures managed with open reduction and internal fixation.

MATERIALS AND METHODS

Between 1998 and 2003, open reduction and internal fixation was performed in 15 patients with radial head fractures. There were 7 (46.7%) males and 8 (53.3%) females, with a mean age of 34.1 years (18-49). The mean follow-up time was 54.6 months (42-78). On admission, patients were diagnosed to have radial head fracture based on physical examination and radiographs involving the elbow, forearm and wrist. Mason criteria[17] were used in the classification of fractures. According to this classification system, fracture including more than 30% of the radial head is designated as Mason type II and comminuted fractures of the radial head as Mason type III. If a Mason type III fracture is associated with dislocation of the elbow and ligamentous injuries, it is classified as Mason type IV fracture. There were 3 (20%) Mason type II, 8 (53.3%) Mason type III and 4 (26.7%) Mason type IV fractures. The mechanism of injury was fall on the outstretched hand in 8 (53.3%) and fall on the elbow joint itself in 7 (46.7%). Associated injuries were olecranon fracture in 2 and elbow dislocation in 1. Coexisting olecranon fractures were fixed concomitantly. There were no associated neurovascular injuries.

All the operations were performed with pneumatic tourniquet and under axillary anesthesia. Patients with isolated radial head fracture were approached with Kocher's lateral incision to expose the radial head between the anconeus and extensor carpi ulnaris. The incision was not extended distally in order to not harm the posterior interosseous nerve. Once the fracture fragments were held with small forceps, they were temporarily fixed with 1 mm Kirschner wires. In 1 (6.7%) patient with Mason type III and 1 (6.7%) patient with Mason type IV fracture, the operations were performed under urgent conditions and 1 mm Kirschner wires were used as the fixation material in these cases. We used Normed (Normed, Germany) 2.3 mm cannulated screws in 3 (20%) patients with Mason type II, 6 (40%) patients with Mason type III and 1 (6.7%) patient with Mason type IV fractures. In 2 (13.3%) patients with Mason type IV fracture, Normed low-profile mini plate with screws and cannulated screws (Normed, Germany) were used (Fig. 1). The Kirschner wires, screw heads and mini plate were placed on the nonarticular portion of the radial head in order to not interfere with the forearm pronation and supination in the proximal radioulnar region. The screw heads were countersunk below the articular surface. Ipsilateral olecranon fractures were fixated with tension band wiring technique. After fixation, we examined the alignment and movement of the radial head both radiologically and by manipulating the forearm manually. After irrigation, the tourniquet was deflated and hemostasis was achieved. A drain was placed in the joint space and the incision was closed according to the anatomy.

A long arm plaster splint was applied with the elbow in 90° of flexion. After three days, patients with Kirschner wire fixation were put in long arm cylindrical plaster cast, which was kept in place for four weeks. In the remainder of the patients, long arm plaster splint was used for three weeks. After removal of the cast, physical rehabilitation program was started. Kirschner wires were removed six weeks postoperatively.

Clinical evaluation was done with Broberg and Morrey criteria[1] (Table 1). All the patients were

evaluated and compared with the contralateral extremity. At the last follow-up, any symptoms related to the elbow were recorded. Physical assessment included measurement of range of movement of the elbow and forearm, the stability of the elbow and presence of any problem related to the distal radioulnar joint. A standard, long-limb goniometer was used to measure the range of movement. Flexion and extension of the elbow was measured with the forearm in neutral rotation and range of pronation and supination with the elbow in 90° of flexion. Radiologic assessment included anteroposterior and lateral radiographs of the elbow, forearm and wrist, allowing measurement of carrying angle and evaluation of bony union, congruency of joint surfaces, posttraumatic osteoarthritis, proximal radial migration, ulnar variance, and subluxation or dislocation of the distal radioulnar joint. All the radiological parameters were compared with the contralateral extremity.

RESULTS

All the fractures except one were united without evidence of radial head avascular necrosis. Nonunion was seen in one patient with Mason type III fracture.

One patient with Mason type III fracture had some crepitation and pain in the movements of

Fig. 1. **(a)** Preoperative anteroposterior radiograph of a 43-year-old male patient with Mason type IV radial head fracture. **(b)** Preoperative lateral radiograph of the same patient with Mason type IV radial head fracture. **(c)** Postoperative 65th month anteroposterior radiograph of the same patient with Mason type IV radial head fracture fixated with mini plate and screws. **(d)** Postoperative 65th month lateral radiograph of the same patient with Mason type IV radial head fracture with mini plate and screws. **(e)** Postoperative 65th month photograph of the same patient showing supination of both forearms. **(f)** Postoperative 65th month photograph of the same patient showing pronation of both forearms. **(g)** Postoperative 65th month photograph of the same patient showing flexion of both elbows. **(h)** Postoperative 65th month photograph of the same patient showing extension of both elbows.

Table 1. Broberg and Morrey criteria

Variable	Point
Motion	
degree of flexion (0.2° arc)	27
degree of pronation (0.1° arc)	6
degree of supination (0.1° arc)	7
Strength	
normal	20
mild loss (80% of opposite side)	13
moderate loss (50% of opposite side)	5
severe loss (limits everyday tasks, disabling)	0
Stability	
normal	5
mild loss (80% of opposite side)	4
moderate loss	2
severe loss (limits everyday tasks)	0
Pain	
none	35
mild (with activity, no medication)	28
moderate (with or after activity)	15
severe (at rest, constant medication, disabling)	0

95-100: excellent; 80-94: good; 60-79: fair; 0-59: bad.

pronation and supination of the forearm. Another patient with Mason type IV fracture, who was a high school teacher, complained of pain and difficulty in writing activities on the blackboard. Her dominant arm had fractured.

Mean flexion of elbow was 135° (20° to 145°) and mean loss of extension was 8° (-38° to 5° hyperextension). Mean pronation and supination of forearm were 71.9° (15° to 80°) and 83.2° (15° to 90°), respectively. In physical examination, no sign of instability in the elbow joints was detected. Reflex sympathetic dystrophy was not observed in any of the patients.

In radiological evaluation, mean increase in carrying angle and ulnar variance were 2° and 1 mm, respectively. In one case with Mason type IV radial head fracture, mild arthritic changes in the elbow joint were observed at the last follow-up.

Implant failure was noticed in one patient with Mason type IV fracture in the early postoperative period and she was managed with prosthetic replacement. No other problems related to the fixation materials were found in the other patients.

According to Broberg and Morrey criteria, the outcome was excellent in 8 (53.3%), good in 4 (26.7%), fair in 1 (6.7%) and bad in 2 (13.3%) patients (Table 2).

Table 2. Details of patients with radial head fracture treated with open reduction and internal fixation

No	Fracture type	Gender	Age	Mechanism of injury	Fracture/ Dominant s.	Coexisting injuries	Operation time (d)	Fixation material	Follow-up time (m)	Range of movement Flexion/ • Pronation/ Extension (°) • Supination (°)	Result
1	II	Male	42	Fall on the outstretched hand	L/R	Left olec. fr.	6	2.3 mm screws	66	145/-2 • 80/90	Excellent
2	II	Male	32	Fall on the outstretched hand	L/R		5	2.3 mm screws	78	145/-5 • 78/88	Excellent
3	II	Male	18	Fall on the outstretched hand	R/R		7	2.3 mm screws	42	145/5 • 80/90	Excellent
4	III	Female	40	Fall on the outstretched hand	R/R		1	2.3 mm screws	72	145/-5 • 78/90	Excellent
5	III	Female	27	Fall on elbow	R/R		2	2.3 mm screws	52	145/0 • 80/90	Excellent
6	III	Female	31	Fall on elbow	L/R		2	2.3 mm screws	47	145/0 • 78/90	Excellent
7	III	Male	38	Fall on the outstretched hand	R/R		3	2.3 mm screws	59	145/0 • 80/90	Excellent
8	III	Female	26	Fall on the outstretched hand	R/R		3	2.3 mm screws	46	143/-5 • 78/90	Excellent
9	III	Female	28	Fall on the outstretched hand	L/R		3	Multiple K wires	58	142/-10 • 68/87	Good
10	III	Male	40	Fall on elbow	R/R		5	2.3 mm screws	54	143/-10 • 75/86	Good
11	III	Female	39	Fall on elbow	R/R	Right olec. fr.	7	Mini plate + Screws	42	138/-15 • 66/85	Bad (Nonunion)
12	IV	Female	28	Fall on elbow	R/R	Elbow dislocation	2	Mini plate + Screws	42	20/-38 • 15/15	Bad (prosthetic repl.)
13	IV	Female	49	Fall on the outstretched hand	R/R		1	Multiple K wires	52	140/-15 • 70/85	Fair
14	IV	Male	44	Fall on elbow	R/R		1	2.3 mm screws	44	142/-10 • 78/86	Good
15	IV	Male	43	Fall on elbow	L/R		4	Mini plate + Screws	65	142/-10 • 75/86	Good

L: Left; R: Right; K: Kirschner; fr: Fracture; -: Loss of extension.

DISCUSSION

Although excision of the radial head in the treatment of radial head fractures, especially if the fracture is comminuted, has yielded good long-term results, it has some disadvantages. Pain and instability in the wrist, forearm and elbow region due to proximal radial migration and cubitus valgus have been reported to be the most frequently encountered problems.[1-5] Additionally, weakness in those extremities in which the radial head was excised and posttraumatic osteoarthritis in the long-term have also been detected.[1-4] To prevent those short- and long-term problems related to excision of the radial head, some researchers have advised reconstruction of the fractured radial head or its replacement with radial head prosthesis when amenable to open reduction and internal fixation.[9,11-13,18-23]

Although it has been known that prosthetic replacement provided immediate stability and good short-term results in the treatment of radial head fractures, studies with prosthetic replacements have yielded different outcomes with respect to the various types of prosthesis.[18-21] Furthermore, the long-term effects of contact between a metal prosthesis and the capitellar articular cartilage are not known and there are problems related with the size and shape of the implant itself, making the application challenging.[21] Knight et al.[19] performed a study in which they applied primary vitallium prosthesis in 31 patients with comminuted radial head fracture. After a mean follow-up of 4.5 years, they had removed two prostheses because of loosening and found no dislocation in any of their patients. Morrey et al.[20] applied primary silicon prosthesis to 17 patients with radial head fracture. After a mean of 6.7 years follow-up, they had found five implant failures in 11 cases with bad results and had removed four of these loosened prostheses. They recommended not using silicon prosthesis in trauma cases. In addition, it has been shown both clinically and biomechanically that the silicon prosthesis could not withstand valgus stress and axial loading.[20,22,23] Bain et al.,[18] in a study with 16 patients, performed titanium prosthesis, ligament repair and early mobilization. After a mean follow-up period of 2.8 years, they reported 8 excellent, 5 good and 3 fair results. Thus, definitive indications for prosthetic replacement in treating radial head fractures are not clear.

Another treatment option for radial head fracture is open reduction and internal fixation. Although this treatment protocol has given good results in Mason type II fractures, studies with Mason type III and Mason type IV fractures have yielded variable functional outcome.[9,11-17] Mason[17] noted that type II partial articular fractures with more than one fragment were particularly likely to lead to restriction of forearm rotation, and he recommended resection. Ring et al.[15] reported four patients with a partial articular fracture as a part of a complex injury pattern resulting in restricted forearm rotation. They pointed out that only isolated partial articular radial head fractures gave good results. In our study, since we had three patients with isolated Mason type II fracture, the excellent outcome according to Broberg and Morrey criteria can be explained by the fracture being isolated. Ring et al.,[15] in the same study with 30 Mason type II and 26 Mason type III radial head fractures, in which the treatment of choice was open reduction and internal fixation, after a mean follow-up period of 48 months, concluded that open reduction and internal fixation gave good results in Mason type III fractures only when the number of comminuted fragments was three or less. Otherwise, they suggested excision of the radial head with or without prosthetic replacement. Sanders and French[16] performed open reduction and internal fixation in eight patients with comminuted radial head fracture and reported the results of six of them. After a mean follow-up of 12 months, they concluded that open reduction and internal fixation was suitable for comminuted fractures of the radial head. They did not observe radial shortening, loss of range of movement or wrist joint dysfunction in their patients. In this study, we had 3 Mason type II, 8 Mason type III and 4 Mason type IV fractures, in which open reduction and internal fixation was used. After a mean of 32 months follow-up, we had 12 excellent and good, 1 fair and 2 bad results. The fair result was a Mason type IV patient who was a high school teacher. She was operated with multiple Kirschner wires in emergent conditions. In the follow-up period, we observed minor degenerative changes in her elbow radiographs and she complained only of some aching pain while writing on the blackboard. We had two bad results. One was Mason type III fracture accompanied with olecranon fracture. Nonunion of the fracture was seen during the follow-up period. The remaining bad result was a patient with Mason type IV fracture. Implant failure in the early postoperative period was noticed and radial head excision with prosthetic replacement was done. She was sat-

isfied with the result. It seems that Mason type IV fracture of the radial head gives the low functional outcome more often than the other types.

For internal fixation of radial head fractures, various fixation materials, such as Kirschner wires, low-profile mini plates with screws and low profile mini screws have been used, with different clinical outcomes reported.[11,15,16] Ikeda et al.[11] used T-shaped low profile mini plates with screws in 13 Mason type III and IV fractures and reported that they achieved union in all patients. They determined no problem with that fixation material. Ring et al.[15] used 2.0 mm plates with screws, 2.0 mm screws and Kirschner wires in their 56 patients with Mason type II and Mason type III radial head fracture. After follow-up, they reported three implant failures and seven implant failures or plate brake due to nonunion. Sanders and French[16] performed open reduction and internal fixation in eight patients with comminuted radial head fractures and found no problem related to the fixation material. In our study, we used Kirschner wires in 1 Mason type III and 1 Mason type IV, and low profile mini plate with screws in 1 Mason type III and 2 Mason type IV fractures. The rest of the fractures were fixated with low profile 2.3 mm screws. We found one implant failure with mini plate and screws in one case with Mason type III fracture.

Different time intervals between injury and operation have been reported in the literature.[10,11,24] Edwards and Jupiter,[24] in a study with seven displaced radial head fractures, operated three of them in one week and concluded that it was important to do the surgery before loss of soft tissue balance. Ikeda et al.[11] performed open reduction and internal fixation in 10 patients with comminuted radial head fracture in a mean time interval of 10 (7-16) days and reported no unsatisfactory results. Geel and Palmer,[10] in their study with 19 patients treated with open reduction and internal fixation, reported 14 excellent and 5 fair results and recommended early open reduction and internal fixation of all displaced or angulated radial head fractures. In our study, patients were operated in the first week in all cases. Although we had no control group with which to compare the timing of surgery, we agree with Edwards and Jupiter[24] and think that our 12 excellent and good outcomes can be attributed to the early surgery applied in our study.

In conclusion, in view of the complications related with excision of the radial head, problems and obscurity associated with applications of prosthetic replacements, improvements in fixation materials, and the satisfactory clinical outcomes observed in our patients with Mason types II, III and IV radial head fractures treated with open reduction and internal fixation, we suggest this treatment protocol in radial head fractures, even in cases of comminuted fractures.

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