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A new technique for distal forearm fractures: the external radius fixator

Distal önkol kırıklarında yeni bir teknik: Eksternal radius fiksatörü

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In fractures of the distal forearm of type B3-C2-C3 according to the Müller classification, besides adaptation wire fixation we use an external fixator as an absolute indication. Ligamentotaxis is the basic principle of the therapy and the results of this treatment are well-known. Herein, a new external fixation technique, "radius fixator", is described whereby adequate stability can be achieved with adaptation wires even without ligamentotaxis. After reduction, two K-wires of 2-mm thread are used for stabilization. The surgical approach begins above the styloid process of the radius and ends on the ulnar cortical surface of the radius proximal to the fracture. The two K-wires make an angle of 30 to 40 degrees in both planes. The next step is the insertion of Schanz screws, 3 mm in diameter, into the radius at an angle of 60-90 degrees to one another in the radial and dorsal directions and in a rectangular position to the longitudinal axis of the radius. The K-wires and Schanz screws are connected with rods, 4 mm in diameter, in longitudinal, parallel or crossed position. Using this technique, we treated 45 patients with fractures of type A3-B2-B3-C1 according to the Müller classification. Radiographic and functional results were good-fair in 89% and 94%, respectively. The reconstruction of the skeleton and its stabilization with K-wires and Schanz screws, rods, and clamps is appropriate. The carpal joint is not immobilized by the external radius fixator, and its function will not be compromised during a 6-week fixation.

Key words: Equipment design; external fixators; fracture fixation/instrumentation; fractures, comminuted/surgery; radius fractures/surgery/radiography; wrist injuries.

Müller sınıflamasına göre tip B3-C2-C3 distal önkol kırıklarında, tel fiksasyonu ile adaptasyon yanı sıra, kesin endikasyon olarak eksternal fiksatör kullanıyoruz. Ligamentotaksis bu tedavinin temel prensibidir ve bu tedavinin sonuçları iyi bilinmektedir. Bu yazıda, ligamentotaksis olmaksızın, adaptasyon telleri ile yeterli stabilitenin sağlanabildiği yeni bir eksternal tespit tekniği (radius fiksatörü) sunuldu. Redüksiyon sonrasında, stabilizasyon için kalınlığı 2 mm olan iki adet K-teli kullanılır. Cerrahi yaklaşım, radiusin stiloid ucunun yukarısından başlar ve kırık proksimalinde, radiusun ulnar kortikal yüzeyinde sonlanır. İki adet K-teli her iki planda 30-40 derecelik bir açı yapar. Sonraki aşamada, 3 mm çapında Schanz vidaları, birbirlerine 60-90 derecelik açı yapacak şekilde, radial ve dorsal yönlerde ve radiusun longitudinal eksenine dik olacak şekilde yerleştirilir. K-telleri ve Schanz vidaları, çapı 4 mm olan çubuklarla, paralel veya çapraz pozisyonda birleştirilir. Bu tekniği kullanarak, Müller sınıflamasına göre tip A3-B2-B3-C1 kırığı olan 45 hastayı tedavi ettik. Radyografik ve fonksiyonel sonuçlar sırasıyla hastaların %89 ve %94'ünde iyi-orta düzeyde bulundu. Bu yolla iskelet rekonstrüksiyonu ve K-telleri, Schanz vidaları, çubuk ve klemplerle stabilizasyon uygun bir teknik olarak görünmektedir. Bu şekilde, altı haftalık tespit sırasında karpal eklem hareketi eksternal radius fiksatörü tarafından engellenmemekte ve fonksiyonu tehlikeye atılmamaktadır.

Anahtar sözcükler: Ekipman tasarımı; eksternal fiksatör; kırık tespiti/enstrümantasyon; kırık, parçalı/cerrahi; radius kırığı/cerrahi/radyografi; el bileği yaralanması.

Intra-articular fractures of the distal radius usually requires operative treatment with percutaneous K-wire or screw fixation, open reduction and internal fixation (ORIF) with dorsal or volar plate, or external fixator. According to the Müller AO classification, there are definite patterns for the treatment.[1-4] Lately, plates and locking screws with angular stability have been available in a wide range of designs to enhance

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stability. Angular stability is resolved in many ways using distributors. It is possible to change the angle of drilling without loosing angular stability. Every method has advantages and disadvantages. Indirect reduction techniques do not preclude the use of adjuvant forms of immobilization such as cast or external fixator. Open reduction allows exact anatomical repositioning, but the rates of neurovascular destruction and septic complication are higher.

In case of open reduction and plate fixation additional external fixation is unnecessary. Although early functional treatment has a good outcome, this technique has the risk for infections and neurovascular complications.

The use of an external fixator

In order to prevent redisplacement of tiny fragments, open reduction is not sufficient for comminuted intra-articular fractures. For the treatment type C2-C3 fractures, ligament taxis is used as a principle of therapy. The fragments are reduced and the articular surface is reconstructed with a distracting force exerted on the joint capsule and ligaments. According to the Müller classification, the use of an external fixator is an absolute indication for the operative treatment of distal forearm fractures of types B3-C2-C3, including adaptation with K-wires. The external fixator protects against the typical redisplacement, namely dorsal tilting and radial deviation. The conventional wrist montage is characterized by volar flexion and ulnar duction. In this position, the second metacarpal bone is situated in the longitudinal axis of the radius (Fig. 1, 2). The elements of the montage include 3-mm Schanz screws, an angled 5-mm rod, and a 3 to 5-mm MC fixation clamp. Insertion sites (surgical approaches) of the montage can be as follows: radial subcapital surface of the second metacarpal bone, dorsal surface above the basis of the second metacarpal bone, medial surface of the radius proximal to the fracture, and dorsal surface of the radius distal to the fracture.

Immobilization of the radiocarpal joint for 6 to 8 weeks by the external fixator may cause significant functional damage.

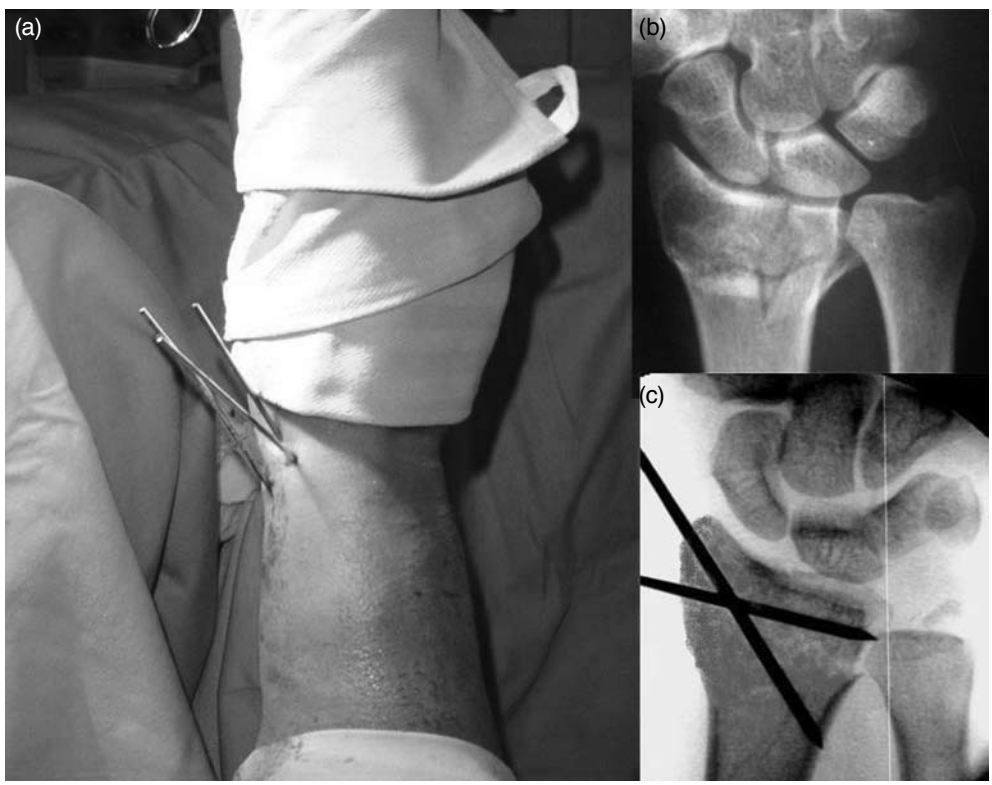


Fig. 1. (a) Adaptation: K-wires used as external fixator pins, inserted into the distal fragment and enclosing an open angle in both planes. **(b)** Primary X-ray: distal, intraarticular radius fracture. **(c)** Adaptational osteosynthesis after reduction, threaded K-wire inserted into the distal fragment.

Fig. 2. (a) Connecting the distal pins with a rod to each other and to the Schanz screw in the proximal fragment. **(b)** Fixing the fracture in reduced position with the radius fixator.

A new method for external fixation: radius fixator

In order to prevent redisplacement, operative treatment is recommended for fractures with articular involvement and for extra-articular fractures with metaphyseal comminution.[5-12]

Our new method for external fixation is based on our concept that two points must be intact for satisfactory stabilization: *(i)* styloid process of the radius, *(ii)* the ulnar corticalis of the radius, proximal to the metaphysis. These two points are connected with a K-wire, which is stabilized with an external fixator, providing angular stability. Additional instability caused by the proximal bony defect is stabilized with a Schanz screw inserted into the radius proximal to the fracture.

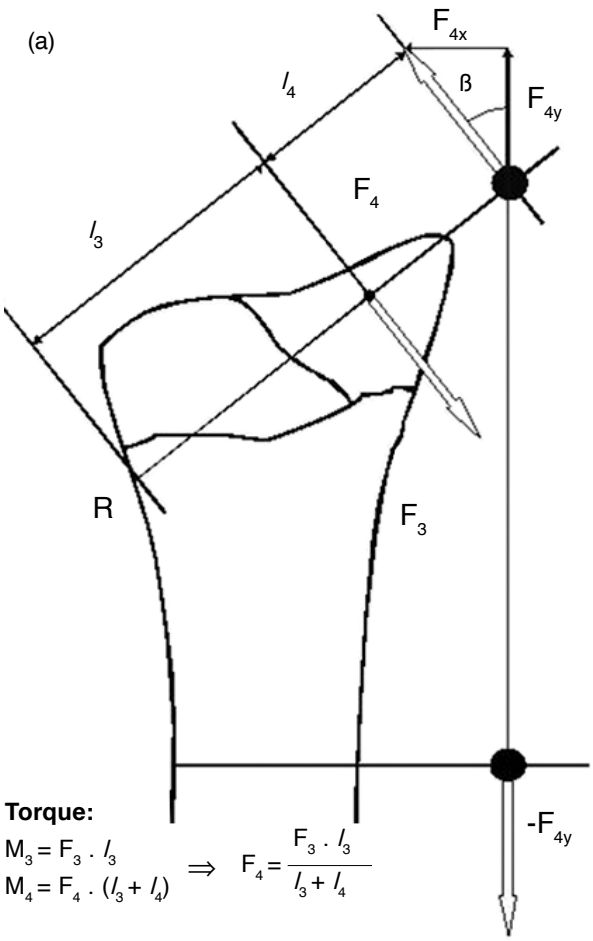
In this technique, pins inserted into the radius are connected with two 4-mm rods placed in parallel or crossed fashion.

The basic concepts of the "radius fixator" is completely different.

1. "Osteotaxis" instead of ligament taxis.
2. Threaded K-wires are the pins of the external fixator.
3. Wire positioned in an angulated manner in all plains.
4. Crossed rods connected with each other providing angular and rotational stability.
5. Free movement of the radiocarpal joint.
6. Simple technique.

Biomechanical considerations

The conservative casting and external fixator use ligament taxis to protect the fragments against typical redisplacement, dorsal and radial tilting. Manual reduction techniques with cast fixation require the application of force in the opposite direction of the force that produced the injury. The carpal bones are adjusted to an overcorrected position causing reduction and retention of the distal fragment by the carporadial ligaments.[13] In external fixator application, the second metacarpal bone is situated in the longitudinal axis of the radius causing the reduction of the distal fragment because of the overcorrection. Both techniques produce permanent traction of the ligaments that contribute to functional deficit.[14] The question is how to preserve sufficient radiocarpal joint function using a minimally invasive operation technique.



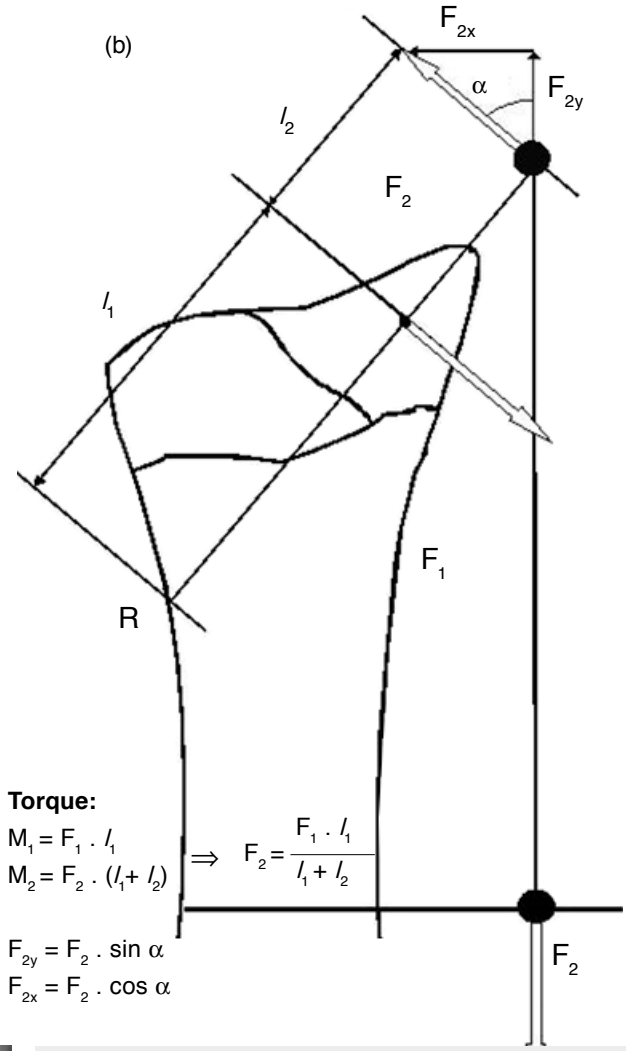
Torque:

$M_3 = F_3 \cdot l_3$

$M_4 = F_4 \cdot (l_3 + l_4) \Rightarrow F_4 = \frac{F_3 \cdot l_3}{l_3 + l_4}$

$F_{4y} = F_4 \cdot \sin ß$

$F_{4x} = F_4 \cdot \cos ß$



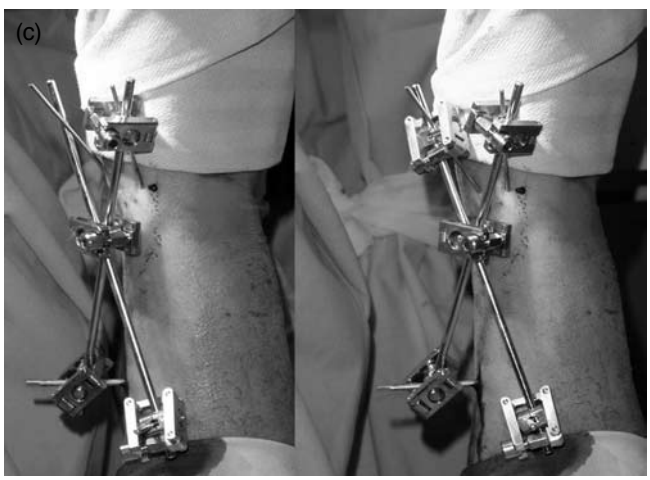
Torque:

$M_1 = F_1 \cdot l_1$

$M_2 = F_2 \cdot (l_1 + l_2) \Rightarrow F_2 = \frac{F_1 \cdot l_1}{l_1 + l_2}$

$F_{2y} = F_2 \cdot \sin \alpha$

$F_{2x} = F_2 \cdot \cos \alpha$



Steps

1. Using a traction force of 5-6 kp-s. – reduction - restoration of the joint surface and stabilization with K-wires in a closed manner (Fig. 3a, b).
2. Insertion of the distal fixator pin in an angulated position in both plains. Insertion of the proximal fixator pin into the radius in two different plains.
3. The pins are connected with rods in crossed position. The “radius fixator” montage is stable both in rotation and angulation.
4. Insertion of the proximal fixator pin into the radius in two different plains (Fig. 3c).

Fig. 3. (a) Relation of the level arms: Rod of the fixator – styloid process of the radius – proximal metaphysis. **(b)** Relation between level arms and K-wires: open angle in both planes. **(c)** Insertion of the second Schanz screw and the complete montage: a biplane system providing rotational and angular stability.

If the distal fragment is reduced in a percutaneous manner without any traction of the ligaments, the functional deficit would be minimized.

On the other hand, anatomical reduction and retention of the bone by K-wires, Schanz screw, rods, and clamps, namely the “radius fixator”,

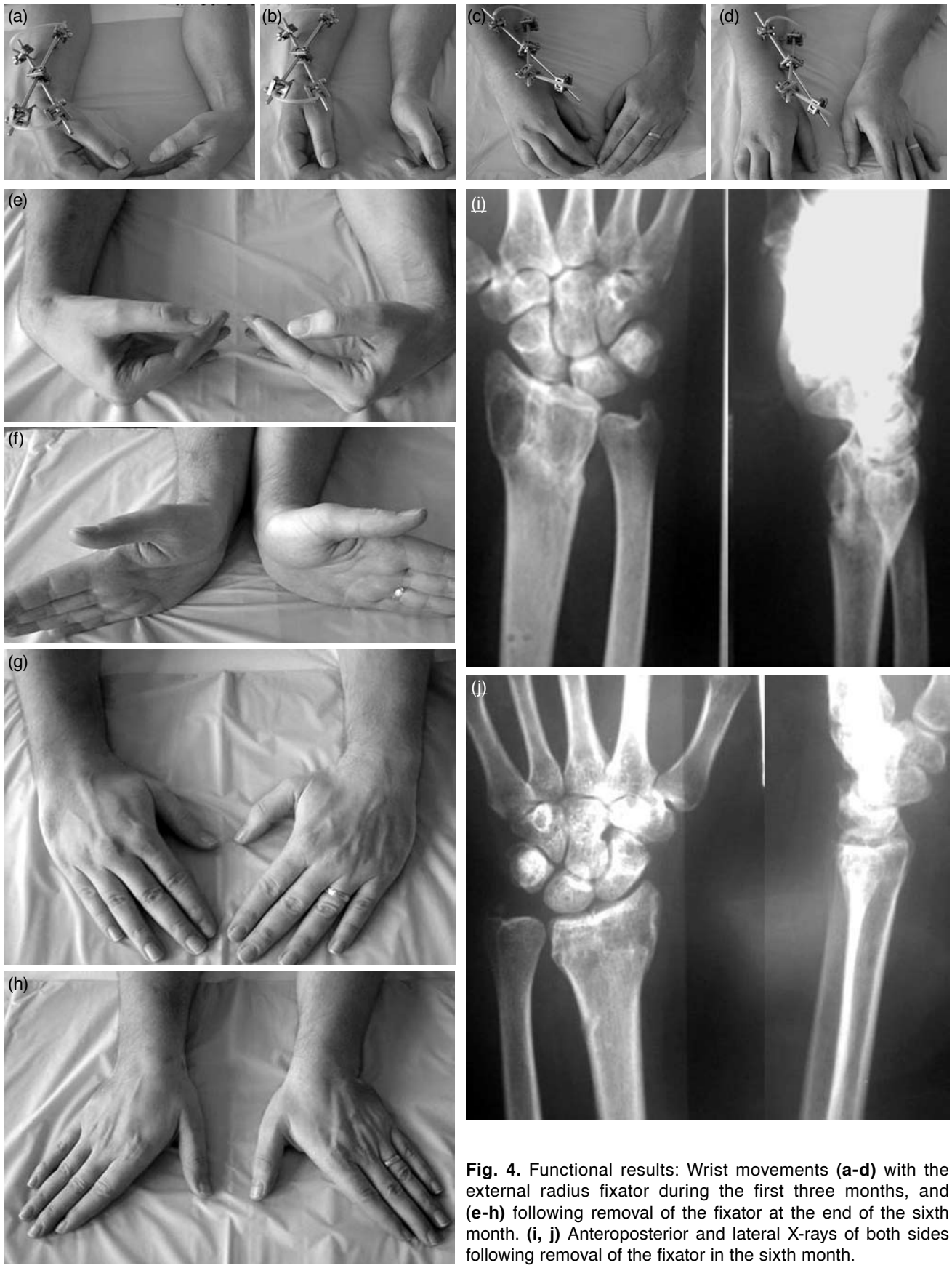


Fig. 4. Functional results: Wrist movements **(a-d)** with the external radius fixator during the first three months, and **(e-h)** following removal of the fixator at the end of the sixth month. **(i, j)** Anteroposterior and lateral X-rays of both sides following removal of the fixator in the sixth month.

TABLE I

Radiographic scoring

Score	Dorsal angle	Radial abbreviation	Radial angle	Radial displacement	Joint incongruence
0	<0	0	> 20	0	0
1	0-20	0-2	10-20	1-2	1-2
2	>20	>2	<10	>2	>2

TABLE II

Functional scoring

Score	Dorsal extension	Volar flexion	Radial duction	Ulnar duction	Sudeck's dystrophy
0	>20	>20	>20	>20	No
1	10-20	10-20	10-20	10-20	Middle
2	<10	<10	<10	<10	Hard

TABLE III

Radiographic and functional results

Result	No. of patients	%
Radiographic		
Good	30	67
Fair	10	22
Poor	5	11
Functional		
Good	34	76
Fair	9	20
Poor	2	4

allows free movements of the radiocarpal joints producing good functional outcome after a six-week immobilization. Thus, fractures of type A3-B2-B3-C1 according to the Müller classification can be treated using this technique.

Operation technique

The first step is the reduction of the fracture in a conventional way exerting a traction force. The surgical approach begins above the styloid process of the radius and ends on the ulnar cortical surface of the radius proximal to the fracture. Two K-wires make an angle of 30 to 40 degrees in both planes. If additional adaptation is necessary, more K-wires can be used parallel to the articular surface.

The next step is the insertion of Schanz screws, 3 mm in diameter, into the radius in an angle of 60-90 degrees to one another in the radial and dorsal directions and in a rectangular position to the longitudinal axis of the radius.

The 2-mm K-wires and 3-mm Schanz screws are connected with rods, 4 mm in diameter, in longitudinal, parallel or crossed position.

We treated 45 patients with fractures of type A3-B2-B3-C1 according to the Müller classification. Radiographic and functional follow-up examinations were performed and the severity of redisplacement was evaluated.

Functional and radiographic evaluations were made at the end of the sixth month (Table I, II). The results of this treatment were satisfactory. Radiographic and functional results were good-fair in 89% and 96%, respectively (Tables I-III, Fig. 4a-j).

Conclusion

The reconstruction of the skeleton and its stabilization with K-wires and Schanz screws, rods, and clamps is appropriate. The carpal joint is not immobilized by the external radius fixator, and its function will not be compromised during a 6-week fixation.

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