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Functional and radiological outcomes of multiple dorsal carpometacarpal fracture dislocations treated with open reduction and internal fixation

Açık redüksiyon ve internal fiksasyonla tedavi edilen çoklu dorsal karpometakarpal kırıklı çıkıkların fonksiyonel ve radyolojik sonuçları

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ABSTRACT

Objectives: This study aims to evaluate the clinical and radiological results of patients with multiple dorsal carpometacarpal (CMC) joint fracture dislocations treated with open reduction and internal fixation (ORIF).

Patients and methods: We evaluated 14 patients (12 males, 2 females; mean age 35.1 years; range, 22 to 64 years) between January 2013 and December 2017. Our main outcome measurements were the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) score, loss of grip strength, limitation of range of motion (ROM), and Kellgren-Lawrence osteoarthritis classification identified with radiographs and computed tomography images.

Results: The mean QuickDASH scores at seventh week and third month were 73.57 (range, 65-90) and 29.11 (range, 25-42.5), respectively. The mean QuickDASH score at seventh, ninth, and 12th month, and final follow-up was 4.64 (range, 0-30) and the QuickDASH score at these follow-up points was not 0 for only three patients. The mean loss of grip strength was 32.14% and two patients (14.29%) had limitation of ROM in third proximal interphalangeal joint at final follow-up. Four patients had grade I, nine patients had grade II, and one patient had grade III osteoarthritis according to Kellgren-Lawrence classification at final follow-up.

Conclusion: Although functional results demonstrated that multiple CMC joint fracture dislocations can be treated with ORIF, the high rate of osteoarthritis is a disadvantage.

Keywords: Carpometacarpal fracture dislocations, grip strength, internal fixation, Quick Disabilities of the Arm, Shoulder, and Hand questionnairee.

ÖZ

Amaç: Bu çalışmada açık redüksiyon ve internal fiksasyon (ARİF) ile tedavi edilen çoklu dorsal karpometakarpal (KMK) eklem kırıklı çıkığı olan hastaların klinik ve radyolojik sonuçları değerlendirildi.

Hastalar ve yöntemler: Ocak 2013-Aralık 2017 tarihleri arasında 14 hasta (12 erkek, 2 kadın; ortalama yaş 35.1 yıl; dağılım, 22-64 yıl) değerlendirildi. Başlıca sonuç ölçümlerimiz Hızlı Kol, Omuz ve El sorunları (QuickDASH) skoru, kavrama gücü kaybı, eklem hareket aralığı (EHA)'nda kısıtlılık ve radyografiler ve bilgisayarlı tomografi görüntüleri ile tanımlanan Kellgren-Lawrence osteoartrit sınıflandırması idi.

Bulgular: Yedinci haftada ve üçüncü ayda ortalama QuickDASH skorları sırasıyla 73.57 (dağılım, 65-90) ve 29.11 (dağılım, 25-42.5) idi. Yedinci, dokuzuncu ve 12. aydaki ve son takipteki ortalama QuickDASH skoru 4.64 (dağılım, 0-30) idi ve bu takip dönemlerinde QuickDASH skoru 0 olmayan sadece üç hasta vardı. Son takipte ortalama kavrama gücü kaybı %32.14 idi ve iki hastada (%14.29) üçüncü proksimal interfalangeal EHA'da kısıtlılık vardı. Son takipte Kellgren-Lawrence sınıflandırmasına göre dört hastada evre I, dokuz hastada evre II ve bir hastada evre III osteoartrit vardı.

Sonuç: Fonksiyonel sonuçlar, çoklu KMK eklem kırıklı çıkıkların ARİF ile tedavi edilebileceğini göstermesine rağmen, yüksek osteoartrit oranı bir dezavantajdır.

Anahtar sözcükler: Karpometakarpal kırıklı çıkıklar, kavrama gücü, internal fiksasyon, Hızlı Kol, Omuz ve El sorunları anketi.

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Carpometacarpal (CMC) joint stability is provided by locked saddle-shaped joint structure, strong ligaments (dorsal, volar, intermetacarpal), and extrinsic and intrinsic muscles. Life-threatening high-energy trauma is required for the injury of CMC joint.[1,2] The fourth and fifth CMC joints on the ulnar side are more mobile than the radial second and third CMC joints. For this reason, ulnar side injuries are easier. The third CMC joint articulates with proximal capitatum. This articulation acts as keystone. Therefore, the other joints are restored after this joint is first reduced.[3]

Multiple CMC fracture dislocations usually occur after high-energy trauma because of the concave structural stabilization, multiple joint configuration, strong ligaments, and capsules and muscles. Less than 1% of the injuries affecting the hand and wrist are multiple fracture dislocations of the CMC joint.[4] Because of the strong ligamentous attachments to the carpal bones, multiple fracture dislocation of the CMC joint usually occurs together with avulsion and impaction fractures.[5] Dorsal dislocations are more common than volar dislocations.[6] Direct traumas forcing metacarpals to hyperflexion cause CMC joint dislocation.[4,6]

In the presence of severe swelling, pain, deformity, ecchymosis, and abrasion of the hand, multiple CMC fracture dislocations should be suspected. Severe swelling can cause compartment syndrome. Neurovascular examination should be assessed as much as possible because the ulnar nerve may be damaged.[7] Due to complex structure of the CMC joints, diagnosis can be easily skipped in the X-ray, particularly because of the overlapping bones.[8] If multiple CMC joint fracture dislocations are missed, it may result in reduced grip strength.[8] These injuries, which are mostly reported as case reports in the literature, are usually dorsally dislocated. In this study, we aimed to evaluate the clinical and radiological results of patients with multiple dorsal CMC joint fracture dislocations treated with open reduction and internal fixation (ORIF).

PATIENTS AND METHODS

We retrospectively evaluated 14 patients (12 males, 2 females; mean age 35.1 years; range, 22 to 64 years) diagnosed with multiple CMC joint fracture dislocations in clinical and radiological terms at University of Health Sciences, Şişli Hamidiye Etfal Training and Research Hospital between January 2013 and December 2017. Patients with complete dislocation of the second, third, fourth, and fifth CMC joints were included in the study (Figure 1). All patients were diagnosed radiographically by preoperative anteroposterior, lateral, and oblique X-rays and computed tomography (CT) scans. Our inclusion and exclusion criteria were presented in Table I. All patients were surgically treated by ORIF with Kirschner wires under general anesthesia within 24-48 hours by the same surgeon (Figures 2 and 3). Permanent implants were not used in any patient. Postoperative three-dimensional X-rays and CT scans were performed. Patients were followed-up once weekly for six weeks with a short splint allowing finger movements. At the end of six weeks, Kirschner wires were removed and physical therapy and rehabilitation were started at six weeks (Figure 4). The study protocol was approved by the University

Figure 1. Preoperative anteroposterior, oblique, and lateral X-ray images.

TABLE I
Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Age ≥18 and <65 years	Less than 4 fracture dislocations of carpometacarpal joints
Complete dislocation of the carpometacarpal joints	Volar dislocation
	Conservative treatments
	Closed reduction and internal fixation
	Primary arthrodesis
	Ipsilateral shoulder, elbow, or wrist injuries
	Previous hand arthrosis
	Cognitive impairment
	Follow-up less than 12 months

of Health Sciences, Şişli Hamidiye Etfal Training and Research Hospital Ethics Committee. A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patients were evaluated in terms of age, gender, sides, dominant hand, injury mechanism, and whether the fracture was open or closed. Other limb and organ injuries caused by high-energy trauma were also studied.

The Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) scoring system was used for all patients at seventh week, third, sixth, ninth, and 12th months, and final follow-up. The range of motion (ROM) of the joints of the fingers, hands and wrist, and grip strengths were measured using a Jamar® Hydraulic Hand Dynamometer (Sammons Preston, Bolingbrook, Illinois, USA) in comparison with the healthy side. The presence of activity-induced pain, cold intolerance, job changes, and CT images were evaluated only at final follow-up since these assessment criteria were considered to be not significant at final follow-up. However, QuickDASH results should be monitored in the first year in addition to the final follow-up. Radiographs and CT images were acquired for detecting joint degeneration and subluxation. Kellgren-Lawrence classification system[9] was used for joint degeneration (Table II).

For fixation, patients were positioned supine on the operation table. Povidone-iodine or chlorhexidine was used for the sterile preparation of the injured limb prior to performing the procedure. Tourniquet was used and approximately 3 cm longitudinal incisions were performed between the second-third and fourth-fifth metacarpal bones. Intraarticular fragments and soft tissues in the CMC joints were removed. Subsequently, osteosynthesis was

Figure 2. Intraoperative incisions during open reduction and internal fixation.

Figure 3. Early postoperative anteroposterior and lateral X-ray images.

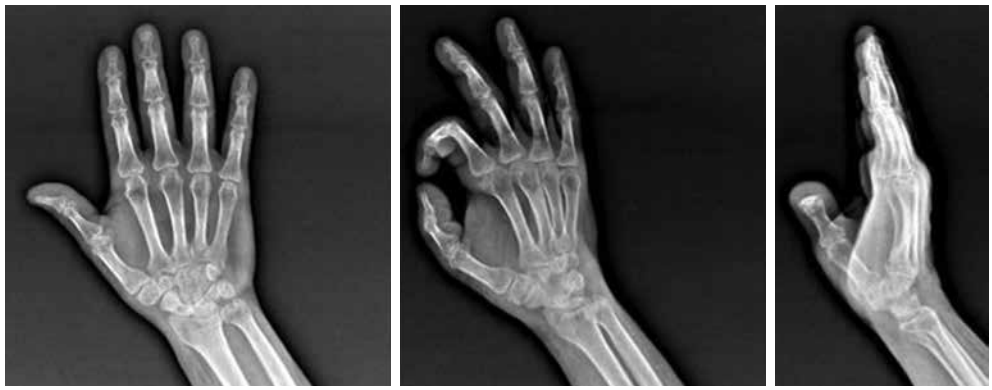

Figure 4. Postoperative sixth week anteroposterior, oblique, and lateral X-ray images after removal of Kirschner wires.

performed with the help of Kirschner wires, which were applied intramedullary starting from distal end of the metacarpal bones, passed through CMC joints, and reached carpal bones. Fracture reduction and Kirschner wires positioning were assessed by fluoroscopy. A drain was not used and incisions were closed. Kirschner wires were left above the skin. All patients were treated with short arm splints after surgery.

A single dose of first generation cephalosporin (cefazolin sodium) (1 g) prophylaxis was administered prior to surgery in all patients; four additional doses of cephalosporin were administered postoperatively.

RESULTS

Two patients had open multiple CMC joint fracture dislocations. There were no patients with bilateral multiple CMC joint fracture dislocations. Four patients had vertebral fracture requiring surgery, four patients had head trauma, two patients had tendon injuries, one patient had a cuboidal fracture of the right foot, and one patient had left radial head fracture. Two patients had an isolated CMC joint injury. The mean follow-up period and other preoperative properties of our patients were shown in Table III.

The mean QuickDASH scores at seventh week and third month were 73.57 (range, 65-90) and 29.11 (range, 25-42.5). At 12th month and final follow-up, the patient with QuickDASH score 30 had a concomitant extensor tendon laceration and the patient with QuickDASH score 25 had a concomitant third finger proximal interphalangeal (PIP) joint fracture. Other QuickDASH results of all patients at follow-ups were listed in Table IV.

At the end of the follow-up period, adduction was weak in the index finger due to first palmar interosseous muscle weakness in one patient as a complication. In another patient, the fifth palmar adduction weakness was observed due to the third palmar interosseous muscle weakness. Of all 14 patients, nine patients had grade II osteoarthrosis according to Kellgren-Lawrence classification system (Figure 5). Other final follow-up clinical and radiological parameters were demonstrated in Table V.

DISCUSSION

Carpometacarpal joints have the overlapping joint structure. For this reason, direct X-ray can be inadequate as a method of imaging, diagnosis can be missed, and it can cause disability. Computed

TABLE II

Kellgren-Lawrence grading system[9]

Grade	Description
I	Doubtful narrowing of the joint space, possible osteophytic lipping
II	Definite osteophytes, possible narrowing of the joint space
III	Moderate multiple osteophytes, definite joint space narrowing, some sclerosis, possible deformity of bone ends
IV	Large osteophytes, marked joint space narrowing, severe sclerosis and definite bony and deformity

TABLE III

Preoperative properties and follow-up period of patients

Variable	n	Means	Min-Max
Age (year)		35.1	22-64
Gender			
Male	12		
Female	2		
Affected side			
Right	5		
Left	9		
Hand			
Dominant	6		
Non-dominant	8		
Mechanism of trauma			
Motor vehicle accident	7		
High level fall	5		
Sports injury	2		
Length of hospital stay (days)		4.14	3-6
Follow-up period (months)		23.85	12-60

Min-Minimum; Max: Maximum.

tomography should be used preoperatively with X-rays. Henderson and Arafa[8] reported that they had skipped CMC joint dislocations in 15 of 21 patients they studied. Lawlis and Gunther[10] observed a decrease in grip strength, an increase in protrusion and arthritis in the hand caused by delayed diagnosis of CMC dislocations. All patients were diagnosed radiographically by preoperative anteroposterior, lateral, and oblique X-rays and CT scans in our study. All patients were operated within 24-48 hours. Postoperative three-dimensional X-rays and CT were performed. There was no case of misdiagnosis in our series.

There is no consensus on the treatment of multiple CMC joint fracture dislocations. Most of the publications in the literature are case reports. Treatment modalities include closed reduction and casting, closed reduction with percutaneous pinning, open reduction and casting, ORIF, and joint arthrodesis.[11-15] It was reported that closed reduction and casting or percutaneous fixation resulted in subluxation.[14,16] Soft tissues, such as muscles and ligaments, which can be interposed between the joints and bone fragments that are avulsed from the metacarpal base, were accused of closed reduction failure. To our knowledge, there is no study in the literature comparing primary arthrodesis and internal fixation. Although Hanel[15] recommended primary fusion, their study included only five patients. Currently, open reduction internal fixation is recommended in the treatment of multiple CMC joint fracture dislocations.[17-19] The most important advantages of open reduction are decreased risk of tendon injury, decreased risk of compartment syndrome due to local hematoma drainage, prevention of reduction failure, and easy removal of soft tissues between fractures and joint surfaces.

Mueller[12] reported limited ROM in two of five patients, while Garcia-Elias et al.[17] reported no limited ROM. Vaksvik et al.[20] demonstrated that approximately two thirds of hand trauma patients

TABLE IV

Quick Disabilities of the Arm, Shoulder and Hand questionnaire scores

Patient no	7th week	3rd month	6th month	9th month	12th month	Final follow-up
1	80	35	0	0	0	0
2	90	42.5	30	30	30	30
3	80	27.5	0	0	0	0
4	67.5	25	0	0	0	0
5	67.5	30	0	0	0	0
6	65	30	0	0	0	0
7	72.5	27.5	0	0	0	0
8	87.5	40	25	25	25	25
9	65	25	0	0	0	0
10	70	20	0	0	0	0
11	72.5	30	0	0	0	0
12	72.5	30	10	10	10	10
13	67.5	20	0	0	0	0
14	72.5	25	0	0	0	0

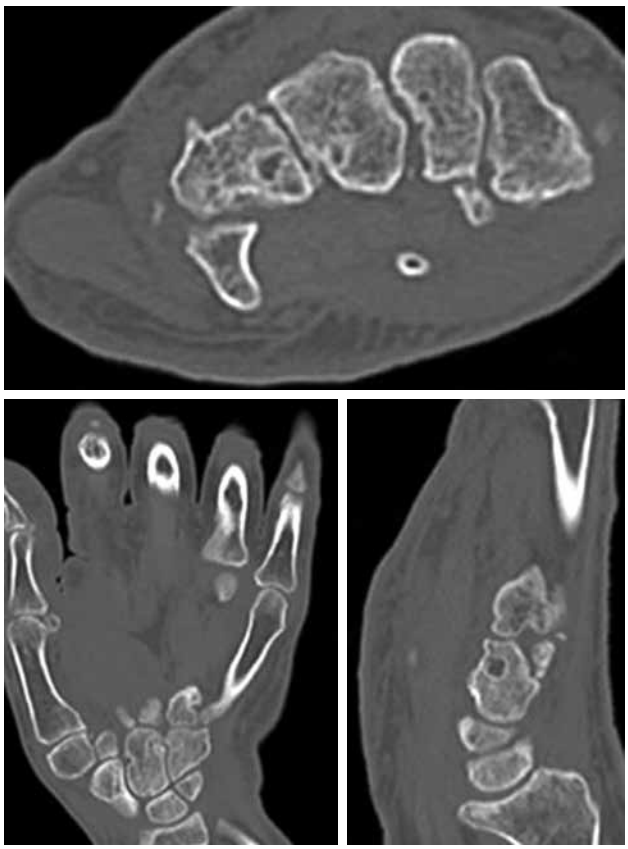

Figure 5. Final follow-up axial **(a)**, coronal **(b)**, and sagittal **(c)** computed tomography images that demonstrated grade II osteoarthritis according to Kellgren-Lawrence classification system.

had cold intolerance in the first three years. However, we found that two patients had limited ROM and all of our patients had cold intolerance.

All of our patients underwent open anatomic reduction, fixation with Kirschner wires, and joint debridement. In our series, 12 of the 14 patients returned to their jobs. In the remaining two patients, poor results were obtained in one patient due to tendon injury and bone loss in the distal part of the fifth metacarpal; whereas in the other patient, spontaneous arthrodesis developed due to the third PIP joint fracture. Because of these reasons, they could not be rehabilitated in the early period, resulting in poor grip strength and restricted ROM. These patients could not return to their jobs. Rehabilitation becomes difficult when there are different injuries on the same extremity.[6] Adduction was weak in the index finger due to first palmar interosseous muscle weakness in a patient as a complication. In another patient, the fifth palmar adduction weakness developed due to the third palmar interosseous muscle weakness. This might be caused by the damage of the ulnar nerve motor branches during trauma at various levels and is not related with the surgical technique. To our knowledge, the largest study in the literature was Prokuski's study that included 10 patients,[6] in comparison to our study on 14 patients.

The presence of high-energy traumas affecting such stable joints suggests that there may be an increase in joint degeneration in long-term follow-up, although no obvious arthrosis was detected in our series.

The limitations of this study are its retrospective design, lack of a control group, and limited number of patients.

In conclusion, although functional results demonstrated that multiple CMC joint fracture dislocations can be treated with ORIF, the high rate of osteoarthritis is a disadvantage. We think that comparative studies should be performed in wider

TABLE V

Final follow-up clinical and radiological parameters (n=14)

Variable	n	Means	Min-Max
Loss of grip strength percentage		32.14	0-53
Increased pain with activity		2	14.29
Limitation of range of motion		2	14.29
Cold intolerance		14	100
Job change		2	14.29
Osteoarthritis	14	100	
Kellgren-Lawrence grade I	4	28.57	
Kellgren-Lawrence grade II	9	64.29	
Kellgren-Lawrence grade III	1	7.14	
Kellgren-Lawrence grade IV	0	0	

Min-Minimum; Max: Maximum.

series regarding the treatment methods of multiple CMC joint fracture dislocations.

Declaration of conflicting interests

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