ORIGINAL ARTICLE

Does simultaneous comminuted fracture of both radial ends represent a distinct fracture pattern?

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ABSTRACT

BACKGROUND: Although isolated distal radius and radial head fractures are common injuries, simultaneous ipsilateral fractures are uncommon. They can range from simple undisplaced fractures at either end to severely comminuted ipsilateral proximal and distal radial fractures. Few cases have been reported with concomitant comminuted distal radius and radial head fractures, and no treatment guidelines are available. Decisions are often based on personal recommendations. The purpose of our study is to increase awareness of this injury pattern and to discuss the mechanism of injury, treatment approach, and functional outcome.

METHODS: Skeletally mature patients with comminuted simultaneous ipsilateral fractures of the distal and proximal radius from 2016 to 2021 were identified and studied retrospectively. Demographic information, mechanism of injury, treatment approach, and complication rate were analyzed. Radiographic assessment for inadequacy or loss of reduction and radiographic parameters of the distal radius, including radial inclination, radial length, and palmar inclination, was performed immediately postoperatively and at the final follow-up. Clinical outcomes were determined by calculating the Visual Analog Scale (VAS) score, measuring the range of motion in both joints, and using the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) score at the final follow-up.

RESULTS: A total of 11 patients met the inclusion criteria. All had ipsilateral Mason III radial head fractures and type C (according to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification) intra-articular distal radius fracture. On-table radial head reconstruction and fixation with a proximal radius plate were used for radial head fractures, and osteosynthesis with an anatomic volar locking plate was used for distal radius fractures. The mean follow-up duration was 32 months (range 12-65 months). At the final follow-up, osseous union of both the radial head and distal radius was observed in all patients. The mean VAS score was 1.5 (range 0-7) at rest and 3.9 (range 0-9) with activities, while the mean QuickDASH score was 32 (range 12-65). No significant complications were recorded.

CONCLUSION: Simultaneous comminuted fractures of the ipsilateral distal radius and radial head represent a distinct injury pattern, most likely resulting from high-energy trauma, such as falling from a height onto an outstretched hand. Greater emphasis should be placed on clinical examination and radiological imaging of the elbow in cases of wrist injuries and vice versa. Treatment involving on-table reconstruction of the radial head and open reduction and internal fixation with a volar plate can lead to good radiological and functional outcomes.

Keywords: Concurrent; distal radius fracture; ex situ reconstruction; ipsilateral; on-table reconstruction; radius head.

INTRODUCTION

Distal radius fractures are the most common fractures of the upper limb.[1] They show a bimodal age and sex distribution, with low-energy fractures seen in elderly women and more comminuted, high-energy fractures seen in younger men.[2,3] Similarly, radial head fractures are regarded as the most common traumatic fractures of the elbow, constituting about one-third of them.[4] Radial head injuries range from low-energy non-displaced fractures to high-energy, severely comminuted fractures with different degrees of elbow instability. Despite the high incidence of both fractures individually, simultaneous

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ipsilateral traumatic fractures of them are uncommon. Such injuries have also been defined as radius bipolar fractures.[5] They can vary from simple undisplaced fractures at either end to severely comminuted ipsilateral proximal and distal radial fractures.[6] This type of injury was first described by Nagaya,[7] since then, only a few cases have been reported in the literature, with unknown incidence rates.

In cases of concomitant comminuted distal radius and radial head fractures, no treatment guidelines are available, and decisions are often based on personal recommendations.[5] A wide range of treatments has been applied, varying from bone graft and external fixation of the distal radius with screw fixation for the radial head fracture,[7] to open reduction and internal fixation (ORIF) of the distal radius fracture and replacement arthroplasty for the radial head fracture,[5] depending on the fracture pattern and associated ligamentous and bony injuries.

The purpose of our study is to highlight the simultaneous comminuted fractures of the ipsilateral distal radius and radial head, and to discuss the mechanism of injury, treatment approach, surgical technique, radiological healing rate, and functional outcomes.

MATERIALS AND METHODS

Following approval by the local ethical committee, medical records of skeletally mature patients with distal radius fractures from 2016 to 2021 were reviewed retrospectively. Patients with concomitant ipsilateral fractures of the proximal radius were identified and included in the study. The inclusion criteria were: (1) concurrent distal radius and radial head fractures; (2) uninterrupted treatment, regular follow-up intervals, and accessible medical records; and (3) a minimum of twelve months of postoperative follow-up. Patients with any other concomitant osseous or ligamentous injury of the affected extremity, and those with open epiphyses, were excluded from the study.

All patients were initially diagnosed in the emergency department using conventional X-rays, followed by a Computed Tomography scan for better visualization and surgical planning. Magnetic Resonance Imaging was not indicated for any of the patients. Ligament injury and instability were assessed perioperatively by physical examination and stress fluoroscopic testing under general anesthesia.

Demographic information, mechanism of injury, treatment approach, and complication rate were analyzed. Osseous union, loss of reduction, heterotopic ossification, radial head avascular necrosis, and signs of posttraumatic osteoarthritis were assessed through postoperative radiological follow-up. Clinical outcomes were determined by calculating the Visual Analog Scale (VAS) score, measuring the range of motion in both joints, and using the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) score at the final follow-up. Medical records search yielded a total of 942 adult patients with distal radius fractures. Of these, 14 patients had ipsilateral distal radius and radial head fractures; however, only 11 patients met the inclusion criteria. Three patients were excluded due to loss of follow-up. All included patients had comminuted intra-articular distal radius and radial head fractures (Mason III). The intra-articular distal radius fracture was classified as type C according to the AO (Arbeitsgemeinschaft für Osteosynthesefragen) classification, with 2 C1, 4 C2, and 5 C3 class fractures. The average age of the patients was 42 years (range 30-48), including three females and eight males. The mechanism of the trauma was the same in all patients, involving a fall from a substantial height onto an outstretched hand. Every identified patient was treated with on-table radial head reconstruction and distal radius volar plating. The mean follow-up duration was 32 months (range 12-65). Surgical intervention occurred within three days of the injury. No significant complications were recorded.

Surgical Technique

Under general anesthesia and following general surgical preparation and draping, the injured limb of the patient, who was in the supine position, was placed on a radiolucent table. A fluoroscopic examination was conducted to exclude any lateral collateral ligament injury or joint instability before making the skin incision. The radial head fracture was addressed first to restore the length of the radius bone and to facilitate the reduction of the comminuted distal radius fracture. The position of the extremity was internally rotated with the elbow at 90° of flexion, and the forearm fully pronated to prevent iatrogenic posterior interosseous nerve injury. The radial head fractures were exposed using the extensor digitorum communis splitting approach and incision of the annular ligament. The

Figure 1. Intraoperative photographs of retrieved radial head fragments and their on-table reconstruction.

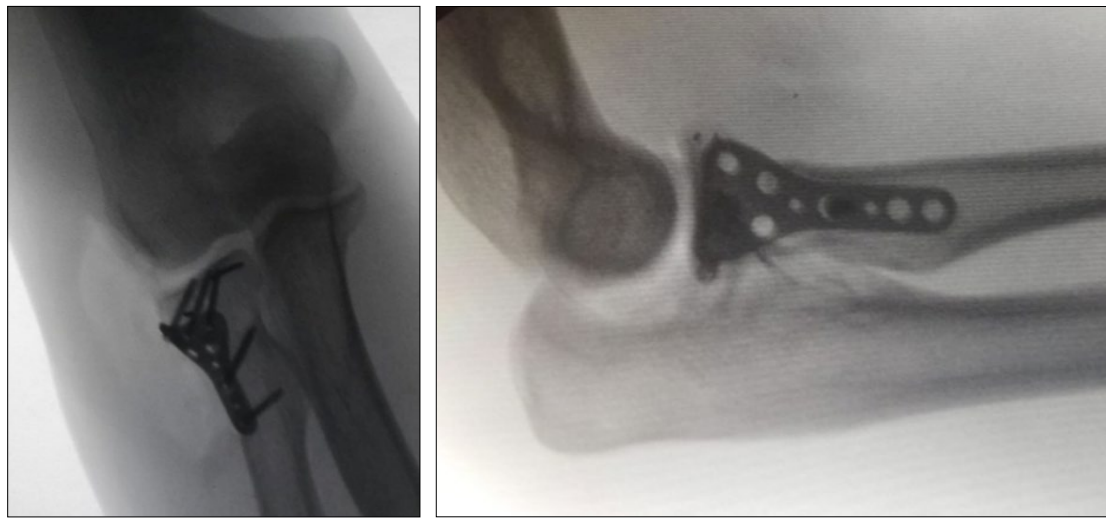

Figure 2. Intraoperative fluoroscopic images of reconstructed radial head repositioned to the shaft and fixed by radial head plate.

bone fragments were retrieved from the joint and assembled extracorporeally on the nurse's table by reduction clamps and threaded K-wires (Fig. 1). Larger fragments were fixed with interfragmentary screws. For small fragments, the threaded K-wires were cut and left embedded. The anatomically reconstructed radial head was then reattached to the shaft and fixed with a radial head plate. Particular attention was given to positioning the plate in the safe zone, i.e., the interval between the radial styloid and Lister's tubercle. Additionally, minimal distal dissection and meticulous retractor placement were necessary to avoid endangering the posterior interosseous nerve. The final assessment of the range of motion and fluoroscopic examination to confirm appropriate fixation (Fig. 2) were followed by the repair of the joint capsule and annular ligament, and layered closure of the wound.

The distal radius fracture was subsequently intervened, and a standard flexor carpi radialis (FCR) approach was performed to expose the fracture fragments. The sheath of the FCR tendon was opened distally and retracted ulnarly. After elevating the pronator quadratus muscle from the radius to the ulna and visualizing the volar ulnar corner, articular reduction was established by longitudinal traction and direct manipulation of the distal starting, starting from the intermediate to the radial column. Provisional stabilization was provided by temporary Kirschner wires and pointed reduction clamps. An appropriate volar locking plate that could engage all fragments was selected and placed. The accurate articular anatomic reduction and proper placement of the volar plate were confirmed under image intensification, ensuring that the watershed line was not crossed by the plate. The sequence of screw insertion was as follows: a proximal non-locking screw, distal ulnar-sided locking threaded screws, distal radial-sided locking threaded screws, and lastly, two more proximal locking screws. The final assessment was conducted using intraoperative imaging to confirm the absence of intra-articular screw penetration and to examine the distal radioulnar joint for forearm rotation and joint stability. Every effort was made to repair the pronator quadratus and cover the hardware; then, the skin was closed.

Postoperative Care

The upper extremity was immobilized with a long-arm splint in a neutral position for a maximum of three weeks. Passive motion exercises started after the removal of the splint, and an arm sling was applied for an additional three weeks. Active elbow flexion-extension and forearm supination-pronation were allowed in the sixth week, followed by strengthening exercises. Full weight-bearing and heavy manual work were permitted in the 12th week, following radiographic confirma-

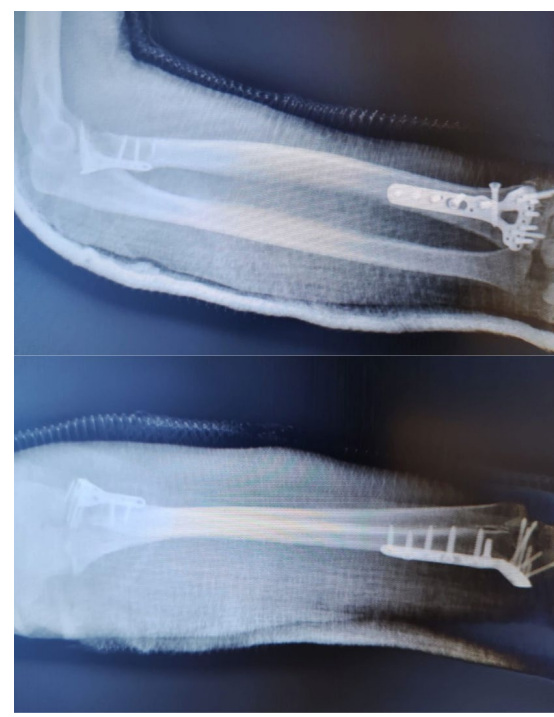

Figure 3. Postoperative posterioanterior and lateral radiographs of affected limb showing the internal fixation of both radial ends.

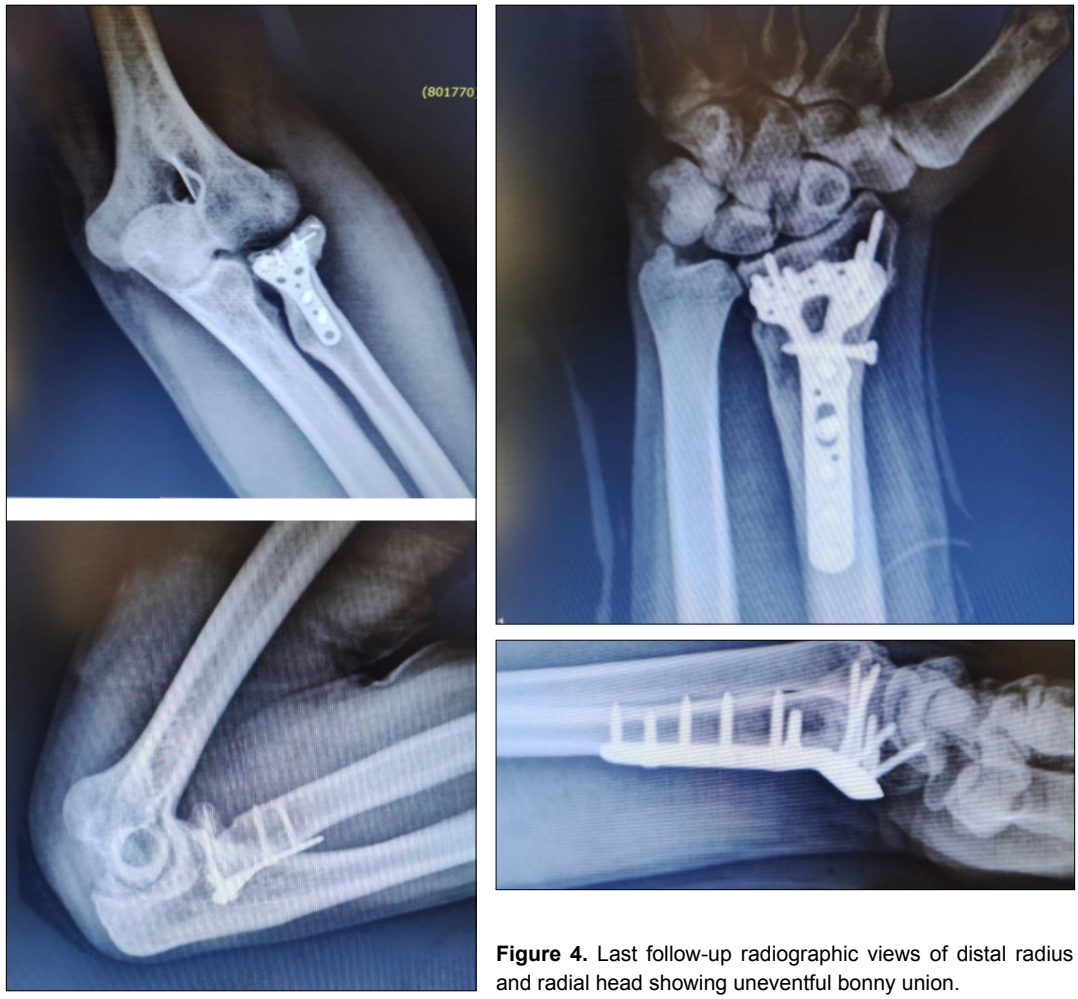

Figure 4. Last follow-up radiographic views of distal radius and radial head showing uneventful bonny union.

tion of bone union. Heterotopic ossification prophylaxis was not prescribed.

Clinical and Radiological Evaluation

Physical and radiographic evaluations were routinely performed in the sixth and twelfth weeks and at the final follow-up, unless any adverse reaction occurred. The physical evaluation included the assessment of both elbow and wrist range of motion using a goniometer, stability tests for the elbow and distal radioulnar joint, and a neurological examination. The pain in the joints was assessed using the VAS,[8] and the functional outcome was measured by the QuickDASH questionnaire.[9]

The radiographic assessment for inadequacy or loss of reduction was performed immediately after the operation (Fig. 3) and at the final follow-up (Fig. 4). Additionally, complete bone union, avascular necrosis, heterotopic ossification, implant failure, and post-traumatic arthritis were evaluated at the final follow-up.

RESULTS

At the final follow-up, the mean elbow flexion was 120° (range 110°-140°), and the mean extension deficit was 20° (range 0-30°). The wrist range of motion, measured with the elbow flexed at 90°, included a mean palmar flexion of 52° (range 35°–78°), dorsiflexion of 45° (range 32°–70°), radial deviation of 15° (range 5°–20°), and ulnar deviation of 32° (range 25°–40°). The maximum forearm supination and pronation were 65° (range 58°–80°) and 56° (range 44°–60°), respectively. None of the patients exhibited any residual distal radioulnar join instability. Osseous union of both the radial head and distal radius was observed in all patients. No patient showed signs of avascular necrosis of the reconstructed radial head. However, degenerative changes were observed in four patients (Grade 1 according to Broberg and Morrey[10]) and mild heterotopic ossification in two elbows (Grade 1 according to Hastings and Graham[11]). The mean radial inclination was 22° (range 18°–28°), volar tilt 8° (range -10°–18°), and radial length 10.2 mm (range 8.5°–13.6 mm).

All patients completed the VAS score and DASH questionnaire. The mean VAS was 1.5 (range 0-7) at rest and 3.9 (range 0-9) with activities, whereas the mean QuickDASH score was 32 (range 12-65).

DISCUSSION

We present a group of patients who sustained an uncom-

mon combination of ipsilateral distal radius and radial head fractures. All injuries resulted from high-energy trauma, typically involving a fall from a height onto an outstretched hand with a hyperextended elbow. We believe that the most probable mechanism of injury involved rebound forces from the ground being strong enough to comminute and dorsally angulate the distal radius, then impacting the radial head against the capitellum, leading to a comminuted fracture of the radial head. It is worth noting that the carrying angle of the elbow converts the longitudinal force into valgus stress upon radiocapitellar impaction during the fall, resulting in a fracture of the proximal radius.[12] Moreover, the comminution pattern and location of the fractures suggest a strong axial force was responsible for this type of injury.

Currently, there is controversy regarding the optimal treatment of displaced, comminuted radial head fractures (Mason III), due to conflicting evidence supporting resection, ORIF, and arthroplasty.[13] Radial head resection was initially proposed due to its initial improved results and relatively simple technique. Several studies have shown good to excellent outcomes with radial head resection in acute fractures.[14] However, the disturbed radiohumeral joint may result in decreased grip strength, proximal migration of the radius,[15] valgus and posterolateral instability of the elbow,[16] and osteoarthritis of the ulnohumeral joint.[17] Furthermore, proximal migration of the radius can be more evident when a radial head fracture is accompanied by a distal radius fracture, as was the case in our patients. Radial head resection could exacerbate this migration, leading to consequent functional loss in both the elbow and wrist joints. Arthroplasty was reserved for cases when in-situ fixation of the radial head fracture is not achievable, showing excellent short- and mid-term results.[18] However, complications such as heterotopic ossification, stiffness, prosthesis loosening, and overstuffing have been frequently reported.[19] Therefore, preserving the radial head and its ex-situ reconstruction might be the initial surgical choice to maintain normal articulation, preserve bone stock, and retain the option for arthroplasty in case of early failed ORIF. Several studies have revealed satisfactory functional outcomes with the on-table reconstruction technique for comminuted radial head fractures,[20-23] and our results are in accord with these findings. In addition to the several reported complications of radial head arthroplasty, the relatively young age of our patients and their long life expectancy were the main reasons for our preference for radial head preservation over arthroplasty, due to its poor long-term survival rate.[24]

The restoration of anatomical alignment and articular congruity in distal radius intra-articular comminuted fractures is essential for optimal functional outcomes both short and long term.[25,26] Open reduction and rigid internal fixation ensure a more consistent correction of displacement and maintenance of the achieved reduction. Due to the high rate of complications associated with dorsal plating, such as extensor tendon irritation and late tendon rupture,[27] and the advancements in fixed-angle plate designs, volar fixation has become the standard approach for unstable dorsally displaced intra-articular distal radius fractures.[28] Distraction-based implants, such as external fixators and bridging plates, despite not showing long-term superior functional results and a slower return of function compared to volar plate fixation,[29] may increase the compression force across the radiocapitellar joint and violate the internal fixation of the comminuted radial head. Our study demonstrates that volar plating provides a successful modality in treating the distal radius fractures of bipolar radial fractures.

Simultaneous fractures of both radial ends are uncommon

Table 1. Summaries of previous publications on patients with simultaneous comminuted fractures of the distal radius and radial head

Study (Year)	Patients	Age	Sex	Mechanism of Injury	Associated Injury	Treatment Radial Head	Distal Radius	Outcomes*
Nagaya et al. (2001)	1	52	F	Fall from height	Ulnar collateral ligament injury	Bioabsorbable screw fixation	Open reduction, bone grafting and external fixator	Excellent
Yan et al. (2015)	1	31	M	Fall from height	-	Miniplate and screw fixation	Volar plate fixation	Excellent
Akma Kamaludin et al. (2019)	1	68	F	Fall from height	-	Radial head prosthesis	Volar plate fixation	Fair
Kastanis et al. (2019)	1	56	F	Fall from height	-	Radial head prosthesis	Volar plate fixation	Excellent
Park et al. (2021)	1	78	F	Fall from height	Coronoid process fracture	Radial head prosthesis	Volar plate fixation	Excellent
Zhang et al. (2023)	1	51	F	Fall from height	Elbow dislocation	Radial head prosthesis	Volar plate fixation	Excellent

*The outcomes of the patients were assessed using either the Cooney score or the QuickDASH score.

injuries with few reported cases.[5-7] A careful review of the literature reveals only six cases of concomitant ipsilateral comminuted distal radius and radial head fractures with fair to excellent outcomes.[7,30-33] The details of the patient's demographics, injury mechanisms, related injuries, treatment options, and outcomes are shown in Table 1. Their treatments varied, with the radial head being replaced in four patients and internally fixed in the other two, while the distal radius fracture was internally fixed with a volar plate in five patients and an external fixator with bone grafting was applied in one case. In our study, all included 11 patients were treated with on-table reconstruction and internal fixation of the radial head, and open reduction and volar plating of the distal radius fractures, yielding comparable outcomes to the reported cases.

Most published case reports have addressed the distal radius first, followed by intervention on the radial head.[30-32] Such a sequence of interventions was recommended due to the restoration of radial length and Lister's tubercle, which are the major two landmarks used in determining the size and rotation of the radial head prosthesis. However, if reconstruction of the radial head is intended to be performed, either the proximal or distal radius can be fixed first.[30] Conversely, we believe that on-table construction of the radial head and its anatomic reattachment to the radial shaft might facilitate the anatomic reduction of difficult comminuted intra-articular distal radial fractures and help in the restoration of their radial length.

The main limitations of the current study are its retrospective nature and the relatively small sample size. Concomitant comminuted fractures of both radial ends are uncommon, making it difficult to collect data on a large number of patients with this type of fracture. Therefore, these fractures have not been reported in large series. Further studies with larger sample sizes, multicenter design, and prospective clinical and biomechanical studies to investigate optimal implants for either fracture are warranted in the future. Despite these limitations, the current report increases awareness of the ipsilateral simultaneous injury of wrist and elbow joints, adds to the limited knowledge regarding this specific type of injury, provides recommendations for treatment, and reports clinical and radiological outcomes.

CONCLUSION

Simultaneous comminuted fractures of the ipsilateral distal radius and radial head represent a distinct injury pattern that results from high-energy trauma, typically involving a fall from a height onto an outstretched hand. Greater emphasis should be placed on clinical examination and radiological imaging of the elbow in cases of wrist injuries, and vice versa. Treatment with on-table reconstruction of the radial head and open reduction and internal fixation with a volar plate can result in good radiological and functional outcomes.

Ethics Committee Approval: This study was approved by the Memorial Bahçelievler Hospital Ethics Committee (Date: 31.10.2023, Decision No: 106).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: A.M.H.; Design: A.M.H.; Supervision: A.M.H., M.B.Y.; Resource: A.M.H.; Materials: A.M.H., M.B.Y; Data collection and/or processing: A.M.H., M.B.Y.; Analysis and/or interpretation: A.M.H., M.B.Y; Literature search: A.M.H.; Writing: A.M.H.; Critical review: M.B.Y.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Radiusun, her iki ucunun eş zamanlı parçalı kırılması farklı bir yaralanma paternini temsil ediyor mu?

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AMAÇ: İzole distal radius ve radius başı kırıkları çok sık görülen yaralanmalar olmakla birlikte, eş zamanlı ipsilateral kırıkları nadirdir. Her iki uçta basit yer değiştirmemiş kırıklardan, aynı tarafta ciddi parçalı proksimal ve distal radyal kırıklara kadar farklı formlarda meydana gelebilir. Parçalı distal radius ve radius başı kırıklarının eşlik ettiği az sayıda vaka rapor edilmiştir; herhangi bir tedavi kılavuzu mevcut değildir ve kararlar kişisel tavsiyelere dayanmaktadır. Çalışmamızın amacı, bu yaralanma şekline ilişkin farkındalığı artırmak, yaralanmanın mekanizmasını, tedavi yaklaşımını ve fonksiyonel sonuçlarını tartışmaktır.

GEREÇ VE YÖNTEM: 2016-2021 yılları arasında distal ve proksimal radius kırıklarının eş zamanlı ipsilateral parçalı kırıkları olan iskelet matüritesini tamamlamış hastalar çalışmaya alındı ve retrospektif olarak incelendi. Demografik bilgiler, yaralanma mekanizması, tedavi yaklaşımı ve komplikasyon oranı analiz edildi. Redüksiyonun yetersizliği veya kaybına yönelik radyografik değerlendirme ve radyal eğim, radyal uzunluk ve palmar eğim dahil olmak üzere distal radiusun radyografik parametreleri ameliyattan hemen sonra ve son takipte yapıldı. Klinik sonuçlar her iki eklem hareket açıklığını ölçen VAS skoru hesaplanarak ve son takipte Quick DASH skoru kullanılarak belirlendi.

BULGULAR: Toplam 11 hasta dahil edilme kriterlerini karşıladı, hepsinde aynı tarafta Mason III radius başı kırığı ve tip C (AO sınıflamasına göre) eklem içi distal radius kırığı vardı. Radius başı kırığı için masa üstü radius başı rekonstrüksiyonu ve proksimal radius plak ile fiksasyonu, distal radius kırığı için ise anatomik volar kilitli plak ile osteosentez yapıldı. Ortalama takip süresi 32 (12-65) ay idi. Son takipte tüm hastalarda hem radius başı hem de distal radiusta osseöz kaynama gözlendi. Ortalama VAS istirahatte 1.5 (0-7), aktivitede 3.9 (0-9), Quick DASH skoru ortalaması ise 32 (12-65) idi. Önemli bir komplikasyon görülmedi.

SONUÇ: Aynı taraftaki distal radius ve radius başının eşzamanlı parçalı kırıkları, çoğunlukla açık el üzerine yüksekten düşme sonucu oluşan yüksek enerjili travmadan kaynaklanabilecek farklı bir yaralanma modelini temsil eder. El bileği yaralanmalarında dirseğin, dirsek travmalarında el bileğinin klinik muayenesine ve radyolojik görüntülemesine önem verilmelidir. Radius başının masa üzerinde rekonstrüksiyonu ve açık redüksiyon ve volar plakla internal fiksasyonu ile yapılan tedavi, uzun vadede iyi radyolojik ve fonksiyonel sonuçlara yol açabilir.

Anahtar sözcükler: Distal radius kırığı; eşzamanlı; Ex situ rekonstrüksiyon; ipsilateral; radius başı; masa üstü rekonstrüksiyon.

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