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Closed Reduction and Cast Immobilization for the Treatment of Distal Radius Fracture: Does Dorsal Metaphyseal Comminution Predict Radiographic and Functional Outcomes?

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Purpose: The purpose of this study was to determine the relationship between dorsal metaphyseal comminution and the radiographic and functional outcomes of patients with distal radius fractures treated by closed reduction and cast immobilization.

Methods: Twenty-six patients with acute distal radius fractures were retrospectively reviewed. The mean age of this patient group was 62.8 years (range, 45−87 years). Eighteeen cases were AO type-A3 and 8 were AO type-A2. Radiographic and functional parameters were analyzed and compared between the patients who presented with or without dorsal metaphyseal comminution on their initial radiographs in order to assess the clinical outcomes. The radiographic parameters included radial inclination, radial length, volar/dorsal tilt, and ulnar variance. In order to measure the functional outcomes, each patient's range of motion, grip strength, Quick disabilities of the arm, shoulder, and hand (DSAH), visual analog scale (VAS), and Mayo score were determined.

Results: Seventeen patients (65%) presented with dorsal metaphyseal comminution on the initial radiographs. Radial inclination, radial length, and volar/dorsal tilt were decreased and ulnar variance was increased on the final radiographs in comparison with the postreduction. However, there were no statistically significant differences between the two groups that presented with or without dorsal metaphyseal comminution ($p>0.05$). None of the functional parameters (i.e., range of motion, grip strength, DASH, Mayo, and VAS score) were significantly different between the two groups ($p>0.05$).

Conclusion: Dorsal metaphyseal comminution seems to have no significant impact on radiographic and functional outcomes when closed reduction and cast immobilization was planned for the treatment of distal radius fracture.

Keywords: Distal radius, Distal radius fracture, Dorsal metaphyseal comminution, Closed reduction, Radiographic outcome, Functional outcome

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INTRODUCTION

Closed reduction and cast immobilization is still the mainstay for treatment of distal radius fracture when clinically indicated. Stable fractures can be conservatively managed using this technique, demonstrating good anatomical and functional results[1]. However, for unstable fractures, it is still debatable if conservative treatment yields successful clinical results. A fracture of the distal radius is considered unstable if it is unable to maintain reduction once it has been anatomically reduced[2]. This instability can be determined on radiographic examination between 1 to 2 weeks later. It is difficult to reliably predict fracture stability using the initial posttraumatic plain radiographs.

Dorsal comminution of the distal radius fracture is more commonly seen in elderly patients with osteoporosis or younger patients following high-energy trauma[3]. Distal radius fracture with dorsal metaphyseal comminution can present as a special challenge to hand surgeons. Extensive comminution in the dorsal aspect of the wrist complicates the proper restoration of the distal fragments when applying the traditional closed reduction maneuver due to the loss of the mechanical dorsal buttress. This challenging fracture pattern will most likely result in the loss of alignment and poor functional outcomes. Dorsal metaphyseal comminution has also been reported as a predictor of fracture stability[4]. Dorsal cortical comminution is defined as the presence of free-floating dorsal fragments, which are considered as an important buttress for maintaining dorsal displacement forces. Although, there are a few reports in the literature on the relationship between dorsal metaphyseal comminution and radiographic parameters[4,5] there are fewer articles that describe both the radiographic and functional outcomes at the same time.

The goal of treatment for distal radius fracture is to recover a pain-free, mobile wrist joint without any functional limitations. Anatomic restoration of fracture fragments has been reported, demonstrating a variety of results, but limited clinical evidence regarding functional outcomes has been reported[6-8].

Considering the huge number of reports on the surgical treatment of distal radius fracture that have been recently published, further analysis of the clinical outcomes of conservative treatment will be of value. Thus, we conducted this study to determine the relationship between comminution at the dorsal metaphysis and radiographic and functional outcomes. This study may provide insight into the use of conservative treatment and be of use to hand surgeons who encounter this fracture on a daily basis.

MATERIALS AND METHODS

We retrospectively reviewed the medical records of patients with acute distal radius fractures who presented at our hospital between August 2009 and November 2011. The inclusion criteria were as follows: 1) a distal radius fracture that was treated using closed reduction and cast immobilization; 2) patients with follow-up time more than 12 months; and 3) patients whose functional and radiographic outcomes were evaluated. The exclusion criteria were: 1) patients with displaced intra-articular fractures, soft tissue defects, or open fractures that required surgical treatment; 2) patients with multiple fractures or ipsilateral upper arm fractures; 3) patients who received follow-up examinations less than 12 months; 4) patients who were noncooperative due to psychological or mental disorders; and 5) pediatric fractures in patients <18 years old.

Initially, all patients were managed using manual closed reduction without using C-arm, under either local anesthesia or intravenous sedation, then a U-slab splint was applied at the emergency department to provide the initial immobilization. Plain radiographs were taken to confirm the satisfactory reduction immediately after the splint placement. Satisfactory radiographic reduction was defined as within 10° of dorsal angulations, 20° of volar angulations, >10° of radial inclination, and <5 mm of radial shortening[8-11]. The U-slab splint was removed and a short arm cast was applied after 5 to 7 days, depending on the amount of swelling. The short arm cast was maintained for five weeks. Total immobilization

period was about six weeks after the initial immobilization. Wrist position of the U-type splint and cast was about 15° of wrist flexion. Plain radiographs were taken until radiographic union was achieved. After the removal of the cast, active range of motion (ROM) and passive stretching exercises of the wrist were encouraged.

1. Measurements of the radiographic parameters

Anteroposterior (AP) and lateral radiographs were collected at four time points: the initial examination (prereduction and postreduction), the first visit to the outpatient clinic, and the final follow-up examination. All radiographs were reviewed in order to measure radial inclination, radial length, volar/dorsal tilt, and ulnar variance. Dorsal metaphyseal comminution was defined as the presence of a free-floating piece of the dorsal metaphyseal cortex on the lateral plain radiograph using the definition provided by Mackenney et al.[2] (Fig. 1).

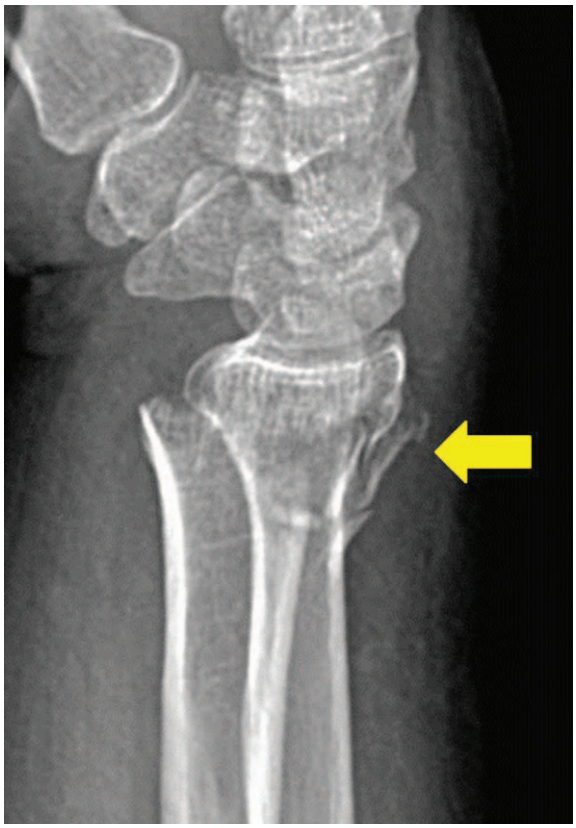

Fig. 1. A 60-year-old woman with a distal radius fracture. A free-floating piece of dorsal metaphyseal cortex (arrow) is shown on a lateral plain radiograph, which was defined as dorsal comminution.

Measurement was done by two orthopaedic surgeons.

2. Evaluation of functional outcomes

We determined the ROM of the wrist (flexion, extension, ulna/radius deviation), grip strength, Quick disabilities of the arm, shoulder, and hand (DASH) score[12], visual analog scale (VAS) score, and Mayo score[6] in order to evaluate each patient's functional outcomes. ROM and grip strength were measured as the percentage in comparison with the opposite (i.e., healthy) wrist.

3. Statistical analysis

When comparing simple proportions between independent groups, the Fisher exact test was used. The student t-test and Mann-Whitney test were used to determine the mean differences between continuous data. Repeated measure analysis of variance was used to determine any differences between the two groups that developed over time. All tests were 2-sided, and a p-value <0.05 was considered statistically significant. Statistical analysis was performed using SPSS ver. 16.0 (SPSS Inc., Chicago, IL, USA). To assess inter-observer reliability, interclass correlation coefficient was used.

RESULTS

Thirty-one patients met the inclusion criteria, and of these five patients (16%) were lost on follow-up. Therefore, data were obtained for 26 patients, 25 of whom were women. The average age of these patients was 62.8 years (range, 45−85 years). The mean follow-up period was 53.7 months (range, 14−83 months). Nine (35%) of 26 fractures were on the right side.

1. Radiographic outcomes

In all parameters, the measurements had excellent reliability (interclass correlation coefficient >0.9).

According to Mackenney et al.[2]'s definition, 17 (65%) of 26 patients presented with dorsal metaphyseal comminution at their initial presentation. Mean age of patients with dorsal metaphyseal comminution (17 patients) was 63.3 and that of patients without dorsal

metaphyseal comminution (9 patients) was 62, and there was no significant difference. Satisfactory radiographic reduction was achieved in all but one patient whose postreduction volar tilt was 23°. Patients with dorsal metaphyseal comminution demonstrated a mean±standard deviation radial inclination of 11.7°±6.6° at prereduction, 21.7°±0.8° at postreduction, 20.0°±0.6° at one week, and 16.4°±0.8° at the final follow-up examination. Those without dorsal metaphyseal comminution demonstrated a mean radial inclination of 12.6°±5.8° at prereduction, 21.2°±1.1° at postreduction, 20.7°±0.8° at one week, and 18.8°±1.1° at the final follow-up examination. Patients with dorsal metaphyseal comminution demonstrated a mean volar tilt of -21.2°±7.5° at prereduction, 10.8°±1.2° at postreduction, 9.29°±1.2° at one week, and 2.7°±1.9° at the final follow-up examination. Those without dorsal metaphyseal comminution demonstrated a mean volar tilt of -13.1°±8.2° at prereduction, 11.4°±1.6° at postreduction, 9.3°±1.6° at 1 week, and 4.5°±2.7° at the final follow-up examination. There were no significant differences in any of the parameters between the two groups (p>0.05) (Table 1). Over time, each group demonstrated a tendency toward decreased radial inclination, radial length, and volar tilt and increased ulnar variance from postreduction through the final follow-up examination (Fig. 2). These tendencies were statistically significant (p<0.01). However, there were no significant differences in terms of the rate of decrease in radial inclination, radial length, and volar tilt and rate of increase in ulnar variance

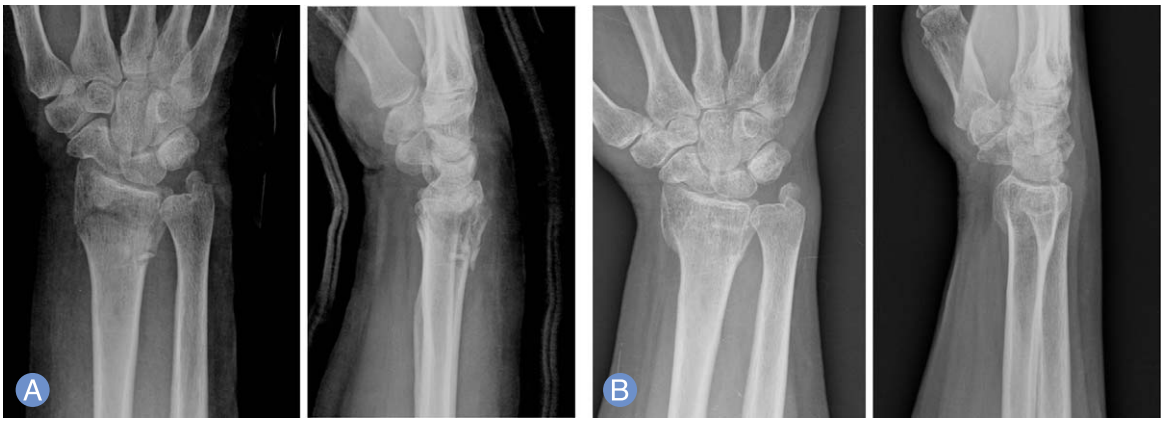

Fig. 2. Each group demonstrated a tendency toward decreased radial inclination, radial length, and volar tilt and increased ulnar variance from postreduction through the final follow-up examination. **(A)** Postreduction. **(B)** Final follow-up.

Table 1. Changes in radiographic parameters

Radiographic parameter	Time	Dorsal comminution (+) (n=17)	Dorsal comminution (-) (n=9)	Effect of dorsal comminution (p-value)
Radial inclination (°)	Postreduction	21.7±0.8	21.2±1.1	0.39
	1 wk follow-up	20.0±0.6	20.7±0.8	
	Final	16.4±0.8	18.8±1.1	
Radial length (mm)	Postreduction	11.2±0.4	10.3±0.5	0.519
	1 wk follow-up	10.2±0.4	9.5±0.6	
	Final	7.5±0.5	8.0±0.7	
Volar tilt (°)	Postreduction	10.8±1.2	11.4±1.6	0.696
	1 wk follow-up	9.29±1.2	9.3±1.6	
	Final	2.7±1.9	4.5±2.7	
Ulnar variance (mm)	Postreduction	-0.3±1.4	-0.3±1.4	0.553
	1 wk follow-up	-0.1±1.3	0.5±1.4	
	Final	2.1±1.5	2.2±1.4	

Values are presented as mean±standard deviation.

between patients with and without dorsal metaphyseal comminution (p>0.05).

2. Functional outcomes

Flexion was measured the mean value at 89.05% in patients with dorsal metaphyseal comminution and 78.90% in patients without dorsal metaphyseal comminution in comparison with the normal side. Extension was 86.55% in patients with dorsal metaphyseal comminution and 84.76% in patients without dorsal metaphyseal comminution. Ulnar deviation was 89.94% in patients with dorsal metaphyseal comminution and 87.30% in patients without dorsal metaphyseal comminution. Radial deviation was 85.74% in patients with dorsal metaphyseal comminution and 79.52% in patients without dorsal metaphyseal comminution. The mean Quick DASH score was 12.06 points for patients with dorsal metaphyseal comminution and 16.91 points for patients without dorsal metaphyseal comminution. The mean Mayo score was 78.53 points for patients with dorsal metaphyseal comminution and 77.22 points for those without dorsal metaphyseal comminution (Table 2). In VAS score, there were 6 patients, with dorsal comminution, and 9 patients, without dorsal comminution, in 0 point category. There were 3 patients with dorsal comminution, and 8 patients without dorsal comminution, in 1 or 3 point category (Table 3). No parameters demonstrated any significant differences between the two groups (p>0.05).

DISCUSSION

Various conservative and surgical techniques have been described in the literature that can be used to restore anatomic congruity following distal radius fracture. However, it is still unclear if anatomic restoration translates into improved functional outcomes. Several studies have attempted to correlate radiographic and functional outcomes in patients with distal radius fractures[7,13,14]. Dorsal metaphyseal comminution in the metaphysis is believed to be important for ensuring fracture stability[4], thus the primary purpose of our present study was to evaluate the relationship between initial dorsal metaphyseal comminution and final radiographic and functional outcomes. In contrast to the huge number of reports describing surgical treatment for this type of fracture, our current study provides some insight into the use of conservative treatment.

Table 2. Functional outcome parameters (except VAS score) of the patients with or without dorsal comminution

Functional outcome	Dorsal comminution (+)	Dorsal comminution (-)	p-value
Flexion	89.05	78.90	0.216
Extension	86.55	84.76	0.807
Ulnar deviation	89.94	87.30	0.678
Radial deviation	85.74	79.52	0.504
Grip strength	95.06	98.00	0.684
Quick DASH score[12]	12.06	16.91	0.978
Mayo score[6]	78.53	77.22	0.831

Values are presented as mean value (%).
VAS: visual analog scale, DASH: disabilities of the arm, shoulder, and hand.

Table 3. Functional outcome parameter (VAS score) of the patients with or without dorsal comminution

Functional outcom		Dorsal comminution (+) (n=9)	Dorsal comminution (-) (n=17)	p-value
VAS score	0	6 (66.7)	9 (52.9)	0.683
	1 or 3	3 (33.3)	8 (47.1)	

Values are presented as number (%).
VAS: visual analog scale.

There are some studies in the literature that assessed the factors that may influence the stability of distal radius fracture after conservative management[4,15]. Lafontaine et al.[15] identified several risk factors that were associated with secondary fracture displacement. These factors included excessive dorsal tilt, comminution, intraarticular involvement, and age >60 years. Makhni et al.[4] also attempted to determine similar correlations in a series of 124 conservatively managed distal radius fractures. Radiographic outcomes were measured, including dorsal angulation, volar angulation, step-off and gap displacement, and radial shortening. They reported that distal radius fractures with dorsal metaphyseal comminution demonstrated significantly higher rates of secondary displacement compared with noncomminuted counterparts. We examined 26 fractures using similar methods. However, we focused on the changes in radiographic parameters that present over time rather than the existence of secondary instabilities. We also measured several functional outcomes, such as subjective survey responses (DASH, Mayo, VAS scores) and objective wrist performance (e.g., ROM, grip strength). We found no association between dorsal metaphyseal comminution and radiographic and functional outcomes.

Regarding instability, our results showed that radiographic parameters tended to deteriorate after reduction through the final follow-up examination. This change was significant, but to some extent this deterioration should be accepted. However, when comparisons were made between the two groups based on dorsal metaphyseal comminution, no significant differences were noted. This suggests that dorsal metaphyseal comminution may not be the main factor that affects this deterioration of the radiographic parameters. These results are contrary to recently published studies[2,15]. Mackenney et al.[2] analyzed approximately 4,000 distal radius fractures and concluded that patient age, metaphyseal comminution of the fracture, and ulnar variance were predictive of radiographic outcomes.

In previously reported studies, wrist pain was significantly associated with intraarticular step-off displacement[16]. Ulnocarpal impingement and distal radioulnar joint incongruency are also associated with radial shortening, which is a reportedly common cause of ulnar-side wrist pain[17]. Porter and Stockley[8] reported that a dorsal angulation >20° and reduction of the radial angle to <10° can result in reduced grip strength. Hove et al.[7] reported that total movement in all directions was diminished by ulna-plus deformities and that pronation and supination are related to the initial radial length and degree of dorsal angulation. However, few studies are specifically focused on the role of dorsal metaphyseal comminution. Our results showed that the presence of dorsal metaphyseal comminution of the metaphysis did not make a significant difference.

The limitations of this study included the limited number of patients and the range of the follow-up periods. And because we excluded severe cases such as intraarticular fracture, open fracture, there could be deviation. However, considering the huge number of surgical techniques that have been recently described in the literature for the treatment of distal radius fracture, this study is unique due to its description of conservative treatment for distal radius fracture. In addition, we didn't checked range of supination, pronation and were studied in a retrospective manner, which are additional inherent weaknesses of this study.

CONCLUSION

In summary, closed reduction and cast immobilization provides reasonable radiographic and functional outcomes as the treatment of distal radius fracture. Dorsal metaphyseal comminution demonstrated limited influence on the radiographic and functional outcomes in our subset of patients.

REFERENCES

1. Cooney WP. Management of Colles' fractures. J Hand Surg Br. 1989;14:137-9.
2. Mackenney PJ, McQueen MM, Elton R. Prediction of instability in distal radial fractures. J Bone Joint Surg

Am. 2006;88:1944-51.
3. Synn AJ, Makhni EC, Makhni MC, Rozental TD, Day CS. Distal radius fractures in older patients: is anatomic reduction necessary? Clin Orthop Relat Res. 2009;467: 1612-20.
4. Makhni EC, Taghinia A, Ewald T, Zurakowski D, Day CS. Comminution of the dorsal metaphysis and its effects on the radiographic outcomes of distal radius fractures. J Hand Surg Eur Vol. 2010;35:652-8.
5. Vatansever A, Piskin A, Kayalar M, Bal E, Ada S. The effect of dorsal cortical comminution on radiographic results of unstable distal radius fractures treated with closed reduction and K-wire fixation. Acta Orthop Traumatol Turc. 2007;41:202-6.
6. Souer JS, Lozano-Calderon SA, Ring D. Predictors of wrist function and health status after operative treatment of fractures of the distal radius. J Hand Surg Am. 2008;33:157-63.
7. Hove LM, Fjeldsgaard K, Skjeie R, Solheim E. Anatomical and functional results five years after remanipulated Colles' fractures. Scand J Plast Reconstr Surg Hand Surg. 1995;29:349-55.
8. Porter M, Stockley I. Fractures of the distal radius. Intermediate and end results in relation to radiologic parameters. Clin Orthop Relat Res. 1987;(220):241-52.
9. Abbaszadegan H, Jonsson U, von Sivers K. Prediction of instability of Colles' fractures. Acta Orthop Scand. 1989; 60:646-50.
10. Altissimi M, Mancini GB, Azzara A, Ciaffoloni E. Early and late displacement of fractures of the distal radius. The prediction of instability. Int Orthop. 1994;18:61-5.
11. Hove LM, Solheim E, Skjeie R, Sorensen FK. Prediction of secondary displacement in Colles' fracture. J Hand Surg Br. 1994;19:731-6.
12. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). Am J Ind Med. 1996;29:602-8.
13. Foldhazy Z, Tornkvist H, Elmstedt E, Andersson G, Hagsten B, Ahrengart L. Long-term outcome of nonsurgically treated distal radius fractures. J Hand Surg Am. 2007;32:1374-84.
14. Aro HT, Koivunen T. Minor axial shortening of the radius affects outcome of Colles' fracture treatment. J Hand Surg Am. 1991;16:392-8.
15. Lafontaine M, Hardy D, Delince P. Stability assessment of distal radius fractures. Injury. 1989;20:208-10.
16. Baratz ME, Des Jardins J, Anderson DD, Imbriglia JE. Displaced intra-articular fractures of the distal radius: the effect of fracture displacement on contact stresses in a cadaver model. J Hand Surg Am. 1996;21:183-8.
17. Geissler WB, Fernandez DL, Lamey DM. Distal radioulnar joint injuries associated with fractures of the distal radius. Clin Orthop Relat Res. 1996;(327):135-46.

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원위 요골 골절에서 도수 정복 및 석고 고정 치료의 결과: 배측 골간단 분쇄가 방사선학적 및 기능적 결과에 미치는 영향

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목적: 배측 골간단 분쇄가 있는 원위 요골 골절 환자에서 분쇄여부와 방사선적, 기능적 결과와의 관계를 알아보고자 한다.

대상 및 방법: 2009년부터 2011 12월까지 본원에서 원위 요골 골절 진단 받은 후 도수 정복 및 석고 부목 치료를 받은 26명의 환자를 대상으로 하였다. 환자 45세부터 87세까지였고, 평균나이 62.8세였다. 환자들의 원위 요골 골절은 AO type A2 18예, AO type A3 8예였다. 임상적 결과 확인하기 위해 배측 골간단 분쇄가 있는 집단과 없는 집단을 나누고, 두 집단에서 방사선학적 변수와 기능적 변수를 분석하였다. 방사선적 변수에는 요골 경사각, 요골 단축, 요골 요배측 경사, 척골 변위를 포함하였고, 기능적 변수로 관절운동범위, 악력, disabilities of arm, shoulder & hand (DASH), visual analog scale (VAS) score, Mayo score를 측정했다.

결과: 총 17명 (65%)의 환자에서 초기 엑스레이 영상에서 배측 골간단 분쇄가 있었다. 방사선적 결과는 외래 추시 중 시행한 마지막 방사선 촬영과, 도수 정복 직후의 방사선 촬영에서 요골 경사각, 요골 단축, 요골 배측 경사, 척골 변위를 비교하였고, 두 집단 사이에 차이는 없었다($p>0.05$). 두 집단 사이의 기능적 결과로 관절운동범위, 악력, DASH, VAS score, Mayo score를 비교하였고, 유의한 차이를 보이지 않았다($p>0.05$).

결론: 원위 요골 골절 뒤 도수정복 및 석고부목 치료받은 환자에서 배측 골간단 분쇄는 방사선적, 기능적 결과에 영향을 미치지 않는다.

색인단어: 원위 요골, 원위 요골 골절, 배측 골간단 분쇄, 도수 정복, 방사선적 결과, 기능적 결과

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