Radiographic Measurements as a Predictor of Correction Loss in Conservative Treatment of Colles’ Fracture

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Abstract: Dorsal displaced distal radius fracture (Colles’ fracture) is very common and could occur from fragility in middle-aged and elderly people. Many Colles’ fractures are still treated conservatively in clinics without hospitalization. Internal fixation using a palmar locking plate has been the standard treatment, but some complications have been reported. The aim of this study was to analyze changes in radiographic parameters over time in patients with conservatively treated Colles’ fractures, and to establish whether the type of fracture influenced these changes. Prospective data collected included patient characteristics and radiological findings. The study was conducted at two private clinics and included 60 patients (13 men and 47 women; mean age, 72.5 years old; range, 55 to 96 years old) with a Colles’ fracture (types of injury: intramedullary [n = 15], anatomical [n = 39], extramedullary [n = 2], and unknown [n = 4]) who were treated conservatively with manipulation and cast immobilization. Conservative, non-surgical treatment with manipulation was performed first, then, cast immobilization continued for 4 weeks. Loss of correction between the time of reduction and the final observation was defined by the following radiographic measurements: palmar tilt, radial inclination, and ulnar variance. The average final follow up period was 4.6 months (1.5–12 months). Immediately after reduction, 11 intramedullary fractures, 42 anatomical fractures and 7 extramedullary fractures were confirmed. Correction loss according to ulnar variance was significantly greater (P = 0.012) during the final observation for patients with an intramedullary injury at reduction than that for patients with extramedullary and anatomical injuries at reduction. We found that the correction loss for ulnar variance from immediately after reduction until the final observation was significantly greater in the intramedullary group, suggesting that an alternative to conservative treatment may be beneficial for patients with intramedullary fractures.

Keywords: Colles’ fracture, correction loss, radiographic measurements, prospective studies, volar cortex.

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ever, complications resulting from this treatment have also been reported [4–6]. Many Colles’ fractures are still treated conservatively in clinics without hospitalization [7]. In 2010, Court-Brown reported that the percentage of distal radius fractures treated conservatively in the United States was 70% [7], indicating that conservative treatment is still the first-line treatment used by orthopedic surgeons. Furthermore, it was reported that the restoration or maintenance of volar cortical alignment during the manipulation of distal radial fractures offers patients the best chance of avoiding the need for further surgery [8].

Using radiographic images, we aimed to elucidate the changes in radiographic parameters over time with conservative treatment of different types of Colles’ fractures.

**Materials and Methods**

The participants were 60 patients with a Colles’ fracture (60 wrists) treated conservatively between April 2009 and December 2014 at two private clinics. There were 13 men and 47 women, with a mean age of 72.5 years old (range, 55 to 96 years old). According to the AO/OTA fracture and dislocation classification [9], the number of patients with types A2, A3, C1, C2, and C3 fractures were 33, 5, 5, 12, and 5, respectively. The average final follow up period was 4.6 months (1.5–12 months). The inclusion criterion was a fall from a standing position as the cause of injury. Exclusion criteria were a concurrent fracture of the distal ulnar metaphysis or comminution of the palmar cortex of distal radius. All patients provided written informed consent at the time of enrollment, and the study was approved by the local committee.

Immediately after diagnosis, all patients underwent manipulation. During manipulative reduction, 5mL of 1% xylocaine was injected into the fracture site through the dorsal wrist. While the assistant stabilized the proximal fracture site with the elbow joint flexed, the physician held and pulled the hand of the affected arm with both hands while the forearm was in a pronated position. Reduction was then performed on the wrist in a temporary Cotton-Loder position while the fracture site was compressed. After reduction, the fractures were immobilized in a sugar-tong splint with the wrist slightly flexioned to neutral position for 4 weeks.

We also classified fractures based on lateral radiographic images of the palmar cortex immediately after reduction. Fractures were classified as “intramedullary” when the palmar cortex of the distal bone fragment was invaginated medially to the proximal part, as “anatomical” when the palmar cortex met the palmar cortex, and as “extramedullary” when the palmar cortex of the distal bone fragment was located laterally to the proximal part (Fig. 1). This classification is our original one. Three parameters—palmar tilt (PT), radial inclination (RI), and ulnar variance (UV)—were measured at the time of injury, immediately after reduction, and at the final observation (that is, after the bone union period). Bone union was evaluated by clinical findings and radiographical findings by three surgeons. The average union time was 3.9 months (2–12 months).

**Statistical analysis**

First, statistical analysis was performed to validate the baseline characteristics of the study population. We performed one-way analysis of variance (ANOVA) for PT, RI, and UV in the intramedullary, anatomical, and extramedullary groups immediately after reduction. Data are presented as mean ± standard deviation. After validating the baseline characteristics of the population, we performed ANOVA for the correction loss of each parameter from immediately after reduction until the final observation for all groups to evaluate the changes from just after the reduction to the final observation. Statistical analysis was performed using the Tukey-Kramer method. The SPSS21.0J software package (IBM company, Chicago, USA) was used for analysis. Statistical significance was set at $P < 0.05$.

**Results**

Tukey-Kramer analysis showed no significant difference among the 3 groups for PT, RI, and UV at immediately after reduction (Table 1).

Immediately after reduction, 11 intramedullary fractures, 42 anatomical fractures, and 7 extramedullary fractures were confirmed (Fig. 1). The number of patients and their classification types at the time of injury,
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immediately after reduction, and during the final observation are presented in Table 2. At the time of injury, we could not evaluate the fracture types. Four patients had unknown fracture types because of lack of the radiography at the injury period only. For PT, the correction loss became negative in each group, and there was no significant difference among the 3 groups (Fig. 2A). The correction loss also became negative for RI in each group, showing no significant difference among the 3 groups (Fig. 2B); however, the UV correction loss became positive in each group. The correction loss was significantly greater in the intramedullary group than in the anatomical and extramedullary groups (*P=0.012). (Fig. 2C). Bone union was achieved in all patients, and there were no cases of non-union.

Table 1. Differences of radiographic parameters among three groups based on lateral radiographic images of the palmar cortex in Colles’ fracture immediately after reduction

|          | Intramedullary | Anatomical | Extramedullary | P*       |
|----------|----------------|------------|----------------|----------|
| PT (°)   | -6.38±7.37     | -0.97±8.18 | 2.7±11.96      | 0.406    |
| RI (°)   | 16.7±5.77      | 20.85±4.91 | 19.15±2.48     | 0.069    |
| UV (mm)  | 0.82±1.37      | 0.84±1.43  | 1.68±1.35      | 0.293    |

*P<0.05 by Tukey-Kramer after one-way ANOVA (ANOVA), PT: palmar tilt, RI: radial inclination, UV: ulnar variance

Table 2. Fracture type by time period

|          | Injury period | Immediately after reduction | Final Follow up |
|----------|---------------|-----------------------------|-----------------|
| Intramedullary | 15            | 11                          | 16              |
| Anatomical     | 39            | 42                          | 36              |
| Extramedullary | 2             | 7                           | 8               |
| Unknown        | 4             | -                           | -               |

*P<0.05 by Tukey-Kramer after one-way ANOVA

Fig. 2A. The correction loss of palmar tilt (PT) among the 3 groups. ANOVA: analysis of variance.

Fig. 2B. The correction loss of radial inclination (RI) among the 3 groups. ANOVA: analysis of variance, Xp AP: X-ray film anteroposterior view.

Fig. 2C. The correction loss of ulnar variance (UV) among the 3 groups. ANOVA: analysis of variance, Xp AP: X-ray film anteroposterior view.
Representative radiographic course change

Two representative cases are shown in Fig. 3. Case1. 72F is of a 72-year-old woman with an intramedullary injury that was restored close to the anatomical type after repositioning; however, it was determined that it had reverted to the intramedullary type at the final follow-up (Fig. 3A). Case2. 74F is of a 74-year-old woman with an anatomical injury that was only slightly affected by the repositioning and remained stable until the final follow-up (Fig. 3B).

Discussion

In this study, the maximum (mean) correction losses until bone union were 21.5°(4.2°) for PT, 11.7°(2.6°) for RI, and 3.3 mm (0.8 mm) for UV. Although Roth et al reported that the maximum (mean) correction losses until bone union were 3.1°(1.0°) for PT, 3.6°(0.8°) for RI, and 2.1 mm (0.5 mm) for UV [10], their target population was limited to patients with distal radius fractures without dislocation. This difference in study results can be attributed to the inclusion of fractures with dislocation in our study. Even when radiographic alignment was acceptable immediately after reduction, we were unsure of how this would change over time.

Utsunomiya et al classified trochanteric fractures into 3 groups immediately after reduction based on lateral radiographic images and compared postoperative reduction volumes [11]. They reported a significantly greater reduction volume in their intramedullary group than in their anatomical and extramedullary groups.

In recent years, immobilization toward the anatomical or extramedullary type has been recommended for reduction [12]. In this study, rather than classifying fractures according to Utsunomiya’s classification, we used lateral radiographic images of Colles’ fractures after reduction. Consequently, radiographic changes in UV over time were significantly greater in the intramedullary group than in the extramedullary and anatomical groups. Accordingly, for patients treated conservatively, we found that lateral radiographic images during reduction can be used to predict subsequent parameter changes. Phillips et al reported that the restoration or maintenance of volar cortical alignment during the manipulation of distal radial fractures offers patients the best chance of avoiding the need for further surgery [8]. In addition, he noted that this factor should be taken into account in the decision-making process for these fractures [12]. According to our study results, we can emphasize the importance of volar cortical alignment at fracture site the same as Phillips mentioned. Regarding an acceptable extent of residual deformation with conservative treatment of distal radius fractures, Kodama et al reported significantly more favorable results when the PT was > –5° and the UV was < 3 mm [13].

This study has some limitations. We could not determine whether changes in radiographic parameters were associated with clinical results, because other factors are involved in changes in radiographic parameters over time. Future study should also consider bone density as a radiographic parameter and its effect on clinical outcomes.

As the population ages, more patients may have contraindications to surgery due to systemic complications, and more patients may wish to receive conservative treatment instead of aggressive treatment. Therefore, the development of comfortable plasters such as
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swim casts is likely to advance [14]. Given the excellent treatment results with palmar locking plates, there is an emphasis on surgical treatment; however, clear guidelines for conservative treatment of distal radius fractures are needed in the future, and we hope that this study will provide a useful perspective and foundation for such guidelines.

Conclusions

In conclusion, our analysis of the radiographic parameter changes associated with conservative treatment of Colles’ fractures over time revealed that the correction loss for UV from immediately after reduction until the final observation was significantly greater in the intramedullary group than in the anatomical and extramedullary groups. Our results suggest that an alternative to conservative treatment may be beneficial for patients with intramedullary fractures.

Conflict of Interest

The Authors declare that there is no conflict of interest.

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Colles骨折に対する保存治療における矯正損失の予測因子としてのX線学的検討

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要旨：中高年者の骨脆弱性を起因とするColles骨折（背側転位型橈骨遠位端骨折）は一般的な外傷であり、多くの整形外科医により治療されている。なかでも掌側ロッキングプレートによる内固定が標準的治療法であるが、近年合併症例の報告も増加している。本研究の目的は、保存的に治療されたColles骨折患者におけるX線パラメータの経時的変化を分析し、骨折タイプがこれらの変化に影響を与えるかどうかを調査することである。本研究は2つの診療所で行われ、Colles骨折を伴う60症例（男性13, 女性47, 平均年齢72.5歳（55～96歳））を対象とした。平均経過観察期間は、4.6ヶ月（1.5～12ヶ月）であった。レントゲン画像上の受傷時の損傷形態は、髄内型（n=15）、解剖型（n=39）、髄外型（n=2）、不明（n=4）であった。まず、非観血的に整復固定を行い、その後、キャスト固定を4週間継続した。整復直後と最終経過観察時の矯正損失は、レントゲン画像における、掌側傾斜（PT）、腕側傾斜（RI）、および尺骨偏位（UV）を用いた。整復直後の損傷形態は、髄内型（n=11）、解剖型（n=42）、髄外型（n=7）であった。UVによる矯正損失は、整復直後に髄内型症例の方が、髄外型および解剖型症例よりも有意に大きかった（P=0.012）。整復直後から最終経過観察時までのUVの矯正損失は、髄内型で有意に大きかったことより、保存的治療を行う際の髄内型症例に対しては、手術治療を含め再整復の獲得などの代替治療を検討する余地がある。キーワード：Colles骨折、矯正損失、レントゲン画像測定、前向き研究、手掌皮質。