RESEARCH ARTICLE

Reliability of Routine Radiographs for Conservatively Treated Metacarpal Shaft and Neck Fractures

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Abstract

Background: To investigate the reliability of orthopedic hand surgeons to evaluate radiographic healing in initial and follow-up radiographs of the conservatively treated metacarpal shaft and neck fractures. The rationale for this study was to reduce the rate of unnecessary, routine radiographs when treating metacarpal fractures.

Methods: Forty sets of digital x-rays, twenty at the initial visit and twenty at the 4-week follow-up, were randomly selected and reviewed. Three hand surgeons evaluated the x-rays for (1) fracture location, (2) radiograph timing, (3) healing status, (4) percentage healed, (5) angulation, and (6) confidence in healing status. Observers reviewed studies in random order and evaluated the same set of radiographs one month after the initial review. Intra- and interobserver agreements were analyzed using Fleiss' kappa (κ) for all parameters and all possible observer pairings.

Results: Interobserver and intraobserver reliability was highest when evaluating fracture location and lowest when assessing the percentage healed. The interobserver reliability was fair for radiograph timing and healing status and fair-to-moderate for angulation. The intraobserver reliability was moderate for radiograph timing and healing status and moderate-to-substantial for angulation. Observers correctly differentiated initial vs. follow-up images 62% of the time and reported to feel somewhat certain in their evaluation of healing status.

Conclusion: When evaluating initial and 4-week follow-up radiographs, hand surgeons were somewhat confident in their assessment of healing but had less than substantial intra- and interobserver reliability following radiographic evaluation. Due to their poor reproducibility, routine radiographs may be unnecessary when evaluating conservatively treated metacarpal fractures. Further studies and guidelines that identify clear indications for the use of routine imaging in metacarpal fracture care are warranted.

Level of evidence: II

Keywords: Fracture, Metacarpal, Radiographs, Reliability, X-ray

Introduction

Metacarpal fractures are among the most common injuries to the hand, with an estimated incidence of 8.4 per 10,000 person-years.[1] The majority of nondisplaced metacarpal fractures can be treated without surgery, which provides satisfactory outcomes.[2] Conservative treatment typically involves 3-4 weeks of immobilization with a cast, splint, brace, or buddy taping. These patients are then followed to assess for interval healing through clinical visits, often at 2, 4, and/or 6 weeks.[3–5] However, there still remains a lack of consensus regarding the optimal follow-up and interval assessment strategies for these fractures.[6–9]

The utility of routine radiographs for patients with

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conservatively managed metacarpal fractures has been an ongoing area of controversy.[2,3,10] Some authors have called into question the value of follow-up visits altogether, recommending only open fractures or those angulated beyond 50^0 be evaluated in follow-up.[5,11] Additional reports have also questioned the routine use of lateral views in managing fourth and fifth metacarpal fractures.[12] While the elimination of follow-up visits reduces financial burden and improves patient satisfaction without compromising clinical outcomes, it still remains common practice for patients to undergo routine imaging and follow-up for up to 6 weeks. [3,5,10,11] Further study is necessary to identify the utility of follow-up radiographs for nonoperatively treated metacarpal fractures.

The purpose of the present study is to investigate the reliability of the assessment of radiographic healing in initial and follow-up x-rays of the conservatively treated metacarpal shaft and neck fractures. We hypothesize that hand surgeons will show poor agreement when assessing the healing status of these fractures, despite being confident in doing so.

Materials and Methods

Institutional review board approval, with a waiver of informed consent, was obtained prior to the initiation of the study. A retrospective review was performed to identify all metacarpal fractures treated conservatively by a single fellowship-trained orthopedic surgeon from 2017-2020. Inclusion criteria included patients with the metacarpal shaft or neck fractures immobilized with a cast or splint and a minimum of one follow-up visit at four weeks post-injury. Seventy-five patients were identified, and an archived search of the digital imaging software system (PACS, SECTRA) was performed. Patients with first metacarpal or metacarpal base fractures, those lost to follow-up, those converted to open reduction with internal fixation, or those missing both initial and follow-up radiographs were excluded. Forty digital x-rays (including anteroposterior [AP], lateral and oblique views), twenty at the initial visit and twenty at the 4-week follow-up, were used as the basis for this study.

The x-rays were reviewed by three fellowship-trained orthopedic hand surgeons (J.M.K., D.A.S., P.K.B.). Radiographs were evaluated for (1) fracture location (shaft vs. neck), (2) radiograph timing (initial vs. follow-up), (3) healing status (healed vs. partially healed vs. not healed), (4) percentage of healing, if partially healed (<33% vs. 34-66% vs. >67%), (5) AP and lateral angulation (degrees), and (6) reviewer confidence in their choice of healing status (not very vs. somewhat vs. very). All angulation measurements were made using the mid- medullary canal method.[13,14] Each surgeon independently reviewed the same set of 40 radiographs, which were blinded to all patient information. To evaluate reliability within each observer, surgeons were asked to evaluate the same set of radiographs one month after the initial review in random order.

Intra- and interobserver agreements were analyzed using the Fleiss' kappa (κ) for all parameters and all possible observer pairings. Weighted κ was used to assess numerical values of AP and lateral angulation. Established guidelines defined for κ agreement were used for interpretation. [15] Estimates of radiograph timing and observer confidence ratings were reported as percentages. The sample size was determined based on the methods described by Matzon et al.16 and Donner and Rotondi.17 We estimated an interobserver κ agreement of $\kappa^0 = 0.80$, minimally acceptable limit of $\kappa^0 = 0.60$, and anticipated detection of healing (π) of 0.30 across 3 observers to be clinically acceptable. These pre-specified values yielded a minimum sample size of 31 patients. All statistical analyses were performed using IBM SPSS Statistics (Version 27).

Results

Table 1 summarizes inter- and intraobserver variability when evaluating fracture location, radiograph timing, healing status, and angulation. Average interobserver agreement was highest for fracture location (κ = 0.83, almost perfect) and lowest for percentage healed (κ = 0.02, slight). There was fair interobserver reliability when evaluating radiograph timing (κ = 0.39), healing status (κ = 0.31), and AP angulation (κ = 0.31). For angulation measurements, interobserver reliability was stronger for lateral views (κ = 0.41, moderate) compared to AP views (κ = 0.31, fair). On average, the intraobserver agreement was highest for fracture location (κ = 0.93, almost perfect) and lowest for percentage healed (κ = 0.44, moderate). There was moderate intraobserver reliability when evaluating radiograph timing (κ = 0.55), healing status (κ = 0.56) and AP angulation (κ = 0.55), and substantial reliability for lateral angulation (κ = 0.66) [Table 1].

Overall, observers correctly gauged radiograph timing (initial x-ray vs. follow-up x-ray) 62% of the time (range, 48%-70%). Observers reported feeling "not very" confident in healing status in 18% of reads, "somewhat" confident in 49% of reads, and "very" confident in 33% of reads. On a scale of 1 (not very confident) to 3 (very confident), observers reported a mean (±SD) confidence level of 2.1±0.7 when evaluating healing status.

Table 1. Average Intra- and Interobserver Reliability (κ) in Assessing Fracture Location, Radiograph Timing, Healing Status, and Angulation

	Interobserver	Intraobserver
Location	0.83	0.93
Radiograph Timing	0.39	0.55
Healing Status	0.31	0.56
Percent Healed (if partial)	0.02	0.44
Angulation (AP)*	0.31	0.55
Angulation (lateral)*	0.41	0.66

*=Weighted kappa

Discussion

The present study aimed to investigate the reliability of the assessment of radiographic healing in initial and follow-up x-rays of the conservatively treated metacarpal shaft and neck fractures. Our findings suggest that despite being somewhat confident in their evaluations, orthopedic hand surgeons have poor reliability when assessing radiographic healing and angulation in the metacarpal shaft and neck fractures. While observers were found to have an almost perfect agreement when evaluating fracture location, there was only slight agreement when assessing healing status in partially healed fractures. Moreover, when asked to identify the timing of radiographs, surgeons were able to differentiate initial injury and follow-up x-rays less than 2/3 of the time. The inability of surgeons to consistently differentiate between acute and 4-week-old fractures suggests that routine 4-week x-rays of metacarpal fractures are unlikely to provide additional benefit.

There remains a lack of consensus concerning the management of metacarpal shaft and neck fractures. In particular, many have debated the utility of routine radiographs and follow-up visits for metacarpal fractures treated nonoperatively.[5,10–12,18,19] Braakman et al. first reported against the use of routine radiographs for conservatively treated fourth and fifth metacarpal fractures, suggesting that physical examination findings of instability or loss of reduction should serve as the sole indicator for follow-up imaging.[10] In a later article, Braakman12 studied the utility of routine lateral x-rays, reporting that findings from lateral views only influenced clinical decisions in 7% of metacarpal fracture cases. As a result, it was proposed that lateral x-rays are best indicated only after a proximal comminution or anteroposterior dislocation is first confirmed on AP or oblique views.[12] Our results contradict these findings and indicate that lateral x-rays serve useful in measuring angulation, as surgeons showed improved intra- and interobserver agreement when assessing angulation on lateral views compared to AP views.

While prior reports have explored the removal of sequential radiographs and follow-up visits for conservatively treated metacarpal fractures, evidence-based recommendations have yet to be established. In contrast, current guidelines on nonoperative management of distal radius fractures recommend that reduced imaging frequency is financially beneficial and does not negatively affect functional outcomes.[20–22] Furthermore, when studying closed treated distal radius fractures, Tantigate et al.[23] found that radiographic parameters changed minimally after 3 weeks post-reduction. The authors suggest that radiographic changes made prior to 3-week follow-up visits are most useful in predicting poorer outcomes in these patients.23 Similar studies are warranted for metacarpal fractures to identify time periods of highest risk for changes in radiographic parameters, malalignment, and worsened function.

The present study has several limitations. First, unlike actual clinical practice, surgeons evaluated radiographic parameters in isolation and were blind to clinical findings. It is likely that knowledge of clinical evaluations would improve a surgeon's ability to interpret radiographic measures and increase their confidence level in doing so. Second, our study did not report on the accuracy of fracture location, healing status or angulation. Although this would have been valuable, there are currently no gold standards for the measurement of these parameters. Nevertheless, the aim of our study was to assess the reliability of surgeons' assessments for conservatively treated metacarpal shaft and neck fractures. Finally, the use of 4 weeks as a time point for repeat radiography is somewhat arbitrary and based on physician preference. In our cohort, all patients were clinically evaluated following 4 weeks of immobilization to discern for persistent symptoms and radiographic healing and alignment. By obtaining follow up x-rays at a later date, this may improve the ability of the evaluating physician to discern the formation of bony callus, and thus improve agreement in evaluating healing.

Our findings suggest less than substantial intra- and interobserver reliability exists, even amongst experienced board-certified orthopedic hand surgeons, when evaluating initial and 4-week follow-up radiographs for the metacarpal shaft and neck fractures. Given this poor reproducibility, one may question the true utility of routine radiographic evaluation at this stage in nonoperative treatment. There exists growing evidence in support of reducing serial follow-up and radiographic assessment for conservatively treated metacarpal fractures. However, further high-quality studies and guidelines are warranted that identify clear indications for the use of routine imaging in metacarpal fracture care.

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