Sensitivity and Specificity of Radiographs in the Diagnosis of Little and/or Ring Carpometacarpal Joint Injuries

Sami Hassan[1] Abdul Aziz[1] Nicholas D. Downing[1] Ryan W. Trickett[2]

[1]Department of Hand Surgery and Orthopaedic Trauma, Queen's Medical Centre, Nottingham University Hospitals, Nottingham, United Kingdom
[2]Department of Trauma and Orthopaedic, Cardiff and Vale University Health Board, University Hospital of Wales, Cardiff, United Kingdom

Address for correspondence Sami Hassan, MBChB, FRCS (Tr&Orth), Department of Hand Surgery and Orthopaedic Trauma, Queen's Medical Centre, Nottingham University Hospitals, Derby Road, Nottingham NG7 2UH, United Kingdom (e-mail: drsamihassan@gmail.com).

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Abstract

Introduction Little and ring finger carpometacarpal joints (CMCJs) injuries are commonly missed due to misinterpretation of radiographs. We aimed to determine the sensitivity and specificity of four different radiographic views.

Materials and Methods Radiographs (posteroanterior [PA], lateral [LAT], pronated oblique [POL], and supinated oblique [SOL] views) showing normal findings or little/ring finger CMCJ injuries were shown to two cohorts of orthopaedic trainees and a cohort of emergency nurse practitioners.

Results The POL view performed best in all three testing scenarios. The SOL view performed least well. The combination of a PA, true LAT, and POL identified 78% of injuries correctly. In no cases did the SOL view correctly identify an injury when the other three views had been interpreted as normal.

Conclusion We recommend a combination of the PA, POL, and LAT views in diagnosing these injuries. Where doubt remains, cross-sectional imaging is essential.

Keywords
- carpometacarpal
- dislocation
- fracture
- hamate
- metacarpal

Introduction

Fracture–dislocations of the ring and little finger carpometacarpal joints (CMCJs) are thought to be common injuries.[1] Often the result of blunt trauma, such as a punch to a hard surface,[2] patients usually present with a grossly swollen hand. This swelling can make eliciting clinical signs difficult.[3] In addition, the interpretation of routine radiographs can be challenging and can potentially lead to a missed diagnosis.[1,3] Missed or delayed diagnosis may result in suboptimal outcomes—pain, stiffness, and weakness of grip, often secondary to degenerative arthritis of the joint(s)[4]—although this was contested by some.[5] The results of salvage surgery are also disputed, having been associated with both poor and reasonable results.[6,7] Successful reduction and stabilization are associated with favorable results, albeit with some loss of grip strength compared with the contralateral side.[8] The optimal management of these injuries remains unknown.[9]

Several techniques were suggested to maximize the diagnostic yield of simple radiographs. Bora and Didizian (1974)[10] suggested a view taken in 30 degrees from full supination to maximize visualization of the palmar aspect of the fifth CMCJ. A similar view taken in 30 degrees pronation from neutral was also suggested.[11] The metacarpal cascade lines on the posteroanterior (PA) view described by Hodgson and Shewring (2007)[1] showed to significantly improve the diagnostic accuracy. Where uncertainty remains, computed tomography scan is warranted.[11]

The purpose of this study was to determine the sensitivity and specificity of routine plain radiographic views in diagnosing little and ring finger CMCJ injuries, and how this varied depending on the observer.

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Materials and Methods

Four patients with confirmed bony injuries to the little and ring finger CMCJs were identified from our trauma records. All patients had fracture-dislocations to the little (and ring) CMCJ complex. Each had been treated surgically for their injuries. Preoperatively, each had undergone four separate radiographic views PA, lateral (LAT), pronated oblique (POL), and supinated oblique (SOL) (►**Fig. 1**). Four control patients were identified from the hospital digital radiograph system. Each had undergone the same four radiographic views for an injury distant from the ulna side of the hand and had normal radiographic appearances throughout. The resulting 32 radiographs (four radiographs for each of the eight patients) were anonymized and each one duplicated once. The duplicate was mirrored in the vertical plane and the resultant 64 radiographs randomly ordered. Thus, each radiographic view was represented 16 times, with 8 demonstrating a little and/or ring finger CMCJ injury and 8 controls.

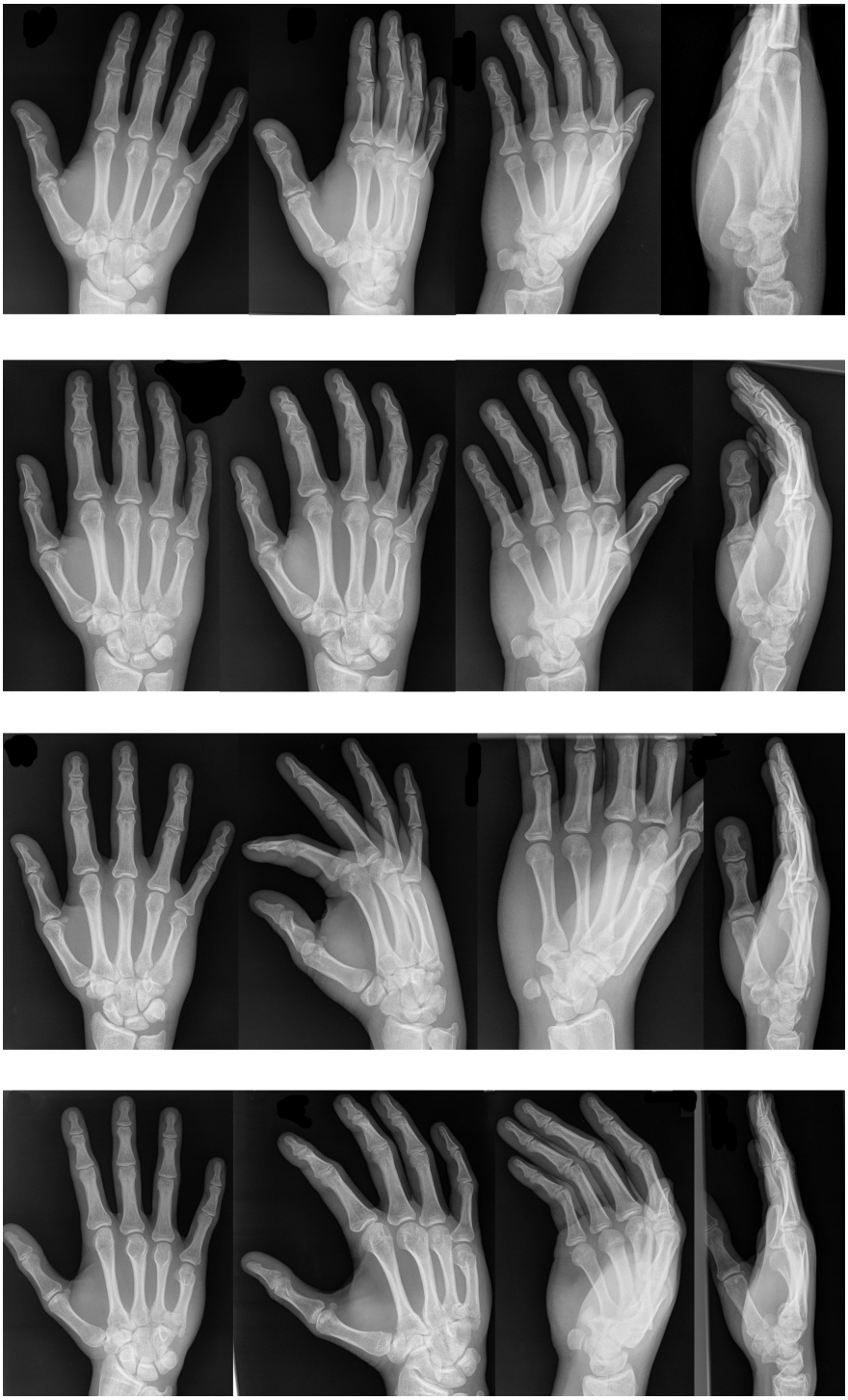

Fig. 1 The four fracture–dislocation radiograph sets used throughout the study demonstrating the fracture–dislocation with a bony injury to the hamate.

Informed consent was obtained from all individual participants in the study. All radiographs were shown to a group of orthopaedic higher trainees (equivalent to residents in dedicated orthopaedic training postgraduate years 4–10) (n = 17) in a timed test (Test 1). The trainees were asked for spot diagnoses for each radiograph, without prior knowledge of the purpose of the study or a case history applicable to the radiograph. Trainees were given 30 seconds for each radiograph. This test was repeated at a later date with a different cohort of similar level trainees (n = 11) with the addition of a single clinical picture at the start of the test demonstrating ulna-sided hand swelling, labeled with a star indicating tenderness at the little finger CMCJ (Test 2). These timed tests were designed to mimic the "quick look at an X-ray scenario" often encountered in a busy emergency department (ED).

Table 1 The radiograph viewing order for Test 3

Case	Radiograph viewing order			
	First	Second	Third	Fourth
1	PA	LAT	PRO	SUP
2	LAT	PRO	SUP	PA
3	PRO	SUP	PA	LAT
4	SUP	PA	LAT	PRO

Abbreviations: LAT, lateral; PA, posteroanterior; PRO, pronation; SUP, supination.

The staffing challenges in modern EDs have seen an increased role for emergency nurse practitioners (ENPs), who are often responsible for the diagnosis and management of "minor" hand injuries.

The same eight cases (four injuries and four controls) were shown to 28 ENPs, in an untimed test, sequentially showing all radiographs from each case but with no clinical history. Duplicate radiographs were removed and the order of views for each case was varied (►**Table 1**).

Sensitivity (number of true positives divided by the number of true positives and false negatives) and specificity (number of true negatives divided by the number of true negatives and false positives) were calculated for each view. The positive predictive value (number of true positives divided by the number of true positives and false positives) and the negative predictive value (number of true negatives divided by the number of true negatives and false negatives) were also calculated.

Results

The sensitivity, specificity, positive predictive value, and negative predictive value were calculated for each radiographic view in each of the three test situations. The overall accuracy of each view was also calculated taking into account both the correctly identified normal and injured hands (►**Table 2**).

Table 2 Sensitivity, specificity, PPV, NPV, and total correct diagnoses for each of the radiographic views across the three tests

		Test 1	Test 2	Test 3	Test 1 + 3
		Timed, no history, (resident equivalent)	History and clinical photograph, (resident equivalent)	Untimed, (ENP)	No history, (resident equivalent and ENP)
PA	Sensitivity (%)	92.6	86.4	17.8	24.1
	Specificity (%)	33.8	34.1	45.2	64.0
	PPV (%)	58.3	56.7	24.5	40.1
	NPV (%)	82.1	71.4	35.5	45.7
	Total correct (%)	63.2	60.2	31.5	44.0
LAT	Sensitivity (%)	89.0	60.2	26.0	38.7
	Specificity (%)	58.1	77.3	46.6	63.4
	PPV (%)	68.0	72.6	32.7	51.4
	NPV (%)	84.0	66.0	38.6	50.8
	Total correct (%)	73.5	68.8	36.3	51.0
POL	Sensitivity (%)	95.6	79.5	31.7	47.4
	Specificity (%)	71.3	84.1	45.2	65.1
	PPV (%)	76.9	83.3	36.7	57.6
	NPV (%)	94.2	80.4	39.8	55.3
	Total correct (%)	83.5	81.8	38.5	56.3
SOL	Sensitivity (%)	77.9	38.6	12.5	18.3
	Specificity (%)	27.2	68.2	43.8	57.3
	PPV (%)	51.7	54.8	18.2	30.0
	NPV (%)	55.2	52.6	33.3	41.2
	Total correct (%)	52.6	53.4	28.1	37.8

Abbreviations: ENP, emergency nurse practitioners; LAT, lateral; NPV, negative predictive value; PA, posteroanterior; POL, pronated oblique; PPV, positive predictive value; SOL, supinated oblique.

The lowest overall accuracy was seen in Test 3, where an injury to the little and ring finger CMCJs was overlooked despite viewing all the four radiographs in 22% of cases. All the four radiographic views yielded more correct diagnoses when tested as a spot diagnosis without a clinical scenario than when viewed with the benefit of the relevant clinical history and a photograph.

Discussion

A variety of factors can lead to a missed or delayed diagnosis of little and ring finger CMCJ injuries including delayed presentation. Clinical deformity can be hard to appreciate.[4] In this situation, a nonspecific set of radiographs screening for "hand injury" without a specific diagnosis in mind may be obtained usually in the ED two or three from the PA, SOL, POL, and LAT views. The commonest views are usually a PA and oblique.[1] The standard protocol in our level 1 trauma center is to provide a PA, SOL, and LAT, and then an additional POL if diagnostic doubt remains.

Our results demonstrated the POL view to be the most sensitive in diagnosing little and ring finger CMCJ injuries. The POL view also yielded the most correct diagnoses considering all conducted tests.

Both the POL and LAT had a good negative predictive value, successfully excluding the diagnosis. Contrary to Dennyson and Stother (1976),[12] both Henderson and Arafa (1987)[13] and Storm (1988)[14] found the LAT view useful in excluding injury. In the scenario of a swollen, painful ulna side of hand, it is useful in diagnosing dorsal triquetral fractures—an important differential, albeit usually with a different mechanism of injury.

The SOL view performed the worst in all tests. More importantly, in Test 3, the SOL view did not correctly identify a fracture in patients where the other three views were thought to be normal, and therefore, did not confer additional benefit.

An unexpected observation was that the provision of a clinical history and photograph did not improve the overall accuracy. Only the SOL showed an improvement, while accuracy of the other three views was reduced. While this was an observed difference, post hoc testing of difference using Pearson's chi-square test (two sided) demonstrated it to be nonsignificant (chi-square = 0.896 [1], $p = 0.353$).

In our institution, between September 2013 and September 2014, there were 179 little and/or ring CMCJ fractures and/or dislocations. All suspected ulna side metacarpal injuries were provided a PA and SOL views as standard, with the LAT view added if a fracture was suspected on other views by the radiographer or requested individually by the clinician. We have shown that the PA and SOL views would be better replaced by the PA and POL views. A LAT view could be added in those patients with no diagnosis confirmed on these two views, improving the negative predictive value.

There is an increasing trend for litigation concerning hand and wrist pathology.[15,16] Compensation for a single missed CMCJ fracture–dislocation of £177,814 (approximately $228,682) has been reported.[17] The spectrum of hand injury expertise varies considerably between hospitals and nations. Those established and dedicated hand surgery services may have more experience and thus better diagnostic accuracy. However, with an increasing role for physicians' assistants and ENPs within EDs and minor injury units, appropriate education and continuing professional development are paramount. In our study, more than one-fifth of injuries were missed in the ENP test, although these were without the aid of a clinical scenario.

A stepwise approach using cascade lines as exemplified by Hodgson and Shewring (2007)[1] would be the most systematic way to approach these suspected injuries. Their method involves the use of superimposed lines through the central longitudinal axis of each digit, with all lines converging toward a common focal point 2 cm proximal to the distal radius articular surface in a normal CMCJ complex (►**Fig. 2**). The "metacarpal cascade lines" provide very few false positives and importantly increased the diagnostic rate from 81.5 to 94.3% in their cohort, and even improved diagnostic accuracy when used by senior surgeons.[10]

A comprehensive history, clinical examination, and appropriate radiographic investigations are the most reliable way to make the correct diagnosis and avoiding the morbidity associated with these injuries. Targeted education is vital for clinicians, such as ENPs, and inexperienced doctors dealing with acute hand trauma.

Our recommendations are as follows:

1. Standardized radiographic views PA, true LAT, and POL to optimize radiographic diagnosis of fracture or dislocation. A tangential POL view (~15–20 degrees pronated from the LAT position) gives a good lateral view of the

Fig. 2 The metacarpal cascade lines.

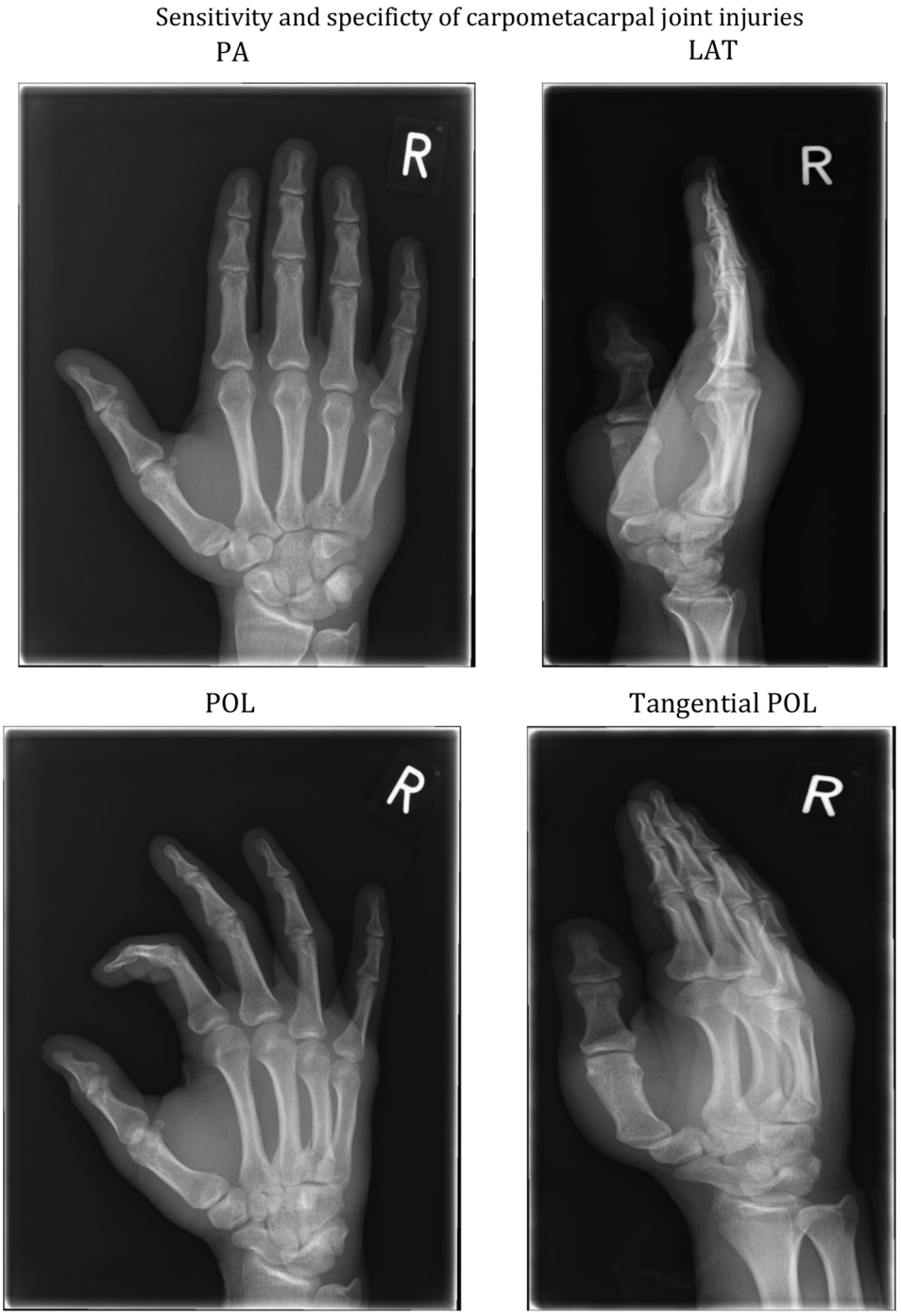

Fig. 3 Multiple views in a patient with a punch injury. The tangential pronated oblique as evidenced by the lateral projection of the fourth and fifth metacarpals shows a small fragment corresponding with the dorsal lip of the hamate. At surgery, the fifth metacarpal was easily dislocatable, and transarticular wiring was performed. LAT, lateral; PA, posteroanterior.

bases of the ring and little fingers (avoiding superimposing the index and middle metacarpals), as well as the dorsal cortex of the hamate. This is useful for detecting subtle hamate fractures, which may suggest instability (►**Fig. 3**) and should be requested in the presence of ulna border hand pain.

2. The LAT view could be considered optional and added to rule out triquetral injury if the other radiographs were negative.
3. Education remains the key to successful diagnosis. An emphasis on "metacarpal cascade lines" will likely improve radiographic diagnosis for all levels of expertise.
4. Perhaps most importantly, ED staff should have a high index of suspicion and a low threshold of referral for a specialist hand surgery opinion.

Conflict of Interest
None declared.

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