

Diagnostic accuracy of history taking, physical examination and imaging for phalangeal, metacarpal and carpal fractures: a systematic review update.

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Abstract

Background The standard diagnostic work-up for hand and wrist fractures consists of history taking, physical examination and imaging if needed, but the supporting evidence for this work-up is limited. The purpose of this study was to systematically examine the diagnostic accuracy of tests for hand and wrist fractures.

Methods A systematic search for relevant studies was performed. Methodological quality was assessed and sensitivity (Se), specificity (Sp), accuracy, positive predictive value (PPV) and negative predictive value (NPV) were extracted from the eligible studies.

Results Of the 35 eligible studies, one described the diagnostic accuracy of history taking for hand and wrist fractures. Physical examination with or without radiological examination for diagnosing scaphoid fractures (five studies) showed Se, Sp, accuracy, PPV and NPV ranging from 15-100%, 13-98%, 55-73%, 14-73% and 75-100%, respectively. Physical examination with radiological examination for diagnosing other carpal bone fractures (one study) showed a Se of 100%, with the exception of the triquetrum (75%). Physical examination for diagnosing phalangeal and metacarpal fractures (one study) showed Se, Sp, accuracy, PPV and NPV ranging from 26-55%, 13-89%, 45-76%, 41-77% and 63-75%, respectively. Imaging modalities of scaphoid fractures showed predominantly low values for PPV and the highest values for Sp and NPV (24 studies). Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Ultrasonography (US) and Bone Scintigraphy (BS) were comparable in diagnostic accuracy for diagnosing a scaphoid fracture, with an accuracy ranging from 85-100%, 79-100%, 49-100% and 86-97%, respectively. Imaging for metacarpal and finger fractures showed Se, Sp, accuracy, PPV and NPV ranging from 73-100%, 78-100%, 70-100%, 79-100% and 70-100%, respectively.

Conclusions Only one study was found on the diagnostic accuracy of history taking for hand and wrist fractures in the current review. Physical examination was of moderate use for diagnosing a scaphoid fracture and of limited use for diagnosing phalangeal, metacarpal and remaining carpal fractures. MRI, CT and BS were found to be moderately accurate for the definitive diagnosis of clinically suspected carpal fractures.

Background

Hand and wrist injuries are among the most common traumatic presentations to the emergency department [1, 2], and commonly affect young people of working age [3, 4]. Scaphoid fractures are the most frequently injured carpal bones, accounting for 61–90% of fractures [4–6]. The diagnosis of a scaphoid fracture may however be difficult to establish on a conventional radiograph [7, 8]. Previous research has shown that 10–35% of scaphoid fractures are missed on primary radiographs [4, 9–12]. Metacarpal fractures are detected in 30–40% of all hand fractures in all emergency department admissions [4, 9, 10].

Hand and wrist injuries represent a considerable economic burden, with high health-care and productivity costs [13]. The total costs have been estimated at US \$410 million per year, with US \$307 million in productivity costs [14].

If not treated properly, patients with hand and wrist injuries may experience lifelong pain and lose their job, which also has major effects on their quality of life [15]. Accurate diagnosis and early treatment of hand and wrist fractures are important because missed diagnosis and delayed initiation of therapy increase the risk of complications and subsequent functional impairment [16–22].

In recent decades, research has predominantly focused on imaging modalities for the diagnosis of wrist fractures. However, the standard diagnostic work-up for wrist complaints that are suspected fractures should also include detailed patient history taking, a conscientious physical examination and, only if needed, imaging [23]. It has been shown that different provocative tests are somewhat useful for diagnosing wrist fractures [24–27], but there is no consensus on imaging protocols due to limited evidence regarding the diagnostic performance of these advanced imaging techniques [28]. Therefore, diagnosing wrist pathologies remain complex and challenging and there is increasing demand for evidence for accurate diagnostic tools [29].

Diagnostic studies performed in hospital care cannot automatically be translated into guidelines for non-institutionalized general practitioner care [30]. The clinical utility of diagnostic tests for hand and wrist fractures is hindered by the low prevalence of true fractures, approximately 7% on average [31].

Currently, there are several systematic reviews available on the diagnostic accuracy of tests for the diagnosis of hand and wrist fractures, as presented in Table 1 [32–39]. Of these, only the review by Carpenter et al. used ‘history’ as a keyword in their search terms, but they could not find studies assessing the diagnostic accuracy of history for scaphoid fractures [37]. All the available systematic reviews only examined diagnostic tests for scaphoid fractures [32–39], while in practice it is often not quite clear during the diagnostic process which hand or wrist anatomical structure or tissue (soft tissue or bone) is affected.

Therefore, the purpose of this literature review is to provide an up-to-date systematic overview of the diagnostic accuracy of history taking, physical examination and imaging for phalangeal, metacarpal and carpal fractures and to distinguishing between studies in hospital and non-institutionalized general practitioner care settings, as test properties may differ between settings.

Methods

Data Sources and Searches

A review protocol was drafted, but central registration was not completed. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement was used to guide the conduct and reporting of the study [40]. A Biomedical Information specialist (Wichor M. Bramer) performed a search for

studies in Medline, Embase, Cochrane Library, Web of Science, Google Scholar ProQuest and Cinahl from 2000 up to 6 February 2019. This starting point was used since multiple reviews are available that already cover the period up to the year 2000 (Table 1). Search terms included phalangeal, metacarpal and carpal injuries, anamnestic assessment, provocative test(s), diagnostic test(s) and imaging tests. The full electronic search strategy for the Embase database is presented in Table 2 (the others are available upon request).

Study Selection

The following selection criteria were used: (1) The study investigated the diagnostic accuracy using (2) history taking, physical examination or imaging as an index test for detecting (3) phalangeal, metacarpal and carpal fractures in (4) an adult study population (age ≥ 16 years). (5) No language restriction was applied and (6) case reports, reviews and conference proceedings were excluded. (7) Distal radius and ulna injuries were also excluded, as they can be diagnosed accurately with plane X-ray or computer tomography imaging.

Two reviewers (PK, YA) read all titles and abstracts independently. Articles that could not be excluded on the basis of the title and/or abstract were retrieved in full text and were read and checked for inclusion by the two reviewers independently. If there was no agreement, a third reviewer (JR) made the final decision. In addition, the reference lists of all included studies were reviewed to check for additional relevant studies.

Data Extraction and Methodological Quality Assessment

Two reviewers (PK, JR) independently extracted the data. Data were extracted describing the study design, characteristics of the study population, test characteristics, study population setting (hospital care or non-institutionalized general practitioner care) and diagnostic parameters. Methodological quality was assessed by two independent reviewers (PK, JR), using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) checklist [41]. Disagreements were resolved by discussion.

Heterogeneity

Key factors in a meta-analysis are the number and the methodological quality of the included studies and the degree of heterogeneity in their estimates of diagnostic accuracy [42]. Heterogeneity in diagnostic test accuracy reviews is expected and the possibilities of performing meta-regression analyses will depend on the number of studies available for a specific index test that provide sufficient information [34]. The data from the included studies were combined when studies showed no limitations according to QUADAS-2 and had no other forms of bias (e.g. incorporation bias).

Data Synthesis and Analysis

The following values were extracted, if documented: sensitivity (Se), specificity (Sp), accuracy, positive predictive value (PPV), negative predictive value (NPV) and likelihood ratio (LR). If these diagnostic outcomes were not reported, they were calculated using published data. If an included study presented results from multiple independent observers, the measures of Se, Sp, accuracy, PPV and NPV were averaged over the observers.

Index Test

Diagnostic tools such as history taking, physical examination or imaging were accepted as index tests.

Reference Standard

There is no consensus about the reference test for the diagnosis of a true fracture of the phalangeal, metacarpal or carpal bones [32]. Therefore, in this systematic review clinical outcome (physical examination or additional treatment) and/or various (combined) imaging modalities during follow-up were used as the reference standard for confirming diagnosis of phalangeal, metacarpal or carpal fractures.

Results

The flow diagram is presented in Figure 1. A total of 35 diagnostic studies were identified, assessed and interpreted. The characteristics of these studies are presented in Table 3. 20 studies were performed in an emergency department, four studies in a traumatology setting and three other studies in a radiology department. The patients in the studies by Mallee et al. [54, 58, 60] were derived from one prospective study; therefore the setting was the same for each study: patients were initially seen by the emergency physicians and in follow-up by the orthopaedic department and/or trauma surgery department, depending on who was on call. In five studies the setting was not specified. To our knowledge, all first authors of those five studies were working in a hospital care setting, so we assume all to have been done in hospital care. History taking, physical examination and imaging as index tests were investigated in 0%, 20% (7/35) [43, 44, 46, 47, 67, 71, 74] and 86% (30/35) [47–73, 75–77] of the studies, respectively.

Quality Assessment

There was considerable underreporting of important quality domains in 23 of the 35 studies (see Table 4). In 13 of the 35 studies [43, 44, 51, 53, 56, 57, 59, 61, 62, 70, 71, 73, 74], patient selection was not well documented. Furthermore, the risk of bias was predominantly due to the absence of a proper description of the index test (9/35) [43, 47, 49, 51, 55, 57, 61, 65, 71] or the reference standard (13/35) [43, 46, 49, 51, 52, 55, 57, 65, 67, 69, 72, 74, 75]. Twelve of the studies (34%) demonstrated no limitations when risk of bias was assessed, according to QUADAS–2 [45, 48, 50, 54, 58, 60, 63, 64, 66, 68, 76, 77]. Eight showed incorporation bias [46, 48–52, 68, 76].

Diagnosing Carpal Fractures in Hospital Care

Table 5 presents the accuracy of the diagnostic tests of all the carpal fractures. One study described the diagnostic accuracy of history taking by asking for patients' pain score, using the Visual Analogue Scale method with anatomical snuffbox tenderness [74]. Physical examination [43, 44, 46, 47] and combined physical and radiological examination [45] for diagnosing scaphoid fractures showed Se, Sp, accuracy, PPV and NPV ranging from 15–100%, 13–98%, 55–73%, 14–73% and 75–100%, respectively.

Repeated physical examination with radiological examination after 38 days [45] for diagnosing other carpal bone fractures showed a Se of 100% with the exception of the triquetrum (75%).

Radiographs used as an index test for diagnosing scaphoid fractures showed Se, Sp, accuracy, PPV and NPV ranging from 25–87%, 50–100%, 48–88%, 14–100% and 49–94%, respectively. For diagnosing scaphoid fractures, Magnetic Resonance Imaging (MRI) as an imaging modality showed Se, Sp, accuracy, PPV and NPV ranging from 67–100%, 89–100%, 85–100%, 54–100% and 93–100%, respectively. Multi Detector Computed Tomography (MDCT) showed Se, Sp, accuracy, PPV and NPV ranging from 33–100%, 85–100%, 79–100%, 28–100% and 86–100%, respectively. Bone Scintigraphy (BS) as an index test for diagnosing scaphoid fractures showed Se, Sp, accuracy, PPV and NPV ranging from 78–100%, 87–97%, 86–97%, 62–78% and 90–100%, respectively. For diagnosing scaphoid fractures, Ultrasonography (US) as an imaging modality showed Se, Sp, accuracy, PPV and NPV ranging from 78–100%, 34–100%, 49–100%, 30–100% and 75–100%, respectively.

Diagnosing Phalangeal and Metacarpal Fractures in Hospital Care

Table 5 also presents the accuracy of the diagnostic tests for metacarpal and/or phalangeal fractures, as described in six studies [67, 69–73]. Physical examination [71] for diagnosing phalangeal and metacarpal fractures showed Se, Sp, accuracy, PPV and NPV ranging from 26–55%, 13–89%, 45–76%, 41–77% and 63–75%, respectively. Imaging for metacarpal and finger fractures showed Se, Sp, accuracy, PPV and NPV ranging from 73–100%, 78–100%, 70–100%, 79–100% and 70–100%, respectively. The reported diagnostic accuracy measures of phalangeal and metacarpal fractures were characterized by markedly heterogeneous results among the eligible studies.

Combined Diagnostic Accuracy of the Studies with No Limitations and No Incorporation Bias

Table 6 shows combined diagnostic accuracy measures of the studies that had no limitations and no incorporation bias. A wide range of results were found for the specificity, accuracy and NPV of MRI, US, CT and BS. The sensitivity of BS and US showed similar, acceptable results. US and MRI are imaging tools that have similar PPV, but with large confidence intervals.

Discussion

In previous reviews, no studies were identified on the diagnostic accuracy of history taking for phalangeal, metacarpal or carpal fractures. In the current systematic review, only one such study was identified. This update included one extra study on physical examinations for diagnosing scaphoid fractures in hospital care, which was not included in previous reviews [44]. Based on these results and those presented in the previous reviews, physical examination is of moderate use for diagnosing a scaphoid fracture. Physicians should be aware that tenderness in the anatomical snuff box (ASB), tenderness over the scaphoid tubercle and pain on longitudinal compression of the thumb have limited added value in a diagnostic process for a scaphoid fracture.

The present systematic review identified eight supplementary imaging studies [52, 60, 65, 66, 70, 75, 76, 77], subdivided into MRI [52], CT [52, 60, 75–77], BS [52] and US [65, 66, 70]. The overall conclusion is that imaging tests were found to be moderately accurate for a definitive diagnosis. However, the standard diagnostic work-up for wrist complaints suspected of being a fracture should also include detailed patient history taking, a conscientious physical examination and, only if needed, imaging [23]. Diagnostic studies focusing on history taking and physical examination of patients with suspected phalangeal, metacarpal and carpal fractures are therefore desired.

Compared with previous reviews, the current systematic review attempted to distinguish between studies based on their setting. Remarkably, no studies examined the diagnostic accuracy of any diagnostic test for phalangeal, metacarpal and carpal fractures in a non-institutionalized general practitioner care setting. It is known that results from hospital care cannot automatically be translated into guidelines for non-institutionalized general practitioner care. For that reason, it is not possible to advise general practitioners properly on the diagnosis of carpal, metacarpal and phalangeal fractures based on the currently available literature. Given the burden of finger, hand and wrist fractures on non-institutionalized care and the importance of proper diagnoses, diagnostic studies focusing on phalangeal, metacarpal and carpal fractures in non-institutionalized general practitioner care are urgently needed [2].

Methodological Quality Assessment

The methodological quality of the eligible studies included in this update was limited, which might affect the estimates of diagnostic accuracy. Many of the included studies had methodological flaws and lacked the necessary details to replicate the studies. There was considerable underreporting of important domains in most of the included studies. The studies in this and previous systematic reviews also had the inherent risk of publication bias. As the mechanisms of publication bias are not yet well understood for diagnostic accuracy studies, there are currently no assessment tools available to investigate this risk other than graphical interpretation. Furthermore, several studies demonstrate incorporation bias, with the risk of overestimation of the diagnostic accuracy [78].

Diagnostic Accuracy of the Diagnostic Tests for Phalangeal and Metacarpal Fractures

The identified studies evaluated a variety of metacarpal and phalangeal pathologies. US may be an option for detecting metacarpal fractures and prevent unnecessary X-ray imaging examinations in

patients presenting to the Emergency Department (ED) with hand trauma. Some advantages of US have increased its utilization in emergency departments; these include a short procedure time, a non-invasive and nonionizing radiation involving nature, availability for use in nonhospital settings or bedside settings, repeatability, and a higher safety in children and pregnant patients [80].

None of the previous reviews included studies showing evidence on the diagnostic accuracy for diagnosing metacarpal and phalangeal fractures. Therefore, this is the first study to systematically summarize the diagnostic accuracy of diagnostic tests for phalangeal and metacarpal fractures. This study concludes that physical examination was of limited use for diagnosing phalangeal and metacarpal fractures.

Diagnostic Accuracy of History Taking and Physical Examination of Carpal Fractures

History taking and physical examination are important tools in a diagnostic process of diagnosing patients with wrist pain [23]. Although common practice in hospital care, only one study was found on the diagnostic accuracy of history taking for carpal fractures in the previous reviews and current review.

Previous reviews reported that tenderness in the anatomical snuff box demonstrated an Se and Sp for scaphoid fractures ranging from 87–100% and 3–98%, respectively [36, 37]. Tenderness over the scaphoid tubercle (ST) demonstrated a Se and Sp ranging from 82–100% and 17–57%, respectively [36, 37]. The Longitudinal Thumb Compression test (LTC) demonstrated a Se and Sp ranging from 48–100% and 22–97%, respectively [36, 37].

The current systematic update included three extra studies on physical examinations for diagnosing scaphoid fractures in hospital care [44, 45, 47]. Based on these results and those presented in the previous reviews, combining provocative tests improved the accuracy of the post-test fracture probability, and physical examination alone was not sufficient to rule in or rule out scaphoid fracture, which may lead to unnecessary out-patient reviews and/or overtreatment. If a patient with wrist pain and normal X-rays has a combination of tenderness in the anatomical snuff box, tenderness over the scaphoid tubercle and longitudinal compression (LC) tenderness towards the scaphoid, supplementary imaging is still recommended. At present, in a patient with a strong suspicion of a scaphoid fracture based on history taking and physical examination despite no deviation on imaging, the wrist will be temporarily immobilized until repeated evaluation of the physical examination and imaging has taken place later [81].

Diagnostic Accuracy of Imaging of Carpal Fractures

In this and previous systematic reviews, the reported diagnostic accuracy measures for imaging modalities were characterized by markedly heterogeneous results among the eligible studies. Plain radiography remained the commonest modality for diagnosing carpal fractures [82–84]. Its advantages include its wide availability, easy accessibility and low costs. Most studies describe diagnostic tests of scaphoid fractures and only a few studies concern other carpal fractures. At present, there is still insufficient scientific evidence regarding the ideal imaging technique for scaphoid fractures [23].

Repeated radiographs seems to have limited value for evaluating suspected scaphoid fractures. The irregular contour, the three-dimensional location in the wrist of the scaphoid and the overlap of the carpal bones render interpretation of scaphoid radiographs difficult, especially in the absence of fracture dislocation [82–84].

The best diagnostic modality for confirmation of the diagnosis of a carpal fracture that is not visible on the initial radiograph is still the subject of debate. As found in previous reviews (Table 1), MRI, CT and BS have been shown to have better diagnostic performance than isolated repeated scaphoid radiographs. Previous reviews by Yin et al. concluded that BS and MRI have equally high pooled sensitivity and high diagnostic value for excluding scaphoid fracture, when the lack of a reference standard is acknowledged [32, 33]. However, MRI is more specific and better for confirming scaphoid fractures when compared to BS. According to the Cochrane review of Mallee et al., statistically BS is the best diagnostic modality for establishing a definitive diagnosis in clinically suspected fractures when radiographs appear normal, but the number of overtreated patients is substantially lower with CT and MRI [34]. Moreover, physicians must keep in mind that BS is more invasive than the other modalities. Previous reviews by Kwee et al. and Ali et al. concluded that US can diagnose occult scaphoid fracture with a fairly high degree of accuracy and Kwee et al. stated that US may be used when CT and MRI are not readily available [38, 39].

As no studies in non-institutionalized general practitioner care were identified, general practitioners who examine patients with a suspected hand or wrist fracture have limited instruments for providing adequate diagnostics. A general practitioner could decide to refer such patients to a hospital for specialized care, but one could question what assessments a specialist can use to come to an accurate diagnosis. In hospital care, one study of the diagnostic accuracy of history taking for phalangeal, metacarpal and carpal fractures was found and physical examination was of moderate use for diagnosing a scaphoid fracture and of limited use for diagnosing phalangeal, metacarpal and remaining carpal fractures. Based on the best evidence synthesis, imaging tests (conventional radiograph, MRI, CT and BS) were only found to be moderately accurate for definitive diagnosis in hospital care.

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Tables

Due to technical limitations, the tables are available in the supplementary section as a download.

Figures

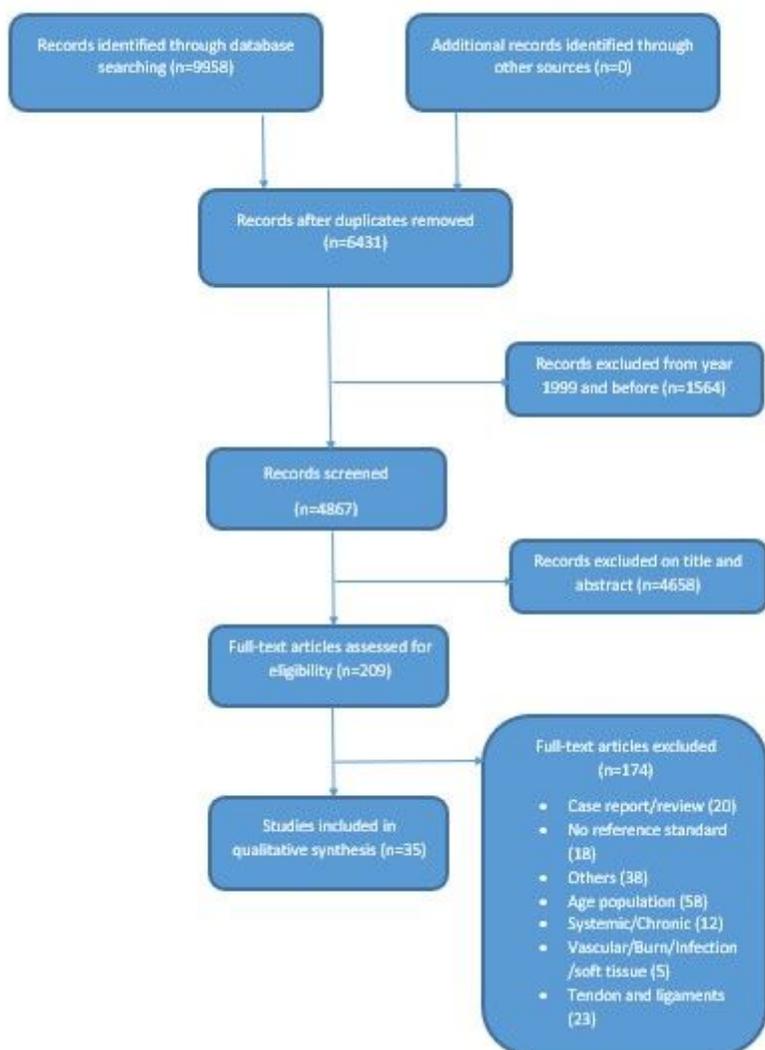


Figure 1

Flow digram

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