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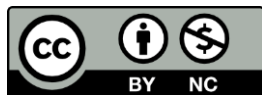
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Which Clinical Features Best Predict Occult Scaphoid Fractures? Systematic Review of Diagnostic Test Accuracy Studies.

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BACKGROUND

Plain radiographs cannot identify all scaphoid fractures; thus Emergency Department (ED) patients with a clinical suspicion of scaphoid injury often undergo immobilisation despite normal imaging. This study determined (1) the prevalence of scaphoid fracture amongst patients with a clinical suspicion of scaphoid injury with normal radiographs and (2) whether clinical features can identify patients that do not require immobilisation and further imaging.

METHODS:

This systematic review of diagnostic test accuracy studies included all study designs that evaluated predictors of scaphoid fracture amongst patients with normal initial radiographs. Quality assessment was undertaken using the Quality Assessment of Diagnostic Accuracy Studies 2 (QUADAS-2) tool. Meta-analyses included all studies.

RESULTS:

Eight studies reported data on 1,685 wrist injuries. The prevalence of scaphoid fracture despite normal radiographs was 9.0%. Most studies were at overall low risk of bias but two were at unclear risk; all eight were at low risk for applicability concerns. The most accurate clinical predictors of occult scaphoid fracture were pain when the examiner moved the wrist from a pronated to a supinated position against resistance (sensitivity 100%, specificity 97.9%, LR 45.0 [95% CI 6.5-312.5], supination strength $\leq 10\%$ of contralateral side (sensitivity 84.6%, specificity 76.9%, LR 3.7 [95% CI 2.2-6.1]), pain on ulnar deviation (sensitivity 55.2%, specificity 76.4%, LR 2.3 [95% CI 1.8-3.0]), and pronation strength $\leq 10\%$ of contralateral side (sensitivity 69.2%, specificity 64.6%, LR 2.0 [95% CI 1.2-3.2]). Absence of anatomical snuffbox tenderness significantly reduced the likelihood of an occult scaphoid fracture (sensitivity 92.1%, specificity 48.4%, LR- 0.2 [95% CI 0.4-0.7]).

CONCLUSION:

No single feature satisfactorily excludes an occult scaphoid fracture. Further work should explore whether a combination of clinical features, possibly in conjunction with injury characteristics such as mechanism, and a normal initial radiograph might exclude fracture. Pain on supination against resistance would benefit from external validation.

KEY MESSAGES

What is already known on this topic?

- Patients suspected of having a scaphoid fracture often require immobilisation and further imaging as these injuries are not always evident on plain radiographs.
- It is unknown whether clinical features can help to identify patients that do not require further assessment after normal initial radiographs.

What this study adds?

- In this systematic review and meta-analysis, we found that no single clinical feature can satisfactorily exclude an occult scaphoid fracture.

How this study might affect research, practice, or policy

- The current practice of immobilising patients for whom there is an initial suspicion of scaphoid fracture but negative x-ray pending further assessment seems appropriate.
- Further research should focus on externally validating pain on supination against resistance and evaluating the diagnostic value of using clinical features in combination.

BACKGROUND:

Suspected scaphoid fractures are typically immobilised (e.g. in a cast or splint) even when initial radiographs are normal¹. This is because scaphoid fractures may be not diagnosed on initial plain radiographs and delayed immobilisation increases the risk of non-union². Patients with suspected scaphoid fractures have conventionally been followed up for interval examination and repeat radiographs¹. However, only a small proportion have an occult scaphoid fracture and so many often young and active patients are immobilised unnecessarily. One study reported that patients were immobilised for a median of 31 days despite only 6% ending up with a confirmed diagnosis of scaphoid fracture³. Immobilisation can cause pressure sores, stiffness, and muscle atrophy⁴ as well as restricting the ability to work. This also imposes a substantial burden on fracture clinic services and with undefinable societal costs⁵.

A number of approaches have been proposed to streamline the management of suspected scaphoid fractures. These include repeat radiographs (e.g. 10-14 days later), CT, bone scintigraphy, and MRI⁶. CT is widely available, highly sensitive (94%)⁷ and can identify other osseous wrist injuries but can fail to distinguish undisplaced fractures from normal vascular markings⁸. Bone scintigraphy is highly sensitive for fracture (up to 100%) but rarely used as it is relatively invasive and suffers from poor specificity⁹. MRI is the gold standard test (sensitivity and specificity up to 100%) and recommended by the National Institute for Health and Care Excellence¹⁰. Although this approach is cost effective¹¹, under and overdiagnosis of scaphoid fractures on MRI has been reported¹² and this modality is a limited resource that is not universally available¹³. Only 13% of NHS hospitals currently offer MRI directly from the ED for patients with a suspected fracture¹³. Other pathway approaches include direct discharge from the ED with follow-up in a virtual clinic⁵. However, all such pathways would benefit from being able to risk-stratify patients based on their likelihood of scaphoid fracture to increase the prevalence of true fractures amongst suspected fractures increases.

Earlier studies have identified predictors of scaphoid fracture amongst patients with wrist injuries¹⁴. However, there have been fewer attempts to identify predictors of occult scaphoid fracture in the population with normal initial radiographs. The aims of this study were (1) to identify the prevalence of scaphoid fracture amongst patients with normal radiographs despite a clinical suspicion of scaphoid injury and (2) to determine whether clinical examination can be used to identify patients that could be safely discharged without immobilisation and further imaging.

METHODS:

A systematic review of diagnostic test accuracy studies was undertaken and reported according to the Preferred Reporting Items for Systematic Review and Meta-Analysis of Diagnostic Test Accuracy studies (PRISMA-DTA) guidelines^{15 16}. The protocol was prospectively published in the PROSPERO database with reference CRD42021290224.

Search strategy

A search strategy was designed with a specialist information librarian using terms that have been previously validated for identifying diagnostic accuracy studies¹⁷. The literature search included Ovid MEDLINE (1946 to November 2021), EBSCO CINAHL, Embase (1947 to 2021) and Web Of Science. The specific search strategies are shown in Supplementary File 1. The reference lists of included studies were used to identify further items and a forward citation search for new studies was undertaken using Google Scholar on 10th August 2022, which did not identify any new studies satisfying the inclusion criteria. Duplicates were removed using EndNote (Clarivate, PA, USA) and unique items imported into Rayyan (Qatar Computing Research Institute, Doha, Qatar) for study selection.

Study selection

Studies were included if they reported the accuracy of clinical findings for an occult scaphoid fracture amongst patients with *normal initial radiographs but on-going clinical suspicion of scaphoid fracture*. Any diagnostic standard was permitted, including delayed repeat radiographs, CT, MRI, or bone scintigraphy. Occult fractures were defined as any breach of the scaphoid cortex that was not visible on the initial radiographs. Studies were excluded if they did not provide sufficient data to construct a 2x2 table even after contacting study authors. No language, geographical, or date limits were applied. Two authors (LC and IO) independently screened titles, abstracts, and then full texts with disagreements resolved by a third author (DM).

Data extraction and quality assessment

Data were extracted into Excel (Microsoft, Redmond, WA, USA) by a single author (LC) and checked by a second (IO). Study authors were contacted for additional data or clarifications when appropriate. Quality and risk of bias assessments were independently undertaken by two authors (LC and DM) using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2)¹⁸ and Rational Clinical Examination¹⁹ tools with disagreements resolved through discussion. QUADAS-2 is a validated tool for evaluating the risk of bias and applicability of diagnostic accuracy studies using four domains: patient selection, index test, reference standard, and flow and timing¹⁸. The Rational Clinical Examination levels of evidence rank diagnostic study designs from level 1 (independent blind comparisons of symptoms against a

reference standard among a large group of >200 consecutive patients) to level 5 (non-independent comparison against a reference standard of uncertain validity amongst a sample of patients)¹⁹.

Statistical analysis

Sensitivity, specificity, and likelihood ratios were calculated with 95% confidence intervals. The likelihood ratio is the likelihood of a given test result in a patient with the disorder compared with the likelihood of that result in patients without the target disorder²⁰. Once the likelihood ratio of a clinical sign is known, it can be used to move from a pre-test to a post-test probability. For example, if the pre-test probability of occult scaphoid fracture was 10%, the presence of a clinical sign with a positive likelihood ratio of 2.0 would lead to a post-test probability of 20% (Figure 1).

A random effect model was used for pooling proportions and the variation across the studies due to heterogeneity was assessed using the I^2 measure²¹. When data about a clinical feature was reported by one study, this was presented as an individual data point. When two studies contributed data, this was presented as a range. Data from three studies were pooled by fitting a univariate random effects model. Data from four or more studies were meta-analysed by fitting multi-level mixed effects logistic regression models and plotting hierarchical summary receiver operating characteristic curves. The unit of analysis was individual wrists. The Haldane correction (i.e. modifying observations to a value close to zero, e.g. 1.0) was used to facilitate statistical analysis of 2x2 tables that included one or more zero cells²². These analyses were undertaken using the `metaprop`, `diagti`, `midas`, `metan`, and `metandi` commands in Stata SE v.15 (StataCorp LLC, College Station, Texas, USA).

Patient and public involvement

Patients and the public were not directly involved in this systematic review.

RESULTS

There were 2,222 unique items that included eight eligible studies²³⁻³⁰ (Figure 2) reporting data on 1,685 wrist injuries and 123 occult scaphoid fractures. The pooled prevalence of occult scaphoid fractures amongst patients with a clinical suspicion but normal initial radiographs was therefore 9% (95% CI 5-13%), although heterogeneity was high ($I^2=91.4%$). An earlier iteration of these data were published in the *EMJ* as an abstract³¹.

Study and participant characteristics

The included studies are described in Table 1. All eight were prospective studies²³⁻³⁰ reporting data from Emergency Departments in Norway²³, the Netherlands²⁹, United Kingdom²⁵⁻²⁸, and United States^{24 30}. The studies used a combination of delayed radiographs (10-14 days)^{25 26 28 30}, CT²⁴, MRI^{23 24 27 29}, and bone scintigraphy^{24 25 28 29} as their diagnostic reference standards.

The clinical features reported by these studies are described in Table 2. The most common tests were the scaphoid compression test in which pain occurs in the anatomical snuffbox on longitudinal compression of the thumb (4 studies²⁵⁻²⁸, 1,321 participants), anatomical snuffbox tenderness (4 studies^{26-28 30}, 1,309 participants), and scaphoid tubercle tenderness (3 studies²⁶⁻²⁸, 1,256 participants). Haematoma and swelling were each contributed to by two studies^{24 29}, and the remaining tests by one study. We were unable to contact the authors of one study²⁴ about inconsistent reporting and so their data about four clinical features (flexion and extension loss >25%, grip strength loss >25%, and pronation and supination strength loss >25%) were not included.

Risk of bias

The risk of bias and applicability assessments are summarised in Table 3. Four studies were at low risk of patient selection bias because they recruited a sample that included all patients, a consecutive series, or that were randomly selected^{25 27-29}. Three were at unclear risk of bias because this was not stated explicitly^{23 24 30}. One study was at high risk of bias because “localized tenderness” was an inclusion criterion and the clinical tests under evaluation were also based on tenderness²⁶.

All studies were at low risk of bias in the index test domain because all examiners were blinded to the final diagnosis²³⁻³⁰. However, six studies were at unclear risk of bias in the reference standard domain because the authors did not guarantee that the assessor was blinded to the index test results^{24 25 27-30}. All studies were at low risk of bias in the flow and timing domain as the reference standard imaging occurred before a true fracture would have healed²³⁻³⁰.

Six studies were at low risk of bias in the flow and timing domain^{23-26 29 30} but two were high risk because they used a range of reference standard modalities (which might be have been influenced by physical examination findings)^{27 28} or considered some patients to be negative for fracture because their symptoms improved (i.e. without definitive imaging)²⁸.

All studies were judged to be at low risk for applicability concerns across the patient selection, index test, and reference standard domains. Four studies included children²⁵⁻²⁸, although these numbers were very small and judged insufficient to downgrade the studies for

applicability in the patient selection domain. The review did not specify how index tests should be conducted or interpreted and so no study was downgraded in the index test domain, although it is possible that this was a source of heterogeneity. All studies made the final diagnosis of scaphoid fracture using one of the specified reference standards.

Predictive characteristics

The predictive characteristics of each clinical sign are shown in Table 4. Hierarchical summary receiver operating characteristic curve (HSROC) plots for ASB tenderness and the scaphoid compression test are shown in Supplementary File 2.

The most useful features for identifying occult scaphoid fractures were pain on supination against resistance (LR+ 45.0 [95% CI 6.5-312.5]; one study at unclear risk of bias but low applicability concerns), supination strength 10% of contralateral side (LR+ 3.7 [95% CI 2.2-6.1]; one study at low risk of bias and low applicability concerns), positive ulnar deviation test (LR+ 2.3 [95% CI 1.8-3.0]; one study at low risk of bias and low applicability concerns), pronation strength \leq 10% of contralateral side (LR+ 2.0 [95% CI 1.2-3.2]; one study at low risk of bias and low applicability concerns), and extension $<$ 50% of contralateral side (LR+ 2.0 [95% CI 1.4-3.0]; one study at low risk of bias and low applicability concerns).

The most useful features for reducing the likelihood of occult scaphoid fracture were absence of anatomical snuffbox tenderness (LR- 0.2 [95% CI, 0.4-0.7]; four studies at overall low risk of bias and low applicability concerns) and no loss of supination strength (LR- 0.2 [95% CI 0.1-0.7]; one study at low risk of bias and low applicability concerns).

One study²³ combined the clinical features to form a scoring system, which was composed of anatomical snuffbox tenderness (3 points), scaphoid tubercle tenderness (2 points) and SCT (1 point). These authors reported that the only statistically significant threshold for this score was $>$ 4 but this only marginally increased the likelihood of occult fracture (sensitivity 76.9%; specificity, 55.0%, LR+ 1.8 [1.2- 2.5]).

DISCUSSION

The pooled prevalence of occult fractures amongst suspected fractures was only 9.0%, which is the best available pre-test probability of an occult fracture amongst patients with a clinical suspicion of scaphoid injury but normal initial radiographs. This low prevalence supports the concern that most patients currently immobilised for a suspected scaphoid injury do not end up with a final diagnosis of fracture⁶. Physical examination findings are often used by clinicians

to adjust the likelihood of an occult scaphoid fracture and help determine which patients require immobilisation and/or further imaging. However, this systematic review and meta-analysis of 8 prospective studies did not find evidence that clinical examination can safely confirm or exclude an occult scaphoid fracture.

Only one clinical sign (pain on supination against resistance) was sufficiently useful to inform clinical decision making. The available data suggest that the presence of this sign converts the pre-test probability of 9.0% to 82% and its absence to 1% (Figure 3). However, this finding should be interpreted with caution for a number of reasons. First, this clinical sign was only evaluated by a single study of 53 patients (8 fractures)³⁰ and had correspondingly large confidence intervals: LR+ 45.0 (95% CI 6.5-312.5) LR- 0.2 (0.1-0.7). Second, that study was similarly optimistic about two other tests (anatomical snuffbox tenderness and pain on longitudinal compression of the thumb), which proved less promising once data were pooled from multiple studies^{26-28 30}. The existing data about pain on supination against resistance therefore require external validation before they are relied upon in clinical practice.

No other clinical sign was sufficiently predictive to safely exclude occult scaphoid fracture. Importantly, these tests performed less well than in studies where they were used to determine which patients with wrist injuries should undergo initial scaphoid imaging¹⁴. For example, one study reported that ASB pain following ulnar deviation of the pronated wrist is 100% sensitive for scaphoid fracture³². Similarly, combinations of clinical signs have been reported to be 91%¹⁴ or even 100%²⁸ sensitive for scaphoid fracture in the broader “wrist injury” population. However, this systematic review found that even a carefully selected combination of clinical signs only yielded a positive likelihood ratio of 1.8 for occult scaphoid fracture. The data therefore suggest that a scaphoid fracture cannot be satisfactorily confirmed or excluded based on clinical examination, which supports the existing common practice of immobilising all patients with suspected scaphoid fracture even if initial radiographs are normal.

Limitations

The studies identified by this review were undertaken prospectively and at low risk of bias across most domains. However, there were a number of limitations. First, the studies included within this review were specifically concerned with identifying occult scaphoid fractures in patients with normal initial radiographs. The diagnostic characteristics of these predictors cannot therefore be used to identify which patients with wrist injuries should undergo initial scaphoid imaging. Second, although the studies all reported data on patients with a clinical suspicion of fracture, they used varying criteria for defining this population. It is likely that findings on physical examination contributed to this suspicion and may have exposed the

studies to selection bias. The included studies varied substantially in terms of the proportion of patients who were subsequently diagnosed with a scaphoid injury and differences in patient selection may have affected the pooled estimate of occult scaphoid fractures. Third, the reference tests are not infallible and so may have misclassified patients. This is a particular problem as reference standards varied between studies and even between patients within the same study, which may have introduced classification bias. False-positive scaphoid fractures may be diagnosed on MRI because of bone bruising or non-specific signal change and on CT by a vascular channel or unicortical fracture³³. Fourth, the included studies spanned a 34-year period from 1987 to 2021 during which time interpretation of plain radiographs moved from silver film and lightboxes to digital systems³⁴. The latter allow radiographs to be manipulated on the screen (e.g. zoom, varying contrast and grey scale)³⁴ and may have affected the population of patients whose plain radiographs were considered normal. Fifth, some clinical tests were undertaken using specialist equipment (e.g. goniometer and dynamometer) which limit their practical value. It is unclear how clinical estimation would affect the predictive characteristics of these signs over direct measurement. Finally, although physical examination findings cannot be used to confirm or exclude scaphoid fracture, it is still possible that clinical signs in combination could be used for this purpose. This is particularly likely when other sources of information (such as age, sex, and mechanism of injury) are included within a clinical prediction rule.

Conclusion

The prevalence of occult fracture in the population of patients with suspected scaphoid injury but normal initial radiographs is 9.0%. Clinical signs – either individually or in combination – cannot currently be used to risk-stratify these patients or safely confirm or exclude an occult scaphoid fracture. One clinical sign (pain on supination against resistance) exhibited promising characteristics in a single study but this requires external validation.

FIGURE LEGENDS

Figure 1 – Nomogram to illustrate the use of likelihood ratios to move from a pre- to a post-test probability. In this example, the disorder prevalence (and so pre-test probability) is 10% and the clinical sign being reported has a positive likelihood ratio (i.e. when present) of 2.0 and a negative likelihood ratio (when absent) of 0.5.

Figure 2 – A PRISMA flow diagram showing the initial database search. A subsequent reverse citation search using Google Scholar on 10th August 2022 retrieved 312 citations but no new studies.

Figure 3 – Nomogram showing reported likelihood ratio for pain on supination against resistance.

ETHICAL APPROVAL

This study does not involve human participants.

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CONTRIBUTORSHIP

LC led the review process (including abstract screening, data extraction, and quality assessments) with IO and supervised by DM. LC and DM drafted the manuscript. IO, BD, AN, and AD contributed to the study design, helped interpret the data, and made critical revisions to the manuscript. DM is guarantor.

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DATA SHARING

The underlying study data is available on request to the corresponding author.

CONFLICTS OF INTEREST

DM and AN are members of the EMJ editorial board.

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Table 1: Characteristics of included studies

Study	Setting	Design	Wrists (fractures)	Population	Index tests	Reference test
Bergh (2013)	Norway	Prospective cohort	155 (13)	Patients attending within a week of acute wrist trauma	Clinical scaphoid score	MRI
Buijze (2011)	USA	Prospective cohort	78 (12)	Patients presenting with suspected scaphoid fracture (ASBT and ASB pain when applying axial pressure on the first or second digit) within 48hours of wrist trauma	Swelling, haematoma*	MRI, bone scintigraphy, interval clinical examination
Esberger (1994)	UK	Prospective cohort	65 (10)	Patients presenting to ED with clinical signs of scaphoid fracture (filling of the anatomical snuffbox, ASBT or pain in radial aspect of wrist on resisted pronation)	SCT	Interval plain radiographs, bone scintigraphy
Grover (1996)	UK	Prospective cohort	193 (1)	Patients suspected of having a scaphoid fracture with any form of localized tenderness	ASBT, STT, SCT	Interval plain radiographs at 10 days
Kodumuri (2021)	UK	Prospective cohort	922 (58)	Patients presenting with aclinical suspicion of scaphoid fracture based on the presence of at least one positive clinical test	ASBT, STT, SCT, pinch test, ulnar deviation test	MRI
Parvizi (1998)	UK	Prospective cohort	141 (8)	Patients presenting to EDwithin 24 hours of acute wrist injury	ASBT, STT, SCT	Interval plain radiographs at 2 weeks, bone scintigraphy
Rhemrev (2010)	Netherlands	Prospective cohort	78 (13)	Patients with suspected scaphoid fracture based on presence of ASBT or pain in ASB when applying axial pressure to the first or second digit	Swelling, haematoma, supination strength loss, pronation strength loss, extension loss, grip strengthloss	MRI, bone scintigraphy, interval plain radiographs at 6 weeks

Waeckerle (1987)	USA	Prospective cohort	53 (8)	Patients complaining of hyperextension injury of the wrist	ASBT, pain on supination against resistance	Interval plain radiographs at 10-14 days
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Abbreviations: ASB = anatomical snuffbox; ASBT = anatomical snuffbox tenderness; ED = Emergency Department; MRI = Magnetic Resonance Imaging; SCT = scaphoid compression test; STT = scaphoid tubercle tenderness.

Table 2: Description of index tests

Test	Definition
Scaphoid compression test	Pain in the ASB with longitudinal pressure down the thumb to compress the scaphoid
Anatomical snuffbox tenderness	Pain on palpation of the anatomical snuffbox
Scaphoid tubercle tenderness	Pain elicited by applying pressure to the scaphoid tubercle
Swelling	Presence of swelling when compared to the uninjured side
Haematoma	Presence of haematoma when compared to the uninjured side
Pinch test	Pain when pinching the thumb and index finger together
Ulnar deviation	Pain on ulnar deviation with the wrist pronated
Pain on supination against resistance	Pain when the examiner moves the wrist from pronation to supination against resistance
Grip strength $\leq 25\%$ of contralateral side	Grip strength of 25% or less than the contralateral side as assessed using a hydraulic handheld dynamometer
Supination strength $\leq 10\%$ of contralateral side	Supination strength of 10% or less than the contralateral side using a custom-made device
Pronation strength $\leq 10\%$ of contralateral side	Pronation strength of 10% or less than the contralateral side using a custom-made device
Extension $< 50\%$ of contralateral side	Reduced range of movement shown by extension less than 50% of contralateral side using a handheld goniometer
Clinical scaphoid score (CSS) ≥ 4	A score of 4 or greater by the presence of a combination of the following three features: anatomical snuffbox tenderness (3 points), scaphoid tubercle tenderness (2 points), scaphoid compression test (1 point)

Table 3: Risk of bias and applicability assessments for included studies

Study	Risk of bias				Applicability concerns		
	Patient selection	Index test	Reference standard	Flow and timing	Patient selection	Index test	Reference standard
Bergh	Unclear	Low	Low	Low	Low	Low	Low
Bujize	Unclear	Low	Unclear	Low	Low	Low	Low
Esberger	Low	Low	Unclear	Low	Low	Low	Low
Grover	High	Low	Low	Low	Low	Low	Low
Kodumuri	Low	Low	Unclear	High	Low	Low	Low
Parvizi	Low	Low	Unclear	High	Low	Low	Low
Rhemrev	Low	Low	Unclear	Low	Low	Low	Low
Waerckerle	Unclear	Low	Unclear	Low	Low	Low	Low

Table 4: Predictive characteristics of index tests

Test	Participants (% fracture)	Sensitivity	Specificity	LR+	LR-
Scaphoid compression test ^{25-27 30}	1321 (33)	64.5 (38.5-82.8)	54.8 (29.9-77.4)	1.4 (1.0-4.1)	0.7 (0.5-1.0)
Anatomical snuffbox tenderness ^{26-28 30}	1309 (51)	92.1 (82.9-96.6)	48.4 (6.5-92.7)	1.8 (0.5-6.2)	0.2 (0.0-0.7)*
Scaphoid tubercle tenderness ²⁶⁻²⁸	1256 (46)	59.2 (38.6-79.8)	54.5 (22.5-86.4)	1.4 (0.8-1.9)	0.7 (0.5-0.9)
Swelling ^{24 29}	156 (46)	41.7-76.9 (15.2-95.0)	36.9-75.8 (25.3-85.5)	1.2-1.7 (0.8-3.8)	0.6-0.8 (0.2-1.8)
Haematoma ^{24 29}	156 (49)	46.2-91.7 (19.2-99.8)	31.8 -76.9 (20.9-86.5)	1.3 -2.0 (1.0-4.2)	0.3-0.7 (0.0-1.8)
Pinch test ²⁷	922 (21)	31.0 (19.5-44.5)	79.2 (76.3-81.9)	1.5 (1.0-2.2)	0.9 (0.7-1.0)
Ulnar deviation ²⁷	922 (26)	55.2 (41.5-68.3)	76.4 (73.4-79.2)	2.3 (1.8-3.0)*	0.6 (0.4-0.8)
Pain on supination against resistance ³⁰	53 (17)	100.0 (63.1-100)	97.8 (88.2-99.9)	405.0 (5.76.5-312.5281.7)*	0.1 (0.0-0.7)
Grip strength ≤25% of contralateral side ²⁹	78 (71)	92.3 (64.0-99.8)	33.8 (22.6-46.6)	1.4 (1.1-1.8)	0.2 (0.0-1.5)
Supination strength ≤10% contralateral side ²⁹	78 (33)	84.6 (54.6-98.1)	76.9 (64.8-86.5)	3.7 (2.2-6.1)*	0.2 (0.1-0.7)*
Pronation strength ≤10% contralateral side ²⁹	78 (41)	69.2 (38.6-90.9)	64.6 (51.8-76.1)	2.0 (1.2-3.2)*	0.5 (0.2-1.1)
Extension <50% contralateral side ²⁹	78 (49)	84.6 (54.6-98.1)	58.5 (45.6-70.6)	2.0 (1.4-3.0)*	0.3 (0.1-1.0)
Clinical scaphoid score (≥4) ²³	155 (47)	76.9 (46.2-95.0)	55.0 (47.1-64.0)	1.8 (1.2-2.5)	0.4 (0.2-1.1)