Provocative wrist tests and MRI are of limited diagnostic value for suspected wrist ligament injuries: a cross-sectional study

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Question: What is the diagnostic value of provocative wrist tests and magnetic resonance imaging (MRI) for suspected wrist ligament injuries? **Design**: Cross-sectional study. **Participants**: 105 people presenting to hand clinics with wrist pain and suspected wrist ligament injuries were evaluated prospectively. **Outcome measures**: The integrity of wrist ligaments was tested with seven provocative tests. The results were compared to the reference standard of arthroscopy. In a subgroup of 55 participants, MRI findings were also compared to arthroscopy. The provocative tests were the scaphoid shift test (SS test), lunotriquetral test (LT test), midcarpal test (MC test), distal radioulnar joint test (DRUJ test), triangular fibrocartilage complex (TFCC) stress test (TFCC test), TFCC stress test with compression (TFCC comp test), and the gripping rotatory impaction test (GRIT). **Results**: Most provocative tests and MRI findings were of little or no value for diagnosing wrist ligament injuries. Exceptions were the SS test (+ve LR 2.88 and –ve LR 0.28), MC test (+ve LR 2.67) and DRUJ test (–ve LR 0.30), all of which were of mild diagnostic usefulness. MRI was moderately useful for diagnosing TFCC injuries (+ve LR 5.56, –ve LR 0.15), and was mildly useful for diagnosing scapholunate (SL) ligament injuries (+ve LR 4.17, –ve LR 0.32) and lunate cartilage damage (+ve LR 3.67, –ve LR 0.33). Adding MRI to provocative tests improved the accuracy of diagnosis of TFCC injuries slightly (by 13%) and lunate cartilage damage (by 8%). **Conclusion**: Provocative wrist tests of SL ligament injuries and midcarpal ligament injuries are mildly useful for diagnosing wrist injuries. MRI diagnostic findings of SL ligament injuries, lunate cartilage damage, and TFCC are mildly to moderately useful. MRI slightly improves the diagnosis of TFCC injury and lunate cartilage damage compared to provocative tests alone. **[Prosser R, Harvey L, LaStayo P, Hargreaves I, Scougall P, Herbert RD (2011) Provocative wrist tests and MRI are of limited diagnostic value for suspected wrist ligament injuries: a cross-sectional study. *Journal of Physiotherapy* 57: 247–253]**

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Introduction

Wrist sprains are common. They are typically due to trauma resulting in tears or ruptures of one or more of the carpal ligaments (Alexander and Lichtman 1988, Bishop and Reagan 1998, Blatt 1998, Bowers 1991, Cooney 1998, Mayfield 1988, Taleisnik 1985, Taleisnik and Linscheid 1998). It is important that clinicians identify correctly which ligaments are injured as this directs appropriate treatment (Anderson 2010, Garcia-Elias 2010, LaStayo 2002, Prosser 1995, Prosser 2003, Skirven 2010, Wright and Michlovitz 2002). The definitive diagnosis of wrist injuries is made with arthroscopy – the reference standard. Evaluation procedures that typically precede arthroscopy include radiography and a clinical examination. Clinical examination includes specific tests that are designed to help identify which wrist ligaments might be injured (Alexander and Lichtman 1988, Bishop and Reagan 1998, Cooney 1998, Gaenslen and Lichtman 1996, LaStayo 2002, Prosser et al 2007, Taleisnik 1985, Taleisnik and Linscheid 1998, Watson et al 1988, Wright and Michlovitz 2002) (see Box 1 for abbreviations of tests and ligaments). These tests are collectively termed 'provocative tests' because they provoke or reproduce an individual's pain by stressing the ligaments.

While provocative wrist tests are routinely used by clinicians to diagnose wrist ligament injuries, there is little evidence of their accuracy. LaStayo and Howell (1995) compared the findings of the scaphoid shift (SS) test, the lunotriquetral ballottement (LT) test and the ulnomeniscotriquetral (also known as the Triangular Fibrocartilage Complex, TFCC) test with arthroscopic results in 50 painful wrists. The sensitivity and specificity data enabled calculation of positive and negative likelihood ratios (LRs), which in turn can be used to estimate the probability of a diagnosis of ligament injury (Fischer et al 2003, Portney and Watkins 2009, Schmitz et al 2000). The positive LRs for the SS test, the LT test and the TFCC test were 2.0, 1.2, and 1.8, and the negative LRs were 0.47, 0.80, and 0.53, respectively. These results suggest that the three provocative tests are of limited use for diagnosing wrist ligament injuries. To our knowledge no other study has examined the accuracy of these or other provocative tests of wrist ligament injuries. Therefore, the first aim of this study was to determine the accuracy of seven provocative tests commonly used to diagnose wrist ligament injuries. The seven tests were the SS test for the scapholunate (SL) ligament, the LT test for the lunotriquetral (LT) ligament, the midcarpal test (MC test) for the arcuate ligament, the distal radioulnar joint test (DRUJ test) for the

What is already known on this topic: Provocative wrist tests and magnetic resonance imaging are used to diagnose wrist ligament injuries, but there is little evidence of their diagnostic accuracy.

What this study adds: Provocative wrist tests are generally of limited value for diagnosing wrist ligament injuries, although they are mildly useful in the diagnosis of scapholunate and arcuate ligament injuries. If combined with provocative tests, MRI slightly improves the diagnosis of triangular fibrocartilage complex injury and lunate cartilage damage.

Box 1: Summary of abbreviations for wrist structures and associated tests

Wrist structure	Abbreviation	Test	Abbreviation
Scapholunate ligament	SL ligament	scaphoid shift test	SS test
Lunotriquetral ligament	LT ligament	lunotriquetral ballottement test	LT test
Arcuate ligament (also known as the deltoid or v ligament)	Arcuate ligament	midcarpal test	MC test
Distal radioulnar joint ligaments	DRUJ ligaments	distal radioulnar joint test	DRUJ test
Triangular fibrocartilage complex	TFCC	1. TFCC stress test 2. TFCC stress test with compression	1. TFCC test 2. TFCC comp test
Lunate cartilage damage	Lunate cartilage damage	gripping rotary impaction test	GRIT

distal radioulnar joint (DRUJ) ligaments, and the gripping rotary impaction test (GRIT) for lunate cartilage damage (also known as Ulnar Impaction Syndrome). Two TFCC tests were also investigated for the triangular fibrocartilage complex (TFCC), namely the TFCC stress test (TFCC test) and the TFCC stress test with compression (TFCC comp test). Box 1 presents a summary of the abbreviations. The results of all provocative tests were compared to the results of arthroscopy, which is the reference standard.

While arthroscopy is the reference standard for the diagnosis of wrist ligament injuries, it is an invasive and expensive test. Partly for these reasons, clinicians have increasingly used magnetic resonance imaging (MRI) rather than arthroscopy for establishing definitive diagnoses. However, it is not clear whether MRI is as accurate as arthroscopy. A comprehensive review by Faber and colleagues (2010) found that studies looking at the accuracy of MRI were difficult to interpret because of small sample sizes, failure to provide clear definitions of diagnoses, lack of blinding, and lack of consideration of underlying prevalence. In addition, no studies of the accuracy of MRI have reported LRs (Faber et al 2010). Faber and colleagues concluded that the accuracy of MRI for diagnosing wrist ligament injuries was unclear. Accordingly, the second aim of this study was to determine the accuracy of MRI for diagnosing wrist ligament injuries. For this purpose findings from MRI were compared to arthroscopy.

The two research questions therefore were:

1. How accurate are seven provocative tests commonly used to diagnose wrist ligament injuries?
2. How accurate is MRI for diagnosing wrist ligament injuries?

Method

Design

This was a cross-sectional study in which the diagnostic accuracy of seven ligament tests was evaluated prospectively among people with wrist pain. The diagnostic accuracy of MRI was also assessed in a subgroup of participants. Wrist arthroscopy was used as the reference standard.

Participants

From April 2005 to May 2009, consecutive patients with undiagnosed wrist pain of at least four weeks duration who presented to any of three private hand clinics were screened for inclusion in the study. Patients were from a broad geographical catchment area including surrounding metropolitan and rural areas. Potential participants were excluded if they had wrist fractures (confirmed radiologically), previous carpal surgery, rheumatoid arthritis, or complex regional pain syndrome. Complex regional pain syndrome was diagnosed according to the 2005 definition of the International Association of the Study of Pain on the basis of pain, oedema, joint stiffness, muscle tightness, reduced motion, changes in hair and nail growth, and vasospasm causing colour and temperature changes (Charlton 2005).

Outcome measures

All participants underwent clinical examination prior to arthroscopy. A subgroup of participants also underwent MRI investigation prior to arthroscopy. The decision to undertake an MRI investigation was made at the surgeons' discretion. The order of the provocative tests and MRI was dictated by convenience, but both the provocative tests and MRI were completed before the arthroscopy. All provocative tests were performed as close as possible to arthroscopy. The longest delay was 21 days. Provocative tests were conducted blind to the results of MRI, and MRIs were interpreted blind to the results of the provocative tests. The surgeons performing the arthroscopies were blinded to the results of the provocative tests but not to the results of the MRIs.

Clinical examination

Clinical examinations were performed primarily (87%) by one hand therapist (RP) with 27 years of experience. The other clinical examinations were performed by two therapists with 20 and 10 years of experience. Initially, a subjective assessment was undertaken and included questions to determine the time of injury, location of pain, and the functional demand on the wrist. The functional demand placed on the wrist by work and activities of

Table 1. Cross-tabulation of provocative tests and arthroscopy findings (n = 105).

	Arthroscopy positive	Arthroscopy negative	Likelihood ratio
SS test for SL ligament			
Positive	27 (26%)	13 (12%)	2.88 (1.68 to 4.92)
Uncertain	9 (9%)	9 (9%)	1.39 (0.60 to 3.21)
Negative	8 (8%)	39 (37%)	0.28 (0.15 to 0.55)
LT test for LT ligament			
Positive	1 (1%)	16 (15%)	1.03 (0.16 to 6.52)
Uncertain	2 (2%)	21 (20%)	1.57 (0.48 to 5.18)
Negative	3 (3%)	62 (59%)	0.80 (0.35 to 1.80)
TFCC test (combined TFCC test and TFCC comp test) for TFCC			
Positive	35 (33%)	14 (13%)	1.88 (1.15 to 3.04)
Uncertain	8 (8%)	7 (7%)	0.86 (0.34 to 2.19)
Negative	17 (16%)	24 (23%)	0.53 (0.33 to 0.86)
MC test for arcuate ligament			
Positive	2 (2%)	15 (14%)	2.67 (0.83 to 8.60)
Uncertain	3 (3%)	26 (25%)	2.31 (1.05 to 5.08)
Negative	0 (0%)	59 (56%)	*
DRUJ test for DRUJ			
Positive	9 (9%)	26 (25%)	1.79 (1.03 to 3.11)
Uncertain	5 (5%)	11 (10%)	2.35 (0.94 to 5.91)
Negative	3 (3%)	51 (49%)	0.30 (0.11 to 0.86)
GRIT for lunate cartilage damage[a]			
Positive	17 (17%)	45 (44%)	1.12 (0.80 to 1.57)
Negative	9 (9%)	32 (31%)	0.83 (0.46 to 1.50)

*Not able to be calculated due to low prevalence, [a]GRIT data were missing on 2 participants

daily living was classified by participants on a 3-point scale designed for this study. On this scale 'light' reflected sedentary or office work, 'moderate' reflected intermittent use with heavier activities such as gardening, and 'heavy' reflected manual work or participation in manual sports such as martial arts and racquet sports on a regular basis. Participants were also asked to self-rate perceived wrist stability on a 4-point scale designed for this study. The levels of the scale were 'does not give way', 'gives way with heavy activity', 'gives way with moderate activity', and 'gives way with light activity'. Pain and function were assessed with the Patient-Rated Wrist and Hand Evaluation questionnaire (MacDermid and Tottenham 2004).

The physical examination consisted of an assessment of the integrity of various wrist ligaments, the TFCC, and the lunate cartilage. The tests used were the SS test, LT test, MC test, TFCC test, TFCC comp test, DRUJ test, and the GRIT (LaStayo and Weiss 2001). Both asymptomatic and symptomatic wrists were tested to establish if there was hypermobility in the symptomatic wrist with respect to the asymptomatic wrist and to determine if there was pain. The outcomes of tests were reported as positive, negative or uncertain except for the GRIT which was only reported as positive or negative. A test was only reported as positive if it reproduced the participant's pain (with or without hypermobility compared to the contralateral side). A test was reported as uncertain if there was hypermobility (compared to the contralateral side) or if the pain produced was not the primary pain that the participant presented with. The order of the wrist tests was varied depending on the location of pain, with the most painful area examined last.

The SS test as described by Watson and colleagues (1988) and the LT test as described by Reagan and others (Bishop and Reagan 1998, Garcia-Elias 2010, Reagan et al 1984) were used to assess the integrity of the SL and LT ligaments, respectively. The SS test requires pressure to be applied through the examiner's thumb to the scaphoid tubercle. This produces a dorsally directed subluxation pressure that stresses the SL ligament and opposes the normal rotation of the scaphoid as it moves from ulnar to radial deviation. The LT test is a simple dorsal volar glide shear test of the triquetrum on the lunate. The MC test was used to evaluate the integrity of the arcuate ligament (also known as the deltoid or v ligament) (Alexander and Lichtman 1988, Gaenslen and Lichtman 1996). The MC test was only considered positive if there was a 'catch-up clunk' in the midcarpal joint in addition to the participant's pain.

The TFCC test was used to test the integrity of the TFCC. The test was performed as described by Hertling and Kessler (1990) with the wrist in ulnar deviation while applying a shear force across the ulnar complex of the wrist. The TFCC comp test was performed in the same position as the TFCC test but with axial compression. A positive result on either of the two TFCC tests was considered positive for the TFCC. The DRUJ test was used to assess the dorsal and volar DRUJ ligaments. It involved gliding the ulna to its maximum dorsal and volar positions in neutral, supination, and pronation. The GRIT was used to assess lunate cartilage

Table 2. Cross-tabulation of MRI and arthroscopy findings (n = 55).

	Arthroscopy positive	Arthroscopy negative	Likelihood ratio
SL ligament			
Positive	12 (22%)	4 (7%)	4.17 (1.54 to 11.30)
Uncertain	5 (9%)	2 (4%)	3.48 (0.74 to 16.40)
Negative	6 (11%)	26 (47%)	0.32 (0.16 to 0.65)
LT ligament			
Positive	0 (0%)	2 (4%)	*
Uncertain	0 (0%)	1 (2%)	*
Negative	3 (5%)	49 (89%)	1.06 (0.99 to 1.14)
TFCC			
Positive	27 (49%)	3 (5%)	5.56 (1.92 to 16.10)
Uncertain	3 (5%)	1 (2%)	1.85 (0.21 to 16.70)
Negative	4 (7%)	17 (31%)	0.15 (0.06 to 0.37)
Arcuate ligament			
Positive	0 (0%)	1 (2%)	*
Uncertain	0 (0%)	1 (2%)	*
Negative	1 (2%)	52 (95%)	1.04 (0.99 to 1.09)
DRUJ			
Positive	1 (2%)	3 (5%)	0.89 (0.10 to 7.89)
Uncertain	4 (7%)	6 (11%)	1.78 (0.59 to 5.43)
Negative	10 (18%)	31 (56%)	0.86 (0.58 to 1.28)
Lunate cartilage damage			
Positive	11 (20%)	8 (15%)	3.67 (1.84 to 7.32)
Negative	4 (7%)	32 (58%)	0.33 (0.14 to 0.78)

* Not able to be calculated due to low prevalence, DRUJ percentages do not add up to 100% because of rounding

damage. Lunate cartilage damage (also known as ulnar impaction syndrome) occurs when loss of axial stability of the DRUJ causes repeated impaction of the ulnar head on the lunate. The GRIT consisted of three grip measurements performed in neutral, supination, and pronation. A GRIT value was calculated by dividing the supinated grip strength by the pronated grip strength. A GRIT of greater than 1.0 was considered positive and indicative of lunate cartilage damage provided it was accompanied by pain (LaStayo and Weiss 2001). The neutral grip strength was not used in any of the analyses.

Magnetic resonance imaging: MRI of the wrist was performed with the following sequences: coronal T1, PD with fat saturation, gradient echo T2, sagittal T1, axial PD and PD with fat saturation. T1 is considered low resolution MRI. The MRI sequences were interpreted by a registered radiologist. All findings for ligament injuries were recorded as either positive (full or partial thickness tear), negative (normal), or uncertain (no tear detected but abnormal 'signal').

Arthroscopy: Arthroscopic technique involved examination of the radiocarpal, midcarpal, and TFCC regions and was performed under general or regional anaesthesia by one of two wrist surgeons, each with more than 15 years of experience. Intra-articular structures, including the articular cartilage, SL ligament, LT ligament, TFCC, and arcuate ligament were examined. Motion between carpal bones (shear and diastasis) was noted and documented. The results for each ligament were recorded as negative (intact) or positive (not intact). A positive ligament injury was diagnosed by direct visualisation of the tear with or without 2 mm of shear or diastasis (Chow 2005, Geissler 2005). This may have included a within-substance tear. In addition, laxity was noted. The location of a TFCC tear was also recorded as either peripheral (indicative of a DRUJ ligament injury) or central (indicative of an articular disc injury). Associated intra-articular pathologies, including synovitis, chondromalacia, and ganglia were documented.

Data analysis

Likelihood ratios were calculated for diagnostic prediction of provocative tests and MRI, using arthroscopy as the reference standard for both. Logistic regression was used to evaluate if MRI improved diagnostic accuracy compared to the provocative tests alone. For MRI, the number needed to scan (NNS) in order to make one additional correct diagnosis was also calculated.

Results

Flow of participants through the study

Of 143 patients screened for inclusion in the study, 105 were eligible to participate. Three declined and 35 did not have an arthroscopy. These patients believed that arthroscopy was not warranted because they were improving. The remaining 105 patients all consented to participate and went on to have arthroscopy. All participants underwent clinical examination prior to arthroscopy. Fifty-five of the 105 participants also underwent MRI investigation prior to arthroscopy. GRIT measures were missing on two participants but the dataset was otherwise complete.

Table 3. A summary of the utility of positive and negative provocative test results and MRI findings for diagnosing wrist ligament injuries. The classifications of utility are based on the LR (see legend). This classification does not take into account the imprecision associated with the LR.

	Provocative test positive	Provocative test negative	MRI positive	MRI negative
SL ligament	Mildly useful	Mildly useful	Mildly useful	Mildly useful
TFCC	Not useful	Not useful	Moderately useful	Moderately useful
LT ligament	Not useful	Not useful	Unclear	Not useful
Arcuate ligament	Mildly useful	Unclear	Unclear	Not useful
DRUJ	Not useful	Mildly useful	Not useful	Not useful
Lunate cartilage damage	Not useful	Not useful	Mildly useful	Mildly useful

Positive LR results
Not useful: less than 2.00
Mildly useful: between 2050 and 5.00
Moderately useful: between 5.00 and 10.00
Very useful: greater than 10.00

Negative LR results
Not useful: more than 0.50
Mildly useful: between 0.20 and 0.50
Moderately useful: between 0.10 and 0.20
Very useful: less than 0.10

Table 4. Number of participants (percentage) correctly diagnosed with or without wrist ligament injuries using provocative tests only, and using provocative tests and MRI. The correct diagnosis was confirmed by arthroscopy.

Ligament	Correctly classified using provocative tests only	Correctly classified using provocative tests and MRI	Difference (*p* value)	Number needed to scan
SL ligament (n = 55)	43 (78%)	44 (80%)	2% (0.002)	55
LT ligament (n = 55)	52 (95%)	49 (94%)	–0.3% *	–
TFCC (n = 55)	40 (73%)	47 (86%)	12.7% (< 0.001)	8
DRUJ (n = 55)	40 (73%)	39 (71%)	–1.8% (0.60)	–
Arcuate ligament	*	*	*	*
Lunate cartilage damage (n = 53)	38 (72%)	42 (79%)	7.5% (< 0.001)	13

* Not able to be to calculated

Ninety-two (87%) of the 105 participants were right-handed, seven were left-handed, and five were ambidextrous. The mean age of participants was 37 years (SD 12). The median (IQR) time from injury to assessment was 9.6 months (3.9 to 14.8). Sixty-two (59%) of the participants' work and activities of daily living necessitated a 'heavy' demand on the wrist, 39 (37%) a 'moderate' demand, and four (4%) a 'light' demand (as defined by the 3-point scale of functional demand on the wrist).

Fifty-eight participants (55%) reported symptoms in the right wrist. Wrist pain was located in the radial region in 15 (14%), in the ulnar region in 56 (53%), in the central region in 30 (29%), and in all regions in four (4%). Forty-seven participants (44%) reported a sensation of giving way in the wrist on the 4-point participant-perceived stability scale. The giving way was reported in approximately equal proportions across heavy, moderate, and light activity. On the Patient-Rated Wrist and Hand Evaluation questionnaire, the mean pain score was 28 out of 50 (SD 10), the mean function score was 21 out of 50 (SD 10), and the mean total score of pain and function combined was 49 out of 100 (SD 19).

Table 1 cross-tabulates the provocative test and arthroscopic findings. Few participants had positive results for both the provocative tests and arthroscopies. For example, of the 105 participants, only 27 (26%) had positive provocative tests and arthroscopies for SL ligament injuries, 35 (33%) had positive provocative tests and arthroscopies for TFCC injuries, 17 (17%) had positive provocative tests and arthroscopies for lunate cartilage damage, 9 (9%) had positive provocative tests and arthroscopies for DRUJ injuries, 1 (1%) had positive provocative tests and arthroscopies for LT ligament injuries, and 2 (2%) had positive provocative tests and arthroscopies for arcuate injuries. Most tests appeared to have little or no diagnostic value. Possible exceptions were positive findings from the SS test (+ve LR 2.88, 95% CI 1.68 to 4.92) and the MC test (+ve LR 2.67, 95% CI 0.83 to 8.60) and negative findings from the SS test (–ve LR 0.28, CI 0.15 to 0.55) and the DRUJ test (–ve LR 0.3, CI 0.11 to 0.86), all of which were mildly useful. There were a number of incidental arthroscopic findings. Arthroscopic findings in addition to ligament injuries and lunate cartilage damage included synovitis (66, 63%), ganglions (17, 16%), and cartilage damage excluding the lunate (24, 23%).

Table 2 cross-tabulates findings of MRI and arthroscopy. Positive MRI findings for SL ligament injuries (LR 4.17, 95% CI 1.54 to 11.30), TFCC injuries (LR 5.56, 95% CI 1.92 to 16.10), and lunate cartilage damage (LR 3.67, 95% CI 1.84 to 7.32) were of mild to moderate diagnostic usefulness. Negative MRI findings for SL ligament injuries (0.32, 95% CI 0.16 to 0.65), TFCC injuries (0.15, 95% CI 0.06 to 0.37), and lunate cartilage damage (0.33, 95% CI 0.14 to 0.78) were likewise of mild to moderate diagnostic usefulness. The usefulness of both provocative tests and MRI for diagnosing ligament injuries is summarised in Table 3 according to a recommended interpretation of positive and negative LRs (Portney and Watkins 2009).

The incremental diagnostic value of adding MRI to provocative tests was statistically significant for TFCC injuries and lunate cartilage damage, as shown in Table 4 ($p < 0.001$). An additional 13% of participants were correctly diagnosed as having or not having TFCC injuries with MRI over and above those correctly diagnosed with provocative tests alone. That is, for every eight scans there was one more correct diagnosis of the presence or absence of TFCC injury (ie, the NNS was eight). The NNS for lunate cartilage lesions was 13. MRI did not significantly improve diagnostic accuracy of any other ligament injury. MRI provided little incremental diagnostic accuracy because 72% to 95% of participants were diagnosed correctly by the provocative tests alone. This was partly because a large proportion of participants who went on to MRI did not have ligament injuries (Table 2).

Discussion

Information about the accuracy of provocative tests for diagnosing wrist ligament injuries is important for clinicians. This study shows that provocative wrist tests are not useful for diagnosing injuries to the TFCC, LT ligament, DRUJ, or lunate cartilage. Positive SS and MC tests, and negative SS tests, are mildly useful for diagnosing SL and arcuate ligament injuries.

The conclusions of this study are dependent on the interpretation of positive and negative LR. A positive LR indicates how well a positive test finding 'rules in' a ligament injury and a negative LR indicates how well a negative test finding 'rules out' a ligament injury. A positive LR greater than ~2 or a negative LR less than ~0.5 may be indicative of a useful test (Guyatt et al 2008, Portney and Watkins 2009). However, the implications of diagnostic accuracy can only be interpreted after taking into account the pre-test probability of a ligament injury. For example, if the clinical history of a participant suggests a pre-test probability of SL ligament injury of 50% and the provocative test has a positive LR of 2.88, these findings together indicate a 73% probability that the participant has a SL ligament injury.

The first question of this study concerned the usefulness of the seven provocative tests commonly used to diagnose wrist ligament injuries. The two most promising provocative tests were the SS test and MC test although neither is very informative (Table 1). The SS test positive LR was 2.88 and its negative LR was 0.28; both were estimated with moderate precision as reflected by the narrow 95% CI. The MC test performed had a positive LR of 2.67, and the LR associated with an uncertain test result was 2.31. These estimates were very imprecise (95% CI 0.83 to 8.60 and 1.05 to 5.08 respectively). While the negative LR for the DRUJ test showed some promise (0.30), this was again associated with considerable imprecision (95% CI 0.11 to 0.86). Imprecision of estimates was also a problem for the LT, DRUJ, and MC tests. This may have been partly due to the low proportion of participants with LT, DRUJ, and arcuate ligament injuries confirmed by arthroscopy. Only 6% of participants had a confirmed LT ligament injury (Table 1). None of the other provocative tests clearly demonstrated diagnostic value. These findings are consistent with those of La Stayo and Howell (1995) who also reported similar poor positive LRs for the LT and TFCC tests (1.2 and 1.8 respectively, calculated from data provided in the paper).

The second question addressed in this study was the usefulness of MRI for diagnosing wrist ligament injuries (Table 2). The data show that positive and negative MRI findings of TFCC injuries are moderately useful for ruling in (+ve LR 5.56, 95% CI 1.92 to 16.10) and ruling out (–ve LR 0.15, 95% CI 0.06 to 0.37) these injuries. MRI was also mildly useful for ruling in and out SL ligament injuries (+ve LR 4.17, 95% CI 1.54 to 11.30; –ve LR 0.32, 95% CI 0.16 to 0.65), and lunate cartilage damage (+ve LR 3.67, 95% CI 1.84 to 7.32; –ve LR 0.33, 95% CI 0.14 to 0.78). MRI findings for SL ligament injuries classified as 'uncertain' on the provocative tests (indicated by hypermobility or pain that was not the pain the participant presented with) were mildly useful for ruling in SL ligament injuries (positive LR 3.48, 95% CI 0.74 to 16.40). MRI was not useful in diagnosing other wrist ligament injuries. The MRI findings need to be interpreted with caution because surgeons who performed the arthroscopies were not blinded to the MRI results.

While it is possible that our MRI results may have been better if we had used high resolution rather than low resolution MRI, this would seem unlikely. Faber and colleagues (2010) reported no difference in the positive predictive values of high and low resolution MRI for diagnosing TFCC injuries, although higher resolution MRI was slightly better for ruling out TFCC injuries. Anderson and colleagues (2008) argued that high resolution MRI was more useful than low resolution MRI for diagnosing wrist ligament injuries, however when we used the authors' data to derive LRs we found that their results were very similar to our own.

MRI combined with provocative tests improved the proportion of correct diagnoses of TFCC injuries by 13% and lunate cartilage damage by 8%. That is, eight additional scans would need to be performed to make one more correct diagnosis of the presence or absence of TFCC injury compared to diagnosis by provocative tests alone, and 13 additional scans would need to be performed to make one more correct diagnosis of the presence or absence of lunate cartilage damage. There was no benefit in performing MRI in addition to provocative wrist tests for diagnosis of SL, LT, arcuate ligament, and DRUJ injuries. The additional diagnostic benefit of MRI scans needs to be weighed against the cost of 8–13 scans for one more correct diagnosis.

The results of the arthroscopies indicated that 63% of wrists had synovitis. Synovitis is often due to an inflammatory reaction following trauma in the absence of arthritis. Perhaps those who had synovitis had an injury to the joint capsule. This might partly explain the limited value of the provocative tests for diagnosing wrist ligament injuries. This possibility was explored with post hoc exploratory analyses in which any finding of wrist synovitis was cross tabulated with the SS test and then with the TFCC test. The TFCC test did not perform any better. The positive LR associated with an 'uncertain' test result (ie, hypermobile or pain different to the primary pain the participant presented with) for the SS test appeared to be moderately useful, but the estimate of diagnostic utility was very imprecise (LR 4.77, 95% CI 0.67 to 34). Further studies could explore the value of provocative tests for diagnosing wrist synovitis or other conditions.

Strengths of this study include the recruitment of a consecutive sample of participants suspected of wrist ligament injuries, and that all participants were tested with the reference standard. A limitation of this study was that MRI was conducted at the surgeon's discretion and performed on only a subgroup of participants. Arthroscopies were not conducted blinded to the results of the MRIs but were performed blinded to the results of the provocative tests. These limitations would tend to inflate estimates of the accuracy of MRI.

In summary, the results of this study indicate that provocative wrist tests are of limited value for diagnosing wrist ligament injuries. The SS test and MC test are mildly useful in the diagnosis of SL and arcuate ligament injuries. MRI slightly improves the diagnosis of TFCC injury and lunate cartilage damage compared to provocative tests alone. ■

Ethics: The University of Sydney Ethics Committee approved this study. All participants gave written informed consent before data collection began.

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