Evaluating Accuracy of Plain Magnetic Resonance Imaging or Arthrogram versus Wrist Arthroscopy in the Diagnosis of Scapholunate Interosseous Ligament Injury

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Abstract

Introduction Scapholunate interosseous ligament injury (SLIL) is the most common cause of wrist instability and a cause of morbidity in a proportion of patients with wrist injuries.

Aim To evaluate the accuracy of plain magnetic resonance imaging (MRI) and MR arthrogram (MRA) in the diagnosis of SLIL injury against the existing gold standard-wrist arthroscopy.

Materials and Methods We retrospectively reviewed 108 cases by comparing MRI/MRA reports and their wrist arthroscopy operation notes.

Results Overall MRI sensitivity to SLIL injuries was 38.5% (91.0% specificity). When broken down into plain MRI and MRA the results were: plain MRI sensitivity = 19.2% (91.4% specificity) and MRA sensitivity = 57.7% (90.5% specificity).

Conclusion Neither MRI nor MRA scanning is sensitive enough compared with the gold standard. Positive predictive value remains too low (62.5 and 88.2%, respectively) to consider bypassing diagnostic arthroscopy and treating surgically. The negative predictive value (60.4 and 63.6%, respectively) is inadequate to confirm exclusion of injury from MRI results alone.

Keywords
- scapholunate ligament injury
- diagnosis
- evaluation
- magnetic resonance imaging
- arthroscopy

Introduction

Scapholunate interosseous ligament (SLIL) injury is the most common cause of wrist instability[1] and is most commonly associated with a fall on an outstretched hand with wrist hyperextension and forearm pronation.[2] It can either occur in isolation or occur with distal radius fractures and its associated instability can be a cause of morbidity, causing chronic pain often exacerbated by physical activity.[3] Additionally, some patients are left with a degree of disability due to a reduction in functional movements and grip strength, leading to occupational issues.[4] Untreated SLIL injury can lead to scapholunate advanced collapse (SLAC) arthritis, which is the main long-term complication of this injury, although the proportion of SLIL injuries that lead to a SLAC remains unclear, with few studies following the natural history of SLIL injury.[5]

Swift detection of SLIL injury is paramount to the success of corrective surgery as the ability of the ligament to heal is highest in the acute phase of injury.[1,6] A thorough history and clinical assessment is paramount. There are various clinical tests such as the Kirk-Watson test that can elicit signs of SLIL injury; however even in the context of patients with high grade instability, this test is only 68% sensitive and 66% specific.[7] Following on there are several investigations that are useful to varying degrees in on our ability to accurately diagnose SLIL injuries. These include plain radiographs, dynamic stress tests under fluoroscopic imaging,

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plain magnetic resonance imaging (MRI), MR arthrogram (MRA) or wrist arthroscopy. The latter is regarded as the gold standard for diagnosing SLIL injuries; however, it is the most invasive investigation available performed in the operating theater setting.[8,9]

MRI thus has a role to play as a noninvasive diagnostic tool, being used since the late 1980s with varying levels of accuracy.[10] Additionally, the use of contrast injection within the MRI protocol to highlight any defects in the ligament has been explored extensively.[11] The role of contrast is to highlight any visible communications between compartments, which changes the outcomes of MRI results and presents its own challenges in the form of differences in sensitivity and specificity.[12]

The expense and difficulty of performing arthroscopy warrants further investigation into the effectiveness of MRI and MRA in the diagnosis of SLIL injury to guide clinical decision-making and to add to the existing literature base exploring this subject. This study aims to do so by analyzing retrospectively collected data from past arthroscopies and thus measure the effectiveness of MRI and MRA studies against this gold standard.

Materials and Methods

Data Collection

We identified 251 wrist arthroscopies done in a 7-year period within our department. Of these cases, 67 arthroscopies were excluded as they had no corresponding MRI scans, another 75 patients were not included as the MRI reports were not available internally at the time of review. This left 109 patients with scans and operation notes available. One other case was excluded due to loss of operation note findings, leaving 108 patients for further analysis.

Retrospectively, MRI/MRA reports and wrist arthroscopy operation notes were then compared. There were 36 males and 72 females with ages ranging between 16 and 74 with an average age of 37.9 years. Within our cohort, 61 patients had plain MRI scans prior to arthroscopy the remaining 47 underwent MRA scans.

Arthroscopy Methods

For all 108 patients, a standard tricompartmental diagnostic arthroscopy was performed by fellowship-trained hand surgeons, the operation notes were reviewed, and findings were classified according to the Geissler classification,[13] with additional findings noted within a proforma such as the state of ligaments, soft tissue, and bone.

Magnetic Resonance Imaging Methods

All 108 cases had MRI reports overseen or written by senior radiologists. Over 15 different radiologists contributed to these reports as our patient cohort included referrals from a variety of district hospitals. Thus, it was not possible to determine the level of specialization of the radiologists due to the retrospective nature of the study, and although the methods of performing scans were similar, they were not entirely constant. The strength of the MRI scanners across all hospitals was not recorded either.

There were no set criteria used universally among the radiologists to determine SLIL injury on reviewing the scans. Signs that the radiologists looked for included:

- Contrast leak from the radiocarpal joint compartment to the midcarpal compartment that may indicate SLIL tear on arthrogram.
- Visual disruption of the ligament when viewed on axial and coronal views.
- Increased signal strength in the region of the SLIL.

Results

Combined Results of Magnetic Resonance Imaging/Arthrogram Cases versus Arthroscopy

Throughout the whole study sample, 52 patients were found to have SLIL injuries on arthroscopy. A total of these 37 injuries were classified as Geissler score 2 or above. Of the remaining 15 cases, 12 were classified as Geissler 1 scores and 3 were classified as between 1 and 2 (►**Table 1**).

MRI reporting sensitivity with/without contrast in diagnosing all SLIL injuries was 38.5%, with specificity at 91.1%. The positive predictive value (PPV) was 80% and the negative predictive value (NPV) was 61.5% (►**Table 2**).

Geissler 1 grade injuries do not feature tears; thus, it can be inferred that they may be more difficult to diagnose on MRI scanning. The table of combined results for all injuries shows that higher Geissler's scores have higher rates of diagnosis on MRI and lower scores such as Geissler 1 grade injuries are diagnosed only 16.7% of the time. When Geissler's scores of less than 2 are excluded the number of false negatives becomes 20 and the sensitivity rises to 45.9% (same level of specificity). PPV subsequently fell to 77.3% and NPV rose to 71.8% (►**Table 2**).

Plain Magnetic Resonance Imaging Results

Within the plain MRI group, 26 out of 61 had some degree of damage to the SLIL confirmed by arthroscopic investigation (41.9%) and 18 of the SLIL injury cases were classified as Geissler 2 score or above. Of the remaining eight injuries,

Table 1 Combined results of magnetic resonance imaging/arthrogram versus arthroscopy

Geissler classification	All tears	Geissler 1	Geissler 2	Geissler 3	Geissler 4
Number of patients (out of 108)	52	12	20	8	12
Number of injuries correctly diagnosed on MRI/MRA	20	2	6	4	8
Percentage of injuries correctly diagnosed on MRI/MRA (%)	38.5	16.7	30	50	66.7

Abbreviations: MRA, resonance imaging arthrogram; MRI, magnetic resonance imaging.

seven were scored as Geissler stage 1 and one case was classified as in between Geissler 1 and 2 (►**Table 3**).

Plain MRI reporting sensitivity in diagnosing all SLIL injuries was 19.2%, with specificity at 91.4%. The PPV and NPV are 62.5 and 60.4%, respectively. Furthermore, when Geissler 1 scores are also excluded the number of false negatives becomes 13 and the sensitivity rises to 27.8%; PPV remains the same; however, NPV rises just over 10 to 71.1% (►**Table 4**).

Magnetic Resonance Arthrogram Results

Within the MRI with contrast group, 26 out of 47 cases were demonstrated to have some degree of SLIL injury on arthroscopy and 19 of these cases were classified as Geissler 2 score or above. Of the remaining seven injuries, five were scored as Geissler stage 1 and two cases were classified as in between Geissler 1 and 2 (►**Table 5**).

MRA reporting sensitivity in the diagnosis of all SLIL injuries was 57.7%, with specificity at 90.5%. The PPV is

Table 2 Magnetic resonance imaging/arthrogram versus arthroscopy sensitivity and specificity

	SL injury positive on arthroscopy (Geissler 1–4)	SL injury positive on arthroscopy (Geissler 2+ only)	SL injury (negative on arthroscopy)	Geissler 1–4 predictive values	Geissler 2+ predictive values
Total no. of cases	52	37	56	PPV = TP/(TP + FP) = 20/(20 + 5) = 80%	PPV = TP/(TP + FP) = 17/(17 + 5) = 77.3%
	Sensitivity = TP/(TP + FN) = 20/(20 + 32) = 38.5%	Sensitivity = TP/(TP + FN) = 17/(17 + 20) = 45.9%	Specificity = TN/(TN + FP) = 51/(51 + 5) = 91.1%	NPV = TN/(TN + FN) = 51/(51 + 32) = 61.5%	NPV = TN/(TN + FN) = 51/(51 + 20) = 71.8%

Abbreviations: FN, false negative; FP, false positive; NPV, negative predictive value; PPV, positive predictive value; SL, scapholunate; TN, true negative; TP, true positive.

Table 3 Results of plain magnetic resonance imaging diagnosed scapholunate interosseous ligament injuries

Number of patients (out of 61)	26	7	8	3	8
Number of injuries correctly diagnosed on MRI	5	0	0	1	4
Percentage of injuries correctly diagnosed on MRI (%)	19.2	0	0	33.3	50

Abbreviation: MRI, magnetic resonance imaging.

Table 4 Sensitivity and specificity of plain magnetic resonance imaging versus arthroscopy

	SL Injury positive on arthroscopy (Geissler 1–4)	SL injury positive on arthroscopy (Geissler 2+ only)	SL Injury (negative on arthroscopy)	Geissler 1–4 predictive values	Geissler 2+ predictive values
Total no. of cases	26	18	35	PPV = TP/(TP + FP) = 5/(5 + 3) = 62.50%	PPV = TP/(TP + FP) = 5/(5 + 3) = 62.50%
	Sensitivity = TP/(TP + FN) = 5/(5 + 21) = 19.2%	Sensitivity = TP/(TP + FN) = 5/(5 + 13) = 27.8%	Specificity = TN/(TN + FP) = 32/(32 + 3) = 91.4%	NPV = TN/(TN + FN) = 32/(32 + 21) = 60.4%	NPV = TN/(TN + FN) = 32/(32 + 13) = 71.1%

Abbreviations: FN, false negative; FP, false positive; NPV, negative predictive value; PPV, positive predictive value; SL, scapholunate; TN, true negative; TP, true positive.

88.2%, meaning with a positive MRI result only 11.8% of patients who undergo diagnostic arthroscopy will have no concordant injury. The NPV was 63.6% and rises to 67.9% when Geissler 1 scores are excluded (►**Table 6**).

Discussion

Despite some missing scan reports, this is one of the larger studies of MRI/MRA versus arthroscopy in the diagnosis of SLIL injury. When considering the results for the overall sensitivity of MRI against arthroscopy, the results for the combined MRI (38.5%) and plain MRI (19.2%) fall into the range of results found in the literature, although the MRA sensitivity was slightly lower at 57.7%.[14–18]

On assessing sensitivity of plain MRI versus arthroscopy, published data varied between 18.5 and 89%, with varying levels of specificity.[14–16] The large variation in results might be explained by the varying strengths of magnet used; studies that used a strength of 3 Teslas (T) both found the sensitivity to be 89% with a high specificity.[19,20] Whereas those that used 1.5T strength magnets found specificities of 66% and below.[21]

When looking more specifically into the sensitivity of MRI in diagnosing different stages of SLIL injury, it is evident that the higher Geissler's scores are associated with the highest pick up rates on MRI. At the lower end of the Geissler scale, sensitivity was zero for plain MRI. Considering this, the sensitivity of plain MRI for higher Geissler scores increases by a greater proportion than MRA (44.5% higher sensitivity over the original result compared with 9.5%) and MRA results then fall into the range found in the literature review at 63.2%.[21–23] The lower end of Geissler scale has shown to have interobserver and intraobserver variations,[18,24] which could have influenced our results too.

Regarding sensitivity of MRA versus arthroscopy, this ranged from 63 to 100% with specificities of above 80% in all cases.[16,25] Schmitt et al made a distinction between diagnosis of partial and full tears of the SLIL on MRA; 62% of partial tears were detected in a study involving 125 patients, compared with 91% sensitivity for the detection of full tears.[25]

Comparing MRI and MRA, the sensitivity and specificity of MRI is lower compared with MRA; MRI are readily available and comparatively cheaper compared with MRA. The major drawback that we found that at times the referring district hospital logistically could not perform MRA in the first instance, and thus, MRI becomes a very valuable diagnostic tool for patients with clinically suspected dorsal wrist pain and positive Kirk-Watson test. The diagnostic accuracy of plain MRI varies widely depending on multiple factors. In our study, it was believed that patients who were referred for MRI scan had positive clinical signs and symptoms (such as a Kirk-Watson test) for SLIL injury. In nonspecific cases where the clinical signs are not definite, and the patient continues

Table 5 Results of magnetic resonance arthrogram diagnosed scapholunate interosseous ligament injuries

Geissler classification	All tears	Geissler 1	Geissler 2	Geissler 3	Geissler 4
Number of patients (out of 62)	26	5	12	5	4
Number of injuries correctly diagnosed on MRI	15	2	6	3	4
Percentage of injuries correctly diagnosed on MRI (%)	57	40	50	60	100

Abbreviation: MRI, magnetic resonance imaging.

Table 6 Sensitivity and specificity of magnetic resonance arthrogram versus arthroscopy

	SL Injury positive on arthroscopy (Geissler 1–4)	SL injury positive on arthroscopy (Geissler 2+ only)	SL Injury (negative on arthroscopy)	Geissler 1–4 predictive values	Geissler 2+ predictive values
Total no. of cases	26	19	21	PPV = TP/(TP + FP) = 15/(15 + 2) = 88.2%	PPV = TP/(TP + FP) = 12/(12 + 2) = 85.7%
	Sensitivity = TP/(TP + FN) = 15/(15 + 11) = 57.7%	Sensitivity = TP/(TP + FN) = 12/(12 + 7) = 63.2%	Specificity = TN/(TN + FP) = 19/(19 + 2) = 90.5%	NPV = TN/(TN + FN) = 19/(19 + 11) = 63.6%	NPV = TN/(TN + FN) = 19/(19 + 7) = 67.9%

Abbreviations: FN, false negative; FP, false positive; NPV, negative predictive value; PPV, positive predictive value; SL, scapholunate; TN, true negative; TP, true positive.

with pain then performing an MRI may also be beneficial in reaching a diagnosis. Furthermore, the incidence of SLIL injury in scaphoid waist fractures is relatively higher than previously reported.[26] Thus, this makes it even more important to consider MRI/MRA based on clinical findings.

Although MRA appears to be superior to MRI alone and 3T scans superior to 1.5T, a recent systematic review has also demonstrated that MRA is better than 3T MRI and 1.5T MRI scans with a sensitivity of 82.1% and specificity of 92.8%.[27] However, the sensitivity still appears significantly lower than the gold standard, making it an inadequate alternative so far despite the use of a contrast solution to enhance imaging and diagnostic ability.[14]

Overall the results show that both MRI and MRA are not appropriate replacements for diagnostic arthroscopy; neither have high enough sensitivity rates and both have a NPV that is much lower than the gold standard meaning that a negative MRI test result is not enough evidence to exclude an SLIL injury.[22] It can also be debated that although MRI is a more reliable test for higher grade injuries, the clinical suspicion for these injuries also rises in tandem; this could mean that clinical tests could be of similar or higher accuracy in diagnosing SLIL injury, decreasing the usefulness of MRI.[28] Correlating arthroscopic findings with those found during the surgical procedure was beyond the scope of this study.

Due to the retrospective nature of this study, there is a higher opportunity for bias and the level of evidence; this study provides would not be as high as a prospective study with more rigid criteria for diagnosing SLIL injury on MRI especially. As mentioned in the methods, the criteria used by the 15 radiologists to diagnose injuries were not constant; however, arthroscopic criteria used by fellowship trained hand surgeons was constant. Additionally, the magnet strengths and MRI protocols used cannot be concluded to be constant within the study sample, as previously mentioned this variable could have an effect on results, although this is likely to be common in other similarly designed studies; therefore, the results should be applicable to a wider practice. A future study with predetermined criteria for diagnosis of SLIL injury would rectify this. Additionally, with more time available the scanners and protocols used could be sourced for this study to elucidate any differences in the study sample.

In addition to the level of clinical suspicion, an investigation into the comparative costs of MRI, MRA, and diagnostic arthroscopy would be helpful in deciding which modality is appropriate in practice, and whether they are more useful or cost effective than clinical tests alone in the long run.

Conclusion

The diagnosis of SLIL injuries is based on a spectrum of investigations. Neither MRI nor MRA scanning is sensitive enough compared with the gold standard of wrist arthroscopy. PPV remains too low (62.5 and 88.2%, respectively) to consider bypassing diagnostic arthroscopy and treating surgically. The NPV (61%) is inadequate to confirm exclusion of injury from MRI results alone.

Steps that can be taken to improve MRI accuracy may include use of higher strength magnets (3T or over) and increasing the use of contrast. The cost effectiveness of these steps must be evaluated and comparisons with the accuracy of clinical tests must be made to clarify the usefulness of MRI/MRA in future practice.

This subject requires further exploration in the form of a prospective study with better defined criteria, more controlled variables such as MRI strength and protocol and a larger sample size. Once these variables are adjusted for, recommendations on the use of MRI/ MRA in the diagnosis of SLIL injures can be concluded more easily, until then it is only possible to use MRI/ MRA as a diagnostic aid while continuing the use of arthroscopy as a gold standard test.

Conflict of Interest
None declared.

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