The Value of 3.0-Tesla MRI in Diagnosing Scapholunate Ligament Injury

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Abstract

Objective To determine the sensitivity and specificity of 3.0-tesla (T) magnetic resonance imaging (MRI) and a dedicated hand coil in diagnosing scapholunate ligament (SLL) injury compared with intraoperative findings.

Methods From January 2006 until September 2010, 3.0-T MRI scans were performed on 38 wrists (37 patients) with clinically unclear but suspected lesions of the SLL. These scans were evaluated by two experienced radiologists. Radiological findings were compared with intraoperative findings during arthrotomy. Sensitivity, specificity, accuracy, and positive and negative predictive value were calculated.

Results An SLL lesion was identified during arthrotomy in 37 wrists. The first radiologist identified an SLL lesion on MRI in 26 wrists, all of which were confirmed intraoperatively. The second radiologist identified SLL lesions in 31 patients; however, intraoperatively it was found that there was no lesion of the ligament in one patient. Sensitivity ranged from 70 to 81% with a specificity of 100% and a positive predictive value of 97 to 100%. Accuracy measured 71 to 79%.

Conclusions 3.0-T MRI of the wrist is moderately sensitive and very specific for detection of SLL lesions. However, if there is a high clinical suspicion of an SLL rupture, a 3.0-T MRI does not often have an additional value.

Level of Evidence Diagnostic, level II

Keywords

- 3.0 Tesla
- magnetic resonance imaging
- scapholunate ligament lesion
- wrist arthrotomy

Diagnosis of a complete scapholunate ligament (SLL) injury is most often largely based on history, clinical examination, and plain radiographs.^{1–3} Unfortunately, an unequivocal diagnosis cannot always be made because a rupture is partial or because a complete rupture has intact secondary scaphoid stabilizers (the scaphotrapezotrapezoidal, scaphocapitate, and radioscaphocapitate ligaments).^{4,5} These cases require a more extensive diagnostic workup. Arthroscopy and conventional or magnetic resonance (MR) arthrography are the preferred diagnostic tools to assess the state of the SLL in cases with a suspected rupture of the ligament. Although widely accepted, these diagnostic tools have their downsides. Many

surgeons consider arthroscopy the gold standard for direct visualization of the involved structures. Others perform arthroscopy only rarely because the procedure is invasive, costly, and potentially associated with complications.^{2,6} Also, when a SLL rupture is identified, immediate arthroscopic treatment options are limited, often requiring conversion to arthrotomy.

X-ray or MR arthrography can demonstrate abnormal contrast fluid leakage between carpal rows, which can be suggestive of SLL rupture. However, it has been reported that the incidence of degenerative perforations of the SLL increases with age, causing false positive results.⁷

Currently, MR imaging (MRI) of the wrist is most often performed using the standard magnetic field strength of 1.5 tesla. It is widely available, relatively inexpensive, and noninvasive, and it avoids the need for regional or general anesthetics.² In practice, this field strength is not sufficient to visualize the small and complex carpal ligaments adequately.^{2,8} As higher-field-strength MRI is becoming more widely available, imaging may become more accurate by the use of 3.0 T instead of the standard 1.5-T field strength.^{9–12}

The purpose of this retrospective cohort study was to determine the sensitivity and specificity of 3.0-T MRI in diagnosing SLL lesions by comparing MRI findings to direct intraoperative visualization of the SLL.

Materials and Methods

From January 2006 until September 2010, 37 patients (38 wrists) underwent a wrist arthrotomy for a highly suspected SLL lesion. In all these patients, arthrotomy was indicated based on history and physical examination (positive Watson scaphoid shift test), but on conventional plain X-ray images there were no evident findings of an SLL lesion.³ To assess the value of additional imaging in patients with a high clinical suspicion of an SLL lesion, wrists of this cohort were scanned preoperatively using 3.0-T MRI. The results of this MRI were not included in clinical decision making.

Patients with an evident SLL lesion, based on history, physical examination, and conventional X-ray findings—scapholunate (SL) diastasis > 3 mm, dorsal intercalated segment instability (DISI) deformity, and/or positive ring sign—were listed for elective surgery without performing a preoperative MRI scan and were therefore not included in this study.

MRI was performed using a 3.0-T superconducting magnet (MR Philips Achieva, the Netherlands). An optimized eight-channel transmit-receive wrist coil (Philips, the Netherlands) was used. All patients were placed in the MRI apparatus in the feet-first supine position with the elbow extended beside the trunk. The involved wrist was placed inside the wrist coil in the neutral position with all fingers in extension. The hand was immobilized with a splint and foam cushions to reduce motion artifacts. The surface coil was placed off-center in the imager. The imaging sequences included two T2-weighted non-fat-suppressed fast spin-echo sequences in the coronal and transversal directions [time to repetition / echo time 4094/30 ms; field of view $80 \times 80 \times 39.4 \text{ mm}^3$ and acquired resolution $0.3 \times 0.4 \times 2.0 \text{ mm}^3$ in coronal direction, and field of view $60 \times 60 \times 23.64 \text{ mm}^3$, and acquired resolution $0.3 \times 0.4 \times 1.2 \text{ mm}^3$ in transversal direction] (**► Figs. 1 and 2**).

MRI scans were evaluated by two hand and wrist-experienced radiologists who were not informed about the operative findings. The scans were reviewed for the presence of a partial or complete rupture of the volar, proximal, and dorsal aspects of the SLL.

During surgery, the SLL was inspected. If a complete rupture or a lesion of the dorsal part of the SLL was present, a three-ligament tenodesis reconstruction according to

Fig. 1 3.0-T transversal T2-weighted wrist MRI scan. Gray intraarticular fluid between the scaphoid (left) and the lunate (right) is separated from the radiocarpal fluid by the intact dorsal SLL (black, see the white arrow).

Garcia-Elias et al was performed.¹³ All operations were performed by one senior hand surgeon.

Findings on MRI were compared with the intraoperatively visualized status of the SLL. Results were analyzed statistically.

Statistical Analysis

Sensitivity, specificity, accuracy, and positive and negative predictive value for detection of SLL tears were calculated for the 3.0-T MRI scans compared with intraoperative findings.

Sensitivity was calculated as follows: number of true positives / (number of true positives + number of false negatives) $\times 100\%$. Specificity was defined as: number of true negatives / (number of true negatives + number of false positives) $\times 100\%$. Also, predictive value positive was

Fig. 2 3.0-T transversal T2-weighted wrist MRI. Gray intraarticular fluid between the scaphoid (left) and the lunate (right) is continuous dorsally with the radiocarpal fluid, confirming a lesion of the dorsal SLL (white arrow).

calculated as: number of true positives / (number of true positives + number of false positives) $\times$ 100%. Predictive value negative is the number of true negatives / (number of true negatives + number of false negatives) $\times$ 100%.

The kappa multi-rater measure was used to estimate agreement among the radiologists. Kappa = (observed agreement - expected agreement) / (1 - expected agreement).

Interpretation of this value was done according to the scale proposed by Altman et al: 0 to 0.20, poor strength of agreement; 0.21 to 0.40, fair agreement; 0.41 to 0.60, moderate agreement; 0.61 to 0.80, good agreement; 0.81 to 1.0, very good agreement.¹⁴

Results

Of the 38 wrists, only one wrist was found to have an intact SLL intraoperatively. The other 37 wrists showed carpal instability due to at least a partial rupture of the dorsal part of the SLL and were treated with a three-ligament tenodesis reconstruction. Solitary (partial) volar tears were not encountered intraoperatively in this cohort.

The first radiologist identified a dorsal SLL lesion on MRI in 26 wrists, all of which were confirmed intraoperatively (► **Table 1**). The second radiologist identified a dorsal SLL lesion in 31 patients. However, intraoperatively there was no lesion of the ligament in one patient (► **Table 2**). Intraoperatively it was concluded that this patient had a dorsal ganglion cyst and an intact SLL. Both radiologists stated they could not clearly differentiate between partial and complete dorsal SLL tears. Solitary volar tears were not identified. Interobserver agreement between the radiologists was considered moderate, with a kappa calculated to be 0.520. Sensitivity, specificity, accuracy, and positive and negative predictive values were calculated (► **Table 3**).

Discussion

This study demonstrates that in patients with a clinically suspected SLL lesion, the 3.0-T MRI has a high specificity and a moderately high sensitivity. These results are favorable compared with previously published results for 1.5 T and are comparable to recently published, smaller studies of 3.0-T MRI of the SLL.^{15–17}

Hobby et al reviewed the diagnostic performance statistics of 1.5-T MRI for intrinsic carpal ligaments and found a sensitivity of 70%, specificity of 90% and accuracy of 85% for SLL lesions.¹⁵ Anderson et al investigated the diagnostic

Table 1 Lesion found on MRI by radiologist 1 and/or intraoperatively

	Operation: Lesion		Total	
	No	Yes		
MRI: Lesion	No	1	11	12
	Yes	0	26	26
Total		1	37	38

Table 2 Lesion found on MRI by radiologist 2 and/or intraoperatively

	Operation: Lesion		Total	
	No	Yes		
MRI: Lesion	No	0	7	7
	Yes	1	30	31
Total		1	37	38

Table 3 Statistics

	Radiologist 1	Radiologist 2
Sensitivity	70% (52.8–83.6)	81% (64.3–91.4)
Specificity	100% (5.5–100)	Incalculable*
Positive predictive value	100% (84.0–100)	97% (81.5–99.8)
Negative predictive value	8% (4.4–40.2)**	Incalculable*
Accuracy	71%	79%

Values in parentheses represent 95% confidence interval.

*These values are incalculable because one of the boxes contains zero patients.

**Based on a single case.

sensitivity, specificity, and accuracy of the 1.5-T and 3.0-T MRI and correlated the results with findings on arthroscopy in patients with ulnar sided wrist pain. They made 32 MRI scans at 3.0-T to assess multiple carpal ligaments. The number of patients with a suspected SLL injury was not reported, nor the number of SLL tears observed. Still, 3.0-T MRI sensitivity and specificity for the detection of SLL tears were reported to be 70% and 94%, respectively.¹⁶

Magee assessed the sensitivity and specificity of 3.0-T MRI compared with arthroscopy for detection of intrinsic wrist ligament and triangular fibrocartilage complex (TFCC) tears. Eighteen patients with suspected SLL tears were included. The MRI criterion used for diagnosis of a full-thickness SLL tear was the visualization of a complete defect in the ligament. Partial-thickness intrinsic ligament tears were not assessed because the author found arthroscopic correlation for partial-thickness tears difficult to obtain. He reported a sensitivity for detection of complete SLL tears of 89% (16 of 18) and a specificity of 100%.¹⁷

Design of the present study did not allow for inclusion of a control group. Although 3.0-T MR images of patients with low suspicion of SLL lesions or wrists of healthy subjects were available, these images could not be included in calculations of MRI specificity or sensitivity without arthroscopy or arthrotomy to confirm the radiological findings. For this reason, these control images have not been included in our analysis.

Results confirm that 3.0-T MRI is highly specific with a positive predictive value of 97–100% for complete SLL lesions.

In practice, this provides the hand surgeon a powerful argument toward operative treatment without the need for invasive diagnostic procedures.

Suspicion of SLL lesions based on history and physical examination was very high in this cohort, but not confirmed clearly on conventional X-ray imaging. The high index of suspicion may have introduced a bias toward cases with complete (dorsal) SLL lesions. In this group, results do confirm that 3.0-T MRI is a valuable addition in the diagnostic workup toward surgical treatment. If clinical suspicion of an SLL lesion is not as clear (in case of a partial tear, for example), 3.0-T MRI may be of less value. Even with the 3.0-T field strength, differentiation between partial and complete dorsal lesions remained difficult. MRI therefore does not seem the right modality to assess the SLL in detail. Indeed, diagnostic arthroscopy provides more definitive detail than MRI.

Also, based on one case, negative predictive value of 3.0-T MRI was low. An intact ligament on MRI therefore does not justify definitive nonoperative treatment. If clinical presentation is less clear, and MRI does not demonstrate a lesion but clinical suspicion remains high, arthroscopy remains a valuable option to diagnose SLL lesions.

In the diagnostic workup of SLL lesions, MRI does not seem to be a genuine replacement of the diagnostic arthroscopy. It does not provide the amount of detail with the same amount of certainty. It does, on the other hand, provide a noninvasive confirmation of a high clinical suspicion of an SLL tear. In these cases, arthroscopy can be averted and MRI can be used instead.

In the near future, increased MR imaging quality could eventually provide enough detail to overcome its current shortcomings. Indeed, techniques of MRI are constantly evolving. Use of additional sequences using fat suppression or use of higher-field-power MRI (7.0-T or 8.0-T MRI) is expected to increase reliability of visualization of the carpal ligaments.^{9,10,18}

In conclusion, 3.0-T MRI of the wrist is moderately sensitive and very specific for detection of complete SLL tears, reducing the need for invasive diagnostic techniques in some cases. Future studies are needed to investigate whether more sequences or ultrahigh-field MRI scans can also be used to raise the sensitivity and accuracy of detecting (partial) SLL injuries.

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