Scintillation Sign, A Magnetic Resonance Imaging (MRI) Feature That Contributes To Identify L-Shaped Non-Traumatic Rotator Cuff Tears

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Research Article

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Abstract

Objective

To determine the value of scintillation sign from Magnetic Resonance (MR) in assessing the tear of rotator cuff before operation.

Method

Preoperative MRI from 52 cases were system reviewed, two independent imaging physicians were invited to read the results. The results were further confirmed by the interoperative observations from the arthroscope. Statistical analysis was performed to estimate the sensitivity and specificity of scintillation sign.

Result

The specificity and sensitivity of the scintillation sign are relatively high stable, when used between different imaging physician or the same imaging physician at different times.

Conclusion

Scintillation sign is a very meaningful sign in identifying the L-shape tear with a high sensitivity and specificity, which is helpful for a better preoperative plan for the rotator cuff repair.

Background:

Non-traumatic rotator cuff tear is a common disease occurs in the shoulder joint. Magnetic resonance examination has been widely applied in the preoperative preparation of rotator cuff tear[1], because MRI has higher value than the other methods in the diagnosis and preoperative evaluation of rotator cuff tear. However, the efficiency of preoperative MR examination in distinguishing the type of rotator cuff tear is still low[2, 3]. Accurate determining the type of tear is the key point of the successful rotator cuff repair surgery. Therefore, it would undoubtedly be clinically beneficial to improve the efficiency of preoperative MR examination in identify the type of rotator cuff tear.

According to the canonical geometric classification [4], rotator cuff tears are divided into four subtypes including: crescent, longitudinal tear (including L-shaped and U-shaped), massive tear and rotator cuff tear combined with rotator cuff arthropathy. To date, crescent-shaped and longitudinal tears present the best prognosis of repair, which can be achieved by suture to the anatomical attachment area directly. U-shaped tears can be transformed into crescent-shaped tears after relatively symmetrical side-to-side sutures for further repair. While the L-shaped tear needs to find the inflection point of the longitudinal and

transverse cracks, which could be used as the boundary to stitch the longitudinal slit side-to-side, to transform the L-shaped tear into a crescent shape and make further repairs. So, the accurate preoperative recognition of L-shaped tear will make great sense. Currently, there is still little literature report on how to identify L-shaped tears on magnetic resonance images.

Method:

To increase the diagnosis rate of L-shape tear, a systemic review was designed for the present study. The MRI of the longitudinal tear was selected according to the geometric type of the rotator cuff tear among the non-traumatic tear cases. While the MRI of the shoulder joint in the oblique coronal position was read dynamically, if there are two adjacent images of the rotator cuff tissue at the torn part in the oblique coronal position, the rotator cuff tissue suddenly appears in the next frame from the continuous rotator cuff tissue or the rotator interval in the previous frame, characterised by the sudden appearance of the stub of the rotator cuff, it is highly indicated that an L-shaped tear may occur. To help the preoperative identification of this type of tear, we defined the magnetic resonance feature as a scintillation sign. The sensitivity and specificity of this sign in identifying L-shaped rotator cuff tears was analysed through the following study.

The preoperative magnetic resonance imaging of the shoulder joint of patients undergoing rotator cuff repair surgery was selected from the hospital imaging system due to the failure of conservative treatment for non-traumatic rotator cuff tears within 5 years. For the geometric classification of splits, 52 patients with longitudinal tears were selected ($\text{Length(L)} > \text{Width(W)}$, $W < 2\text{cm}$). (Figure 1)

Then the oblique coronal MRI of these patients with longitudinal tear were dynamically read from front to back or reversely. The apex of the rotator cuff stump suddenly appeared after the previous continuous rotator cuff tissue was a positive scintillation sign, and which was L-shaped or reverse L-shaped tear. (Figure 2)

Two independent consultants major in medical imaging interpreted and identified the scintillation sign according to the definition described above. The number of cases assessed by 2 doctors as positive for scintillation was recorded in (b) (b11, b21). The result was then validated according to the surgical records by the surgeon who did not participate in the operation. Intraoperative observation was used as the gold standard for the diagnosis of rotator cuff tear (Figure 3). The number of true L-shaped tear cases were recorded in (a) (a11, a21). Then the specificity (Sp) of the two imaging doctors was calculated by the following equation: $\text{Sp11} = a11/b11$, $\text{Sp21} = a21/b21$. The two specificity values are compared between groups to determine whether the difference interfered the specificity of the diagnosis of L-shaped tears.

Surgeons who were not involved in the operation screened a total of 23 patients with L-type from the 52 patients whose MRI geometric classification was longitudinal tear (c), and the two imaging consultants interpreted them independently according to the definition of the scintillation sign before surgery. The interpretation results (d) (d11, d21) from the consultants were compared with the results of the surgical records as sensitivity (Se) ($\text{Se11} = d11/c$, $\text{Se21} = d21/c$), then, the two sensitivity values were compared

between groups to determine whether the difference between the groups interfered with the sensitivity of the scintillation sign to diagnose L-shaped tears.

After 2 months, the two imaging doctors and surgeons interpreted the above data again (b12, b22; a12, a22) (d12, d22). The calculated specificities (Sp12, Sp22) and sensitivity (Se12, Se22) were compared with the first interpretation results to determine whether the differences within the group interfere with the specificity and sensitivity of the scintillation sign in the diagnosis of L-shaped tears.

Result:

According to the geometric classification of MRI rotator cuff tear, 52 cases of longitudinal tear were screened out.

The first interpretation: b11=25, a11=21, Sp11=0.84; b21=26, a21=19, Sp21=0.73. Comparison between groups: Comparison of Sp11 and Sp21 (Table 1).

d11=22, d21=20; Se11=0.96, Se21=0.87. Comparison between groups: Comparison of Se11 and Se21 (Table 2).

The second interpretation: b12=23, a12=17, Sp12=0.74; b22=24, a22=19, Sp22=0.79. d12=20, d22=21; Se12=0.87, Se22=0.91.

Intra-group comparison: comparison of Sp11 and Sp12 (Table 3), comparison of Se11 and Se12 (Table 4). Comparison of Sp21 and Sp22 (Table 5), comparison of Se21 and Se22 (Table 6).

Discussion:

Non-traumatic rotator cuff tear is the most common cause of the should pain which occurs frequently in the elder[5, 6]. Compared the conservative treatment, arthroscopic rotator cuff repair presented good rehabilitation[7]. However, it is still difficult to determine or predict whether the rotator cuff can be repaired and the type of tear in the preoperative planning[4, 8, 9].

Classification of rotator cuff tear (RCT) using shoulder magnetic resonance (MR) imaging is traditionally based on tear width and thickness, not arthroscopic classification. However, for surgical RCT repair, arthroscopic classification is more useful because the surgical method depends on the classification type. Compared with a radiologist's interpretation of knee MRI, in which the shape of a meniscal tear is regularly included in the description, the shape of a rotator cuff tendon tear remains a relatively difficult and misunderstood concept that has not taken a prominent place in the lexicon of the musculoskeletal radiologist. Some scholars have reported that axial MRI images are helpful for correctly dividing crescent tear and longitudinal tear [10], but how to identify L-shaped tear in longitudinal tear has not been reported. Some scholars presume that 3D reconstructions of rotator cuff tears would improve accuracy of the tear shape characterization [11], However, post-processing software limits its application. Other

scholars have studied the diagnostic value of three-dimensional shoulder magnetic resonance arthrography in the classification of rotator cuff tear; however, it was found that the diagnostic efficiency of L-type tear was low [12], and the invasive characteristics of arthrography limit its application. In this study, we use the signs of conventional MRI sequence to interpret L-type tear, which is easier to implement in operation, so it has great application value.

Preoperative MRI presents pivotal role in assessing the type of tear. Although some study reported that preoperative MRI exhibited low efficiency in determining the type of tear or contributing to the preoperative planning[9]. Our research found that the scintillation sign could be well interpreted to distinguish the L-shaped tears. There are also some previous studies believed that after the scar is removed from the stump of the rotator cuff during surgery, the tear shape will change significantly. Therefore, limited sense was regarded in guiding the preoperative plan for the tear classification of preoperative MRI examination [3]. From our study, we found that the intraoperative removal of the scar from the stump may enlarge the tear, for the patients with longitudinal tears at least, but it did not change the tear type. Therefore, we believe that the tear classification of preoperative MRI examination is still instructive for surgery.

Preoperative MRI is often applied to classify rotator cuff tears. According to the geometric classification of rotator cuffs [4], non-large rotator cuff tears can be divided into crescent-shaped ($L < W$, $W < 2\text{cm}$) and longitudinal tear ($L > W$, $W < 2\text{cm}$). Longitudinal tear can be further divided into U-shaped and L-shaped. For L-shaped tears, correct identification and inflection point are the prerequisites for successful repair, whilst crescent tears require only direct tendon-bone sutures. U-shaped tears require more symmetrical side-to-side sutures, then the tendon-bone sutures. The purpose of our research is to identify L-shaped tears more accurate before surgery, to make adequate preoperative plan and increase the efficiency of successful repair. If we lack a correct understanding of L-shaped tears, due to the existing scars, the contracture and remodelling of the tear, it is difficult to correctly identify the inflection points of the transverse and longitudinal fractures of the L-shaped tear to achieve ideal intraoperative repairs [13]. The misalignment will also lead to failed repair of some rotator cuff, namely anatomical reduction, and low-tension repair.

When we found that the scintillation sign combined with the geometric classification of the rotator cuff tear can efficiently identify the L-shaped tear. The principle of the scintillation sign was analysed as follows: from the starting point of anatomy, the L-shaped tear is the longitudinal crack characterized by extremely steep edges on one side and extremely asymmetrical shape. The apex is extremely biased to one side, and the other side of the apex is a relatively less steep gradient shape (Figure 4A). Although the edges of the U-shaped tear are relatively steep, the shape is relatively more symmetrical. As a result, the middle of the crack is more similar to the arc-shaped gradual shape (Figure 4B). The scanning spacing (SP) of our current MRI scan is 4.4mm (4mm for the scanning layer and 0.4 mm for the layer spacing), the apex or sub-apex of the L-shaped tear appears directly in the next frame of the continuous rotator cuff tissue is highly correlated with a visual sign of sudden apex flash, while we were reviewing the oblique coronal scan (Figure 4A). However, the apex of the U-shaped tear often appears in the 2 to 3 frames after the tear occurs due to the above-mentioned anatomical characteristics, and then gradually changes to

continuous rotator cuff tissue (Figure 4B). Therefore, the existence of the scintillation sign is based on the anatomical characteristics of the L-shaped tear and the thin thickness of the existing MRI.

Due to the morphological characteristics of L-type tear, theoretically, the probability of observing scintillation sign in oblique coronal position should be approximately 100%. However, our observation results are not so ideal when judged by the gold standard of the observation results of surgical records. We tried to analyse the possible causes. Firstly, for narrow L-tear, the partial volume effect of MRI may affect the interpretation accuracy of scintillation sign. Therefore, we speculate that using smaller slice thickness and spacing for scanning may improve the sensitivity and specificity of interpretation; Secondly, due to the deviation of intraoperative observation of the operator, some U-shaped tears may be recorded as L-shaped tears, or some L-shaped tears may be recorded as U-shaped tears. Finally, our sample size is small, which may bring statistical deviation. The above conditions will reduce the accuracy of scintillation sign. If there is a larger sample size and further prospective research can be done to better control the above variables, the accuracy of scintillation sign in the diagnosis of L-type tear may be better.

In summary, combined with the MRI geometric classification of rotator cuff tears, the scintillation sign is highly specific and sensitive in identifying L-shaped tears, which contributes to the preoperative identification. The accuracy of the scintillation sign needs further research and observation with a larger sample size to determine.

List Of Abbreviations

magnetic resonance imaging (MRI)

scanning spacing (SP)

rotator cuff tear (RCT)

Declarations

Ethics approval and consent to participate

All methods were carried out in accordance with the [Declaration of Helsinki](#). All experimental protocols were approved by Ethics Committee of Yantai Yuhuangding Hospital (20220106). Written informed consent was obtained from individual or guardian participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author's Contributions

LJS and BQH designed the experiment. LJS, BQH, XJQ, HLS and ZFZ collected the data for the study. WJL and JMQ read the MRI. JW and XFW made the Data analysis. BQH, WJL and LJS wrote the main manuscript text. XJQ and ZFZ prepared the figures. All authors reviewed the manuscript.

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Availability of data and materials:

The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

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Tables

Table 1
Specificity between groups

	Right	Wrong	Total	Sp	P value
Doctor A	21(a11)	4	25(b11)	0.84(Sp11)	0.3431
Doctor B	19(a21)	7	26(b21)	0.73(Sp21)	

Table 2
Sensitivity between groups

	Right	Wrong	Total	Se	P value
Doctor A	22(d11)	1	23(c)	0.96(Se11)	0.6078
Doctor B	20(d21)	3	23(c)	0.87(Se21)	

Table 3
Intra-group comparison on the specificity of doctor A

	Right	Wrong	Total	Sp	P value
Doctor A	21(d11)	4	25(b11)	0.84(Sp11)	0.4869
Doctor A (2 month later)	17(d12)	6	23(b12)	0.74(Sp12)	

Table 4
Intra-group comparison on the sensitivity of doctor A

	Right	Wrong	Total	Se	P value
Doctor A	22(d11)	1	23(c)	0.96(Su11)	0.6078
Doctor A (2 month later)	20(d12)	3	23(c)	0.87(Su12)	

Table 5
Intra-group comparison on the specificity of doctor B

	Right	Wrong	Total	Sp	P value
Doctor B	19(a21)	7	26(b21)	0.73(Sp21)	0.6145
Doctor B (2 month later)	19(a22)	5	24(b22)	0.79(Sp22)	

Table 6
Intra-group comparison on the sensitivity of doctor A

	Right	Wrong	Total	Se	P value
Doctor B	20(d21)	3	23(c)	0.87(Su21)	1
Doctor B (2 month later)	21(d22)	2	23(c)	0.91(Su22)	

Figures

Figure 1

Vertical rotator cuff tear was shown in MRI. (A) The length of the tear was measured in the oblique coronal position. (B) Measurement of the width of the tear.

Figure 2

MRI to show the rotator cuff and its apex. (A and B) MRI scan from the normal rotator cuff to the apex of the tear. (C and D) MRI scan to show the rotator cuff gap to the apex of the tear.

Figure 3

Intra-operative images of the rotator cuff tear. (A) L-shape tear during the operation. (B) U-shape tear during the operation.

Figure 4

Schematic diagram of the L-shaped tear oblique coronal scan. (A) Apex was presented in the first frame with gap. (B) Apex was shown in the second or the third frame with gap.