

Related Factors and Therapeutic Effect of Rotator Cuff Delamination

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Abstract

Objective: This study aims to explore the related factors and treatment result of RCT with delamination.

Materials and methods: From February 2016 to July 2019, a total 155 patients with RCT were enrolled into the present study. Among these patients, 66 were male and 89 were female, and their an average age was 56.4 ± 7.8 years old (41-75 years old). The medical history of each patient was recorded before the operation, and the joint function was evaluated using the Constant score table. During the operation, the RCT was examined using an arthroscope, the delamination was evaluated, and the RCT type was classified. A proper suture technique was executed for these different types of rotator cuff injuries, and routine functional exercises were performed after the operation. Poisson chi-square test was used to analyze the related factors of delamination, and *t*-test was used to analyze the result of the treatment.

Results: Among the 115 patients, 47 patients had delamination, while 68 cases had no delamination. The larger the RCT size, the greater probability of delamination. Furthermore, the delamination probability of a RCT with subacromial impact would also increase. However, there was no statistical correlation between disease history or trauma and delamination. All patients achieved good therapeutic results.

Conclusion: The incidence of rotator cuff delamination remains high, and the occurrence of delamination is correlated to the size of the tear, and the determination of whether this is accompanied by subacromial impact. However, there is no correlation between delamination and trauma or disease duration. For rotator cuff tears with delamination, reasonable surgical techniques can be used to treat the rotator cuff injury, in order to obtain a good effect.

Level of evidence: Level III, Retrospective Cohort Design, Treatment Study

Introduction

Rotator cuff injury is one of the main factors of shoulder pain, which mainly occurs in the supraspinatus muscle, infraspinatus muscle and subscapular muscle. According to the degree of injury, rotator cuff injury can be divided into full-thickness tear and partial tear. However, regardless of whether this is a full-thickness tear or a partial tear, there is a common situation that the rotator cuff stop tear retraction would be accompanied by horizontal delamination, and the incidence rate is relatively high, which can reach as high as 38–92% [1–4], as reported in the literature. To date, there have been many reports on the causes and related factors of delamination [5–6]. In terms of treatment, the technical requirements of rotator cuff surgical suture for delamination are higher. The upper and lower layers of tear retraction are required to restore better tension, and different suture repair methods need to be selected according to the different types of tears.

Clinical Data And Methods

From February 2016 to July 2019, patients with rotator cuff injury as the first diagnosis were included in the present study. Patients with peri-shoulder fracture, shoulder dislocation, massive RCT and frozen shoulder were excluded. A total of 155 patients with rotator cuff tears met the criteria of the present study. Among these patients, 66 were male and 89 were female, and their average age was 56.4 ± 7.8 years old (41–75 years old). All patients accepted surgical treatment for the rotator cuff injury. The medical history of each patient was recorded in detail before the operation, and the joint function was evaluated using the Constant score table.

During the operation, the rotator cuff joint surface injury was examined by arthroscopy in the articular cavity. The bursa side and overall injury of the rotator cuff were examined from the subacromial space, and the subacromial impact was evaluated. The size of the rotator cuff tears and laminar retraction were evaluated using posterolateral and anterolateral approaches during surgery, and grouped according to the size of the tear: <1 cm group, 1–3 cm group, and >3 cm group. Rotator cuffs with delamination were classified according to the method of Hye [7]. Type I refers to the complete rupture of a rotator cuff with delamination (Ia: The rotator cuff is completely broken and delaminated, and the articular surface side is retracted more than the bursal side; Ib: The rotator cuff is completely broken and delaminated, and the bursal side is retracted more than the articular surface side; Ic: the rotator cuff is completely broken and delaminated, and the articular surface retraction equals the bursal side). Type II refers to the incomplete tear of a rotator cuff with retraction of lamination (IIa refers to the articular surface tear of the rotator cuff, in which the tear part of the rotator cuff is layered and retracted from the bursal side; IIb refers to the bursal side tear of the rotator cuff, in which the torn part of the rotator cuff and articular surface are delaminated and retracted; IIc refers to the stop point of the rotator cuff, which is not torn, and the lamination occurs at the remote stop point of the rotator cuff) (Fig. 1).

The subacromial surface of patients with subacromial impact was polished and shaped during the operation, and different suture and fixation methods were applied according to the rotator cuff injury classification. For patients with type I RCT, internal row anchors were implanted, in which double rotator cuffs passed through the sutures and knots at the same time, and the suture bridge technique was used for fixation. Type IIa tears were repaired using the transtendon technique, while type IIb and IIc tears were repaired using the suture bridge or modified Mason-Allen technique. All patients were given routine rehabilitation exercises after the operation (Fig. 2). The data measurements and surgical procedures were performed by the same team of sports medicine physicians. This study was approved by ethics committee of Shanghai Pudong Hospital.

Statistical analysis

In the present study, Poisson chi-square test was used to analyze the factors related to delamination. The *t*-test method was used to compare the joint function scores before and after surgery. $P < 0.05$ was considered to be statistically significant. The statistical software used was SPSS 17.0.

Results

A total of 155 patients with rotator cuff injuries were included in the present study. Among these patients, 73 patients had delamination, while 82 patients had no delamination. According to the type of spallation, 73 patients were classified as follows: Ia, 15 patients; Ib, 12 patients; Ic, nine patients; IIa, 23 patients; IIb, 10 patients; IIc, four patients. The results of the tear size analysis revealed that the size of the tear and the delamination were statistically correlated. The larger the tear was, the greater the probability of delamination became. The result revealed that 77.1% of tears with a length of more than 3 cm are accompanied by delamination.

Subacromial impact is another factor of rotator cuff injury. In this group of patients, 71 patients with subacromial impact were identified by intraoperative arthroscopic examination, while 84 patients had no impact. The statistical analysis results show that the impact under the acromion has a statistical correlation with the delamination ($P=0.002$). Patients who are struck are prone to stratification, especially partial tears on the bursa side, and a large proportion of the performance of the stratification were accompanied by the impact. Patients with impingement are prone to delamination, especially partial tears on the side of the bursa, and these are characterized by delamination with impact in a large proportion.

In addition, 75 patients in this group had a clear history of trauma, while 80 patients had no history of trauma. The analysis revealed that the relationship between trauma and delamination was not obvious, and had no statistical significance. Disease duration is also one of the indicators in the present study. Taking three months as the reference point, the results of the statistical analysis revealed that the length of duration was not correlated to the delamination, and that the proportion of rotator cuff delamination in patients with a long history did not significantly increase.

There were no special complications in this group. All patients were given routine rehabilitation exercise guidance and regular follow-ups. The average follow-up time was 15.1 ± 5.8 months (7–34 months). Furthermore, the overall curative effect was satisfactory, and the Constant score significantly improved.

Further analysis revealed that better postoperative results could be achieved with or without delamination, but there was no statistical difference between these two groups (Table 2). According to the comparison of delamination types, there was no statistical difference in postoperative effect among the different delamination types (Table 3).

Table 1
Related factors of delamination

		Total	Delamination		
			+	-	
Tear size	Small (< 1 cm)	51	21 (41.2%)	30 (58.8%)	P = 0.003 ($\chi^2 = 11.741$)
	Medium (1-3cm)	69	33 (47.8%)	36 (52.2%)	
	Large (> 3 cm)	35	27 (77.1%)	8 (22.9%)	
Impingement	+	71	43 (60.6%)	28 (39.4%)	P = 0.002 ($\chi^2 = 9.536$)
	-	84	30 (35.7%)	54 (64.3%)	
History of trauma	+	75	36 (48%)	39 (52%)	P = 0.827 ($\chi^2 = 0.048$)
	-	80	37 (46.2%)	50 (53.8%)	
Duration of disease	> 3 months	59	27 (45.8%)	32 (54.2%)	P = 0.794 ($\chi^2 = 0.068$)
	< 3 months	96	46 (47.9%)	50 (52.1%)	

Table 2
Comparison of preoperative and postoperative
Constant scores (\pm SD)

	Delamination		
	+	-	
Preoperative	52.2(6.6)	56.3(4.7)	P = 0.523
Last follow-up	80.9(4.8)	82.6(8.3)	P = 0.669
	P < 0.00	P < 0.00	

Table 3
Comparison of preoperative and postoperative Constant scores among the different delamination types
(\pm SD)

	Ia	Ib	Ic	IIa	IIb	IIc	
Preoperative	47.1(5.8)	49.9(6.7)	46.8(6.1)	51.5(8.2)	52.3(7.7)	56.8(7.9)	P = 0.438
Last follow-up	81.2(6.8)	80.5(7.1)	82.7(7.3)	83.6(7.9)	84.9(6.8)	86.1(7.2)	P = 0.327
	P < 0.01						

Discussion

The tear of a rotator cuff is a common manifestation of RCT. However, to date, the characteristics and causes of tears remain unclear. Harryman *et al.* [8] reported that the deep structure of a rotator cuff not only comprises of muscle and tendon tissues, but also the tissue of the joint capsule. Zbigniew *et al.* [5] also reported similar results. Therefore, from an anatomical point of view, the two layers of the tear rotator cuff are not the same. The upper layer comprises of muscle and tendon tissues, while the lower layer comprises of the woven structure of the muscle tendon and joint capsule tissue.

Therefore, when the rotator cuff is teared, the upper and lower layers are not sufficiently combined to cause delamination. Nimura *et al.* [9] further investigated the attachment of the joint capsule. The attachment of the articular capsule at different positions on the greater tuberosity of the humerus also differs. The joint capsule after the supraspinatus muscle stop point is weak at the greater tuberosity, and can easily tear. This may be one of the reasons for the higher incidence of delamination, when accompanied by an infraspinatus tear. Sang *et al.* [10] also found that it is easier to retract backward and inward after tearing of the lower layer. The reason may be that the muscle fibers that constitute the lower layer mainly come from the subscapularis muscle. In the present study, patients with larger tears had a significantly increased probability of delamination, and this is similar to the reported results.

Other factors correlated to rotator cuff delamination have also been reported, but these results were not consistent. MacDougal *et al.* [11] reported that delamination was correlated to age and gender, while Matsuki *et al.* [12, 13] did not reach the same conclusion. Satoshi [13] reported that there was no correlation between delamination and the history and duration of trauma, which is similar to the results of the present study. In addition, in the present study, the correlation between subacromial impact and spallation was analyzed. The results revealed that there was a certain correlation between impact and delamination, especially for patients with partial tears on the bursa side (type IIb), and the probability significantly increased. The reason may be that under repeated impacts of the acromion, the upper rotator cuff stops were broken, while the lower rotator cuff was not involved. The tissue degeneration and relaxation between these two layers causes the upper layer to retract.

It has been reported [1, 2] that the therapeutic effect of rotator cuff injury with spallation is not very good. However, this report did not describe the treatment in detail. Zilber *et al.* [14] reported that the treatment effect was not significantly different from that of patients without stratification. However, a higher proportion of patients with subscapular muscle steatosis and decreased external rotation function could be observed in that report. Indeed, this result may be correlated to the treatment method for subscapular muscle injury. Sugaya *et al.* [15] proposed that the torn layers should be repaired, in order to restore the damaged rotator cuff to a complete structure. Furthermore, the double-layer double-row (DLDR) or double-layer suture bridge (DLSB) technique should be used for completely torn cuffs, in order to obtain very good results. Sonnabend [16] noted that when suturing the upper and lower layers, attention should be given to the freshness between these two layers, and that the synovial and other tissues between these two layers should be cleaned to facilitate the healing between layers

In the present group of patients, DLSB technology was used for patients with full-thickness full-layer tear and spallation. These two layers were cleaned and freshened. Furthermore, the inner row suture was knotted, while the outside row suture was pressed by an external anchor to strengthen the contact between these two layers. Good results were obtained. For patients with upper tears and retraction on the bursal side, the suture bridge technique or modified Mason-Allen technique was adopted according to the size of the tear, and the postoperative results were satisfactory.

Conclusion

Rotator cuff lamination is a common manifestation of rotator cuff injury. A rotator cuff injury with a large tear opening has a greater probability of lamination. The tear and retraction of the upper rotator cuff were common in patients with subacromial impact. However, there is no correlation between spallation and trauma and the course of disease. For rotator cuff injuries with delamination, good results can be obtained by using reasonable surgical techniques.

Abbreviations

RCT: rotator cuff tear; SD:Standard deviation; DLDR:double-layer double-row; DLSB:double-layer suture bridge

Declarations

Ethics approval and consent to participate

This study was approved by ethics committee of Shanghai Pudong Hospital.

Consent for publication

All involved patients gave their written informed consent to publication.

Competing interests

There are no competing interests.

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Author details

Bingli liu – made contributions to the acquisition of data, analysis, interpretation of data and drafting of the manuscript. Jian Hu – made contributions to the acquisition of data, analysis, interpretation of data. Baoqing Yu– made contributions to the conception, design, acquisition of data and figures of the manuscript. I confirm that all authors have read and approved the final manuscript

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Figures

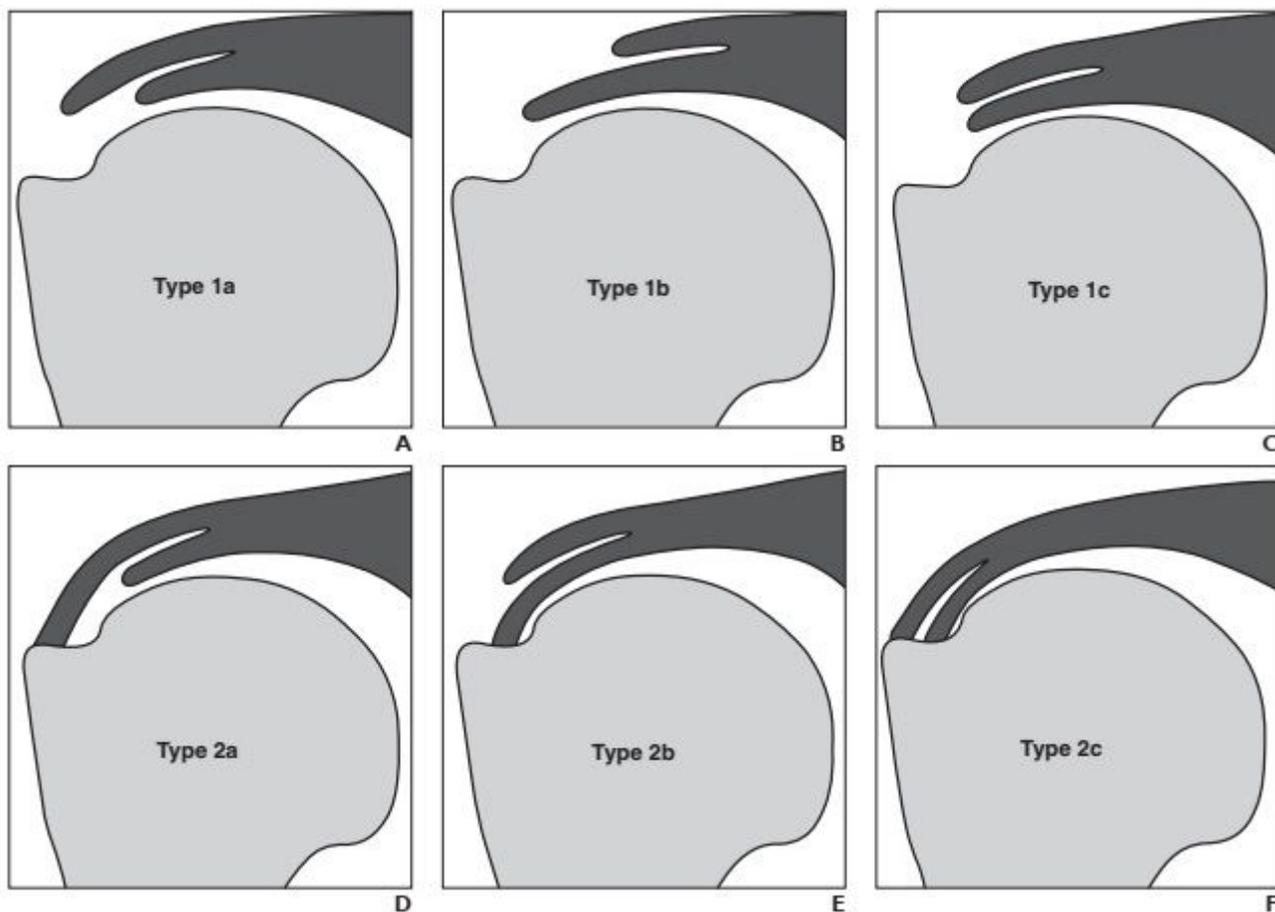


Figure 1

cites the classification of Hye: Type I is a complete rupture of the rotator cuff with delamination (1a: The rotator cuff is completely broken and delaminated, and the articular surface side is retracted more than the bursal side; 1b: The rotator cuff is completely broken and delaminated, the bursal side is retracted more than the articular surface side; 1c: the rotator cuff is completely broken and delaminated, and the

articular surface retraction equals the bursal side). Type II refers to the incomplete tear of a rotator cuff with retraction of lamination (IIa refers to the articular surface tear of the rotator cuff, and the tear part of the rotator cuff is layered and retracted from the bursal side; IIb refers to the bursal side tear of the rotator cuff, and the torn part of the rotator cuff and articular surface are delaminated and retracted; IIc refers to the stop point of the rotator cuff, which is not torn, and lamination occurs at the remote stop point of the rotator cuff).

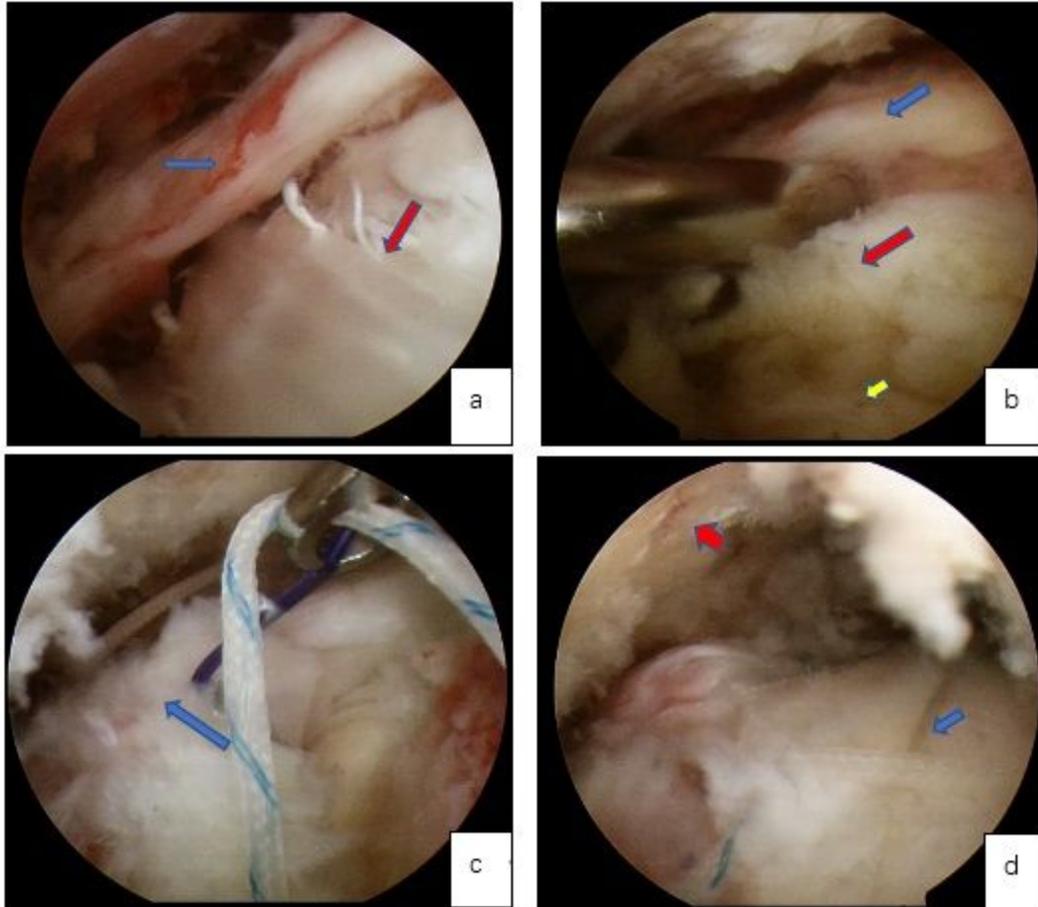


Figure 2

(a) The rotator cuff is partially thickened, torn and laminated, and the side of the bursa is torn and retracted. The blue arrow shows the upper layer of the rotator cuff, and the red arrow shows the lower layer; (b) Fresh treatment of the injured rotator cuff. The blue arrow shows the upper layer, the red arrow shows the lower layer (due to the poor quality of the lower tendon, partially thickened tear was changed to full-thickness tear during the operation), and the yellow arrow shows the humeral head. (c) Simultaneous suture of the upper and lower rotator cuffs; (d) Suture and fixation using the suture bridge technique. The red arrow shows that the shape of the subacromial surface is satisfactory.