



Original Article

Bankart lesion repair: biomechanical and anatomical analysis of Mason-Allen and simple sutures in a swine model[☆]



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ABSTRACT

Objective: To evaluate the labral height and pullout resistance after the repair of Bankart lesions in the glenohumeral joint of swine models, using double-loaded anchors with two suture configurations: simple and Mason-Allen.

Methods: Ten swine shoulders were used, in which Bankart lesions were created. For each specimen, the lesion was sutured randomly with Mason-Allen sutures or simple sutures. The labral height was measured before the lesion was created and after the labral repair. The specimens were submitted to a tensile test for biomechanical evaluation.

Results: In specimens submitted to simple suture ($n=5$), the mean labral height observed before the lesion was 3.86 mm, and after suturing, 3.33 mm. In specimens submitted to Mason-Allen suture ($n=5$), it was observed that the mean labral height before the lesion was 3.92 mm, and after suturing, 3.48 mm. When comparing the labral height after simple suture and Mason-Allen suture, no significant difference was observed. The pullout force at the end of the tensile test on specimens with single suture was 130 N, and in specimens with Mason-Allen suture, 128.6 N. No statistically significant differences were observed between the shoulders treated with single suture and Mason-Allen suture; $p=0.885$.

Conclusions: Repair of Bankart lesions with Mason-Allen suture provides increased labrum height; however, it does not increase the pullout strength.

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Reparo da lesão de Bankart: análise biomecânica e anatômica das suturas tipo Mason-Allen e simples em modelo suíno

R E S U M O

Palavras-chave:

Luxação do ombro
Cápsula articular
Interface osso-implante

Objetivo: Avaliar a altura labral e a resistência ao arrancamento do reparo da lesão de Bankart em articulação glenoumeral de suínos, com âncoras duplamente carregadas com duas configurações de sutura: simples e tipo Mason-Allen.

Métodos: Foram usados dez ombros suínos, nos quais foram criadas as lesões de Bankart. Para cada espécime foi feita a sutura da lesão com suturas tipo Mason-Allen e simples de forma aleatória. A altura labral foi mensurada previamente à confecção da lesão e após o reparo labral. Os espécimes foram submetidos ao ensaio de tração para avaliação biomecânica.

Resultados: Nos espécimes submetidos a sutura simples (n = 5), observou-se altura média previamente à confecção da lesão de 3,86 mm e após a sutura, de 3,33 mm. Nos espécimes submetidos a sutura Mason-Allen (n = 5), observou-se que a altura média previamente à confecção da lesão era de 3,92 mm e após a sutura, de 3,48 mm. Ao comparar a altura labral após a sutura simples e Mason-Allen, não foram observadas diferenças significantes. A força de arrancamento no fim do ensaio de tração nos espécimes com sutura simples foi de 130 N e nos espécimes com sutura Mason-Allen, 128,6 N. Não houve diferença estatisticamente significativa entre os ombros com suturas simples e Mason-Allen, p = 0,885.

Conclusões: O reparo das lesões de Bankart com sutura Mason-Allen proporciona aumento da altura do labrum, mas não eleva a força de resistência ao arrancamento.

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Introduction

Bankart lesions occur in over 97% of patients who suffer the first traumatic episode of shoulder dislocation.¹ This lesion is characterized as a detachment of the anteroinferior capsulolabral glenoid complex, resulting in loss of labral height and elongation of the anterior band of the inferior glenohumeral ligament.² This anatomical defect was described by Bankart as the “essential lesion,” responsible for the perpetuation of shoulder instability. Once this lesion was repaired, dislocation recurrence would cease.³ The surgical techniques available include Bankart surgery, which can be an arthroscopic or open procedure, and consists of suturing the labrum to the glenoid, in order to restore the height and tension of the anteroinferior glenohumeral ligament complex.⁴

Some capsulolabral repair methods have been described with the use of anchors, such as simple suture with double-loaded anchors or more complex constructions, such as the U-shaped, mattress, and Mason-Allen type sutures.^{5,6} There is still no evidence in the literature regarding the best capsulolabral repair technique. This study is aimed at evaluating the labral height and pullout resistance after the repair of Bankart lesions in the glenohumeral joints of swine, using double-loaded anchors with two suture configurations: simple and Mason-Allen. The hypothesis was that labral height could be better restored with the Mason-Allen suture and that a horizontal suture would not result in loss of suture strength.

Material and methods

The study was approved by the Ethics Committee of this institution.

For the study, ten fresh swine shoulders (five specimens; *Sus scrofa domesticus*), purchased at a regional butcher duly certified by health surveillance, were used. All animals were male, young, and had been recently slaughtered. The specimens were carefully dissected; the humeral head was disarticulated from the glenoid and the anteroinferior capsule was preserved until the lateral end of the humerus. After dissection, specimens with degenerative alterations, labral absence and hypoplasia were excluded. After preparation, specimens were labeled and kept at 5 °C for a maximum of two hours until the biomechanical tests. In all models, a Bankart lesion was made; the glenoid labrum was deinserted at the chondrolabral junction using a #15 scalpel. The lesion was created in the anteroinferior quadrant, outlined in the glenoid from a 3 to 6 o'clock position on the right shoulder and from a 6 to 9 o'clock position on the left shoulder.

In each specimen, the Bankart lesion was sutured using two anchors (3.5 mm titanium Corkscrew – Arthrex[®]) positioned at 4 o'clock and 5 o'clock at the anteroinferior border of the glenoid, on the right shoulder. Prior to anchor insertion, a 2.1 mm pilot hole was made. The anchors were loaded with two No. 2 fiberwires (Arthrex[®]). For each pair, the type of suture applied (Mason-Allen or simple) was chosen at random. The fiberwires were passed with 45° suture lasso (Arthrex[®])

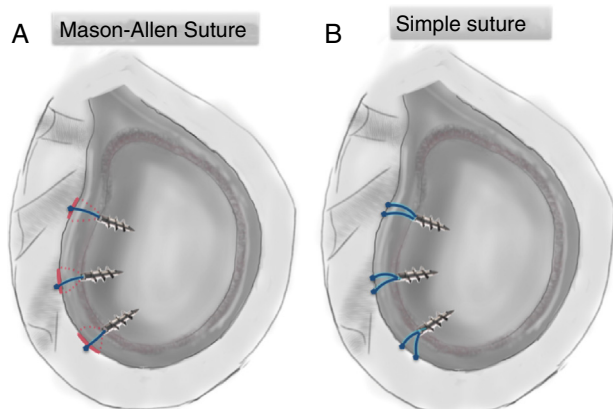


Fig. 1 – (A) Schematic drawing showing anchors positioned at 2, 4 and 5 o'clock in a Bankart lesion repaired with three Mason-Allen sutures; (B) anchors positioned at 10, 8 and 7 o'clock, lesion repaired with six simple sutures. The detail shows that the suture circumferentially surrounds the labrum.

through the joint capsule, wrapping around the labrum at approximately 10mm from the capsulolabral junction; the horizontal distance between the wires was approximately 5 mm. In the Mason-Allen sutures, a simple suture was made, followed by a mattress suture. Subsequently, the wires were secured with a Revo knot (Fig. 1).

Labral height

This parameter was assessed in two moments: prior to the Bankart lesion and after the knotting. A depth digital caliper (0–150 mm/6"; resolution 0.01 mm/0.005"; Digimes®) was used for measurement. The measurement was performed three times, and the arithmetic mean of the measurements was used.

Biomechanical traction test

For biomechanical evaluation, the specimens were submitted to the traction test using the universal Emic DL500-MF test machine with a 500N load cell. The scapula was attached to the lower surface with the aid of a pressure clamp, and the capsule was attached to the upper clamp with an Ethibond No. 5.0 suture. The test was performed by applying traction to the capsule perpendicularly to the articular surface. Initially, a traction of 55 N was applied for two minutes to calibrate the system; subsequently, capsular thickness was measured with an external micrometer with SPC output (Mitutoyo, graduation 0.001 ± 0.002 mm) at three equidistant points. Three measurements were then made and the arithmetic mean of the data was used. The biomechanical test was started with the application of traction at a speed of 15 mm/min and interrupted when the anchor was pulled out from the glenoid surface, or when intramural capsular rupture or capsulolabral junction rupture occurred (Fig. 2).

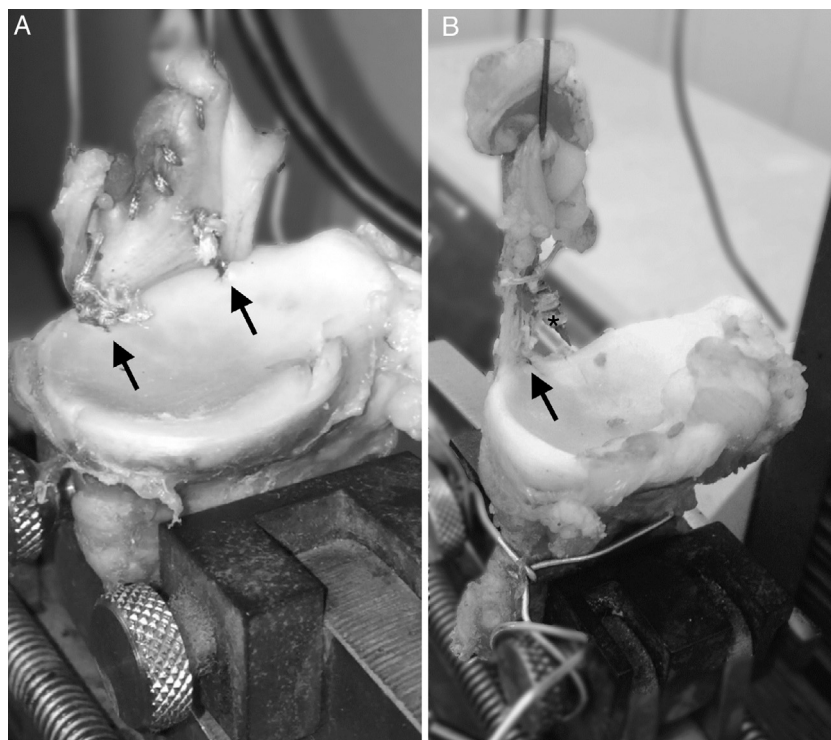


Fig. 2 – (A) Specimen in the universal testing machine. The arrows show the location of the anchor insertion; (B) specimen after traction test. An avulsed anchor is observed at the glenoid level (*). The arrow shows the lower anchor inserted into the glenoid.

Table 1 – Labral height before and after repair, simple suture and Mason-Allen suture.

	Single suture		Mason-Allen suture	
	Labral height before lesion (mm)	Labral height after repair (mm)	Labral height before lesion (mm)	Labral height after repair (mm)
Specimen 1	4.13	3.55	3.67	3.28
Specimen 2	3.35	2.82	4.41	3.94
Specimen 3	4.87	4.22	4.93	4.34
Specimen 4	3.59	3.23	3.32	2.88
Specimen 5	3.38	2.85	3.29	2.99
Med.	3.86	3.33	3.92	3.48
Min.	3.35	2.82	3.29	2.88
Max.	4.37	4.22	4.93	4.34
Std. Dev.	±0.64	±0.57	±0.72	±0.63
<i>p</i>		0.73		0.66

Source: Research data.

For the analysis of descriptive statistics, mean, minimum and maximum values, and standard deviation were used. For continuous variables, the non-parametric Mann-Whitney test and the t-test for independent variables were used; $p < 0.05$ were considered significant. The statistical analysis was performed using SPSS software, version 22.0.

Results

Labral height

In the specimens with simple suture ($n=5$), the mean labral height prior to the lesion was 3.86 mm (3.35–4.37 mm, ± 0.64). After the simple suture, the mean labral height was 3.33 mm (2.82–4.22 mm, ± 0.57). In the specimens with Mason-Allen suture, the mean labral height prior to the labral lesion was 3.92 mm (3.29–4.9 mm, ± 0.72) and after, 3.48 mm (2.88–4.34 mm, ± 0.63 ; Table 1). No statistically significant differences were observed when comparing the labral height after simple suture and Mason-Allen suture ($p = 0.64$).

Biomechanical traction test

The tests were interrupted after glenoid anchor avulsion occurred in 30% of the cases; in another 30%, after a tear at the knot-capsule interface, and in the remaining 40%, after an intrasubstance capsular tear. The required strength at the end of the test was greater in the shoulders with simple sutures, 130 N (100.9–205.7 N, ± 42.9) than in those with Mason-Allen sutures, 128.6 N (89.9–193.8 N, ± 39.51). However, there was no statistically significant difference between the groups with simple sutures and Mason-Allen sutures ($p = 0.885$; Table 2).

Discussion

Capsuloligamentary structures are of fundamental importance for the maintenance of the stability of the glenohumeral joint. An intact labrum contributes to concavity and joint stability, increases glenoid depth by 50%, and broadens the contact surface. Labrum excision decreases anteroposterior stability by 20%.^{4,7} Some studies highlight the fact that

Table 2 – Maximum pullout strength of simple and Mason-Allen sutures.

	Maximum force (N)	
	Mason-Allen suture	Simple suture
Specimen 1	89.9	100.9
Specimen 2	113.4	112.2
Specimen 3	113	109.6
Specimen 4	193.8	205.7
Specimen 5	133.2	121.8
Med.	128.66	130.04
Min.	89.9	100.9
Max.	193.8	205.7
Std. Dev.	±39.51	±42.94
<i>p</i>	0.885	

Source: Research data.

loss of labral height is directly correlated with increased dislocation recurrence. Lazarus et al. demonstrated that, by restoring labral height, the glenohumeral joint is stabilized.⁸ Slabaugh et al.⁴ demonstrated that, by adding a capsular retensioning of approximately 1 cm lateral to the glenoid, it is possible to increase the labral height by 59% after the repair. Although the present study did not aim at evaluating glenohumeral stability, but rather the indirect gain of the stability through the restoration of labral height after the repair, it was observed that even when adding a capsular retensioning to the suture, labral height after the repair was inferior to that of an intact labrum.

Regarding suture methods, Boddula et al.⁹ compared the repair of Slap type II lesions with simple and mattress sutures; at the end of the repair, mattress sutures presented higher labral height than simple sutures. Hagstrom et al.⁶ also found similar results when comparing repairs with simple and mattress sutures. These authors observed that the simple suture presses the labrum toward the glenoid, decreasing its height. The mattress type repair pushes the tissue toward the humeral and lateral side of the glenoid border, which contributes to a height increase. In the present study, labral height in the Mason-Allen suture was greater than that observed in specimens submitted to simple suture; however, the present study

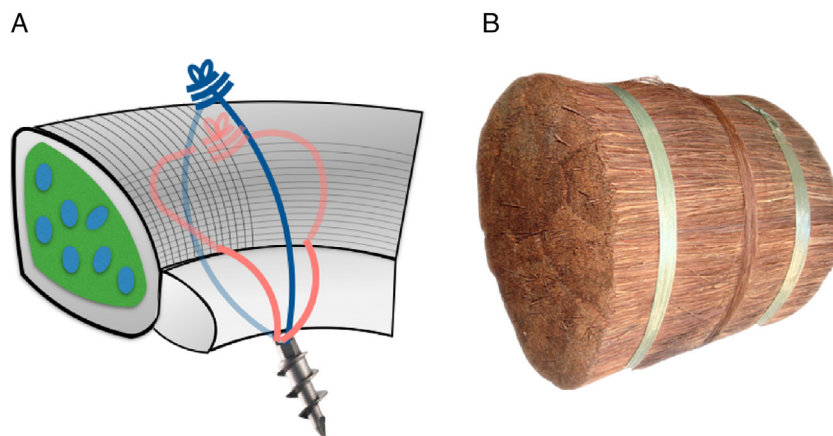


Fig. 3 – (A) Schematic drawing with the three areas of collagen fiber that make up the labrum; the nucleus, composed of fibers circumferential to the glenoid, is the largest area. In the example, the repair was performed using anchors and Mason-Allen suture; (B) an image of a bale of hay representing the circumferential collagen fibers, the best way to secure it is by wrapping the entire bundle perpendicularly in the direction of the fibers, analogous to the simple suture.

also repaired the joint capsule, whereas in the aforementioned study⁶ only the labrum was repaired. However, no statistical difference was observed between the two types of suture, probably due to the small size of the present sample.

In 2008, Castagna et al.¹⁰ described a similar technique for the repair of the Bankart lesion, the Miba suture. It is a combination of the horizontal mattress suture through the capsulolabral complex in the “South-North” direction and a simple vertical suture, also through the capsulolabral complex, in the “East-West” direction. Those authors reported that this repair technique allows restoring capsular tension and decreases the possibility of the suture “cutting” the labrum; the mattress suture gives greater traction and contact between the surfaces.¹⁰ The Mason-Allen suture used in the present study is similar to that used by the aforementioned authors, but the mattress suture was made after the simple suture. Another advantage of the U-shaped or mattress suture is that it faces the capsular surface of the labrum, which reduces the incidence of crackling and pain due to the interference of the knot during shoulder movement.

Hill et al. studied the morphology of collagen fibers of the glenoid labrum through transmission electron microscopy. The authors described three zones: a superficial mesh with braided collagen fibers, a nucleus with bundles of densely packed collagen fibers in a circumferential orientation around the glenoid border, and a third zone, marginal to the nucleus and toward the articular surface.¹¹ The superficial zone is the thinnest of the three, only 200 μm thick; the nuclear zone is the thickest.¹² Thus, U-shaped or mattress sutures would be expected to result in a biomechanical disadvantage, as they are parallel to the nuclear collagen fibers. However, this effect was not observed in the study, because the Mason-Allen suture combines both the simple suture and the mattress suture together (Fig. 3).

Di Raimondo et al. biomechanically assessed the traction strength of the simple and mattress sutures after repair of type II SLAP lesions. The authors concluded that there was no statistically significant difference between the two

repairs. The mean strength until failure was 163 N and 161 N for simple suture and mattress suture, respectively.¹³ Nho et al.⁵ biomechanically compared traction strength in four groups: anchor with single-loaded simple suture, anchor with single-loaded mattress suture, anchor with two double-loaded simple sutures, and suture with anchor without a knot. The authors did not find a statistical difference between the different types of suture.⁵ In the present study, no differences in traction strength were observed in simple and Mason-Allen sutures.

The present study has some limitations. The first is due to the fact that the Bankart lesion was created *in vitro* and does not necessarily represent the anatomical behavior of the *in vivo* lesion, due to the absence of elongation of the inferior glenohumeral ligament complex of swine shoulders. Another limitation is the use of open surgical access and the arthroscopic technique in capsulolabral repair.

Conclusions

In Bankart lesion repair, Mason-Allen sutures restore labral height; however, when compared with simple suture, it did not present a biomechanical strength advantage in the sample studied.

Conflicts of interest

The authors declare no conflicts of interest.

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