STUDY ON THE RESISTANCE OF THE SUPRASPINOUS TENDON USING SIMPLE, MATRESS AND MASON ALLEN STITCHES

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ABSTRACT

Objective: The purpose of this study was to compare the rotator cuff tendon resistance at the interface tendon-suture using three different sorts of stitches (simple, mattress and modified Mason-Allen). Methods: To do this, 30 rotator cuffs were totally dissected from 15 specimens, which were 45 years old on average. The tests were done using a Kratos® 500/2000 machine and the statistical analyses applied were the Student t-test, ANOVA test, Multiple Bonferroni Comparison, and Pearson's correlation coefficients; all the analyses used a significance level of 5%. Results: No significant difference was observed regarding the age, sample sizes and tendon displacement. The tendon resistance was 127.50 N on average when Simple stitches were used, 163.95 N when Double stitches were used and 198.45 N when the Modified Mason-Allen Knot was used. Conclusion: Although the tendon resistance at the interface tendon-suture was higher using the Modified Mason-Allen stitches than it was when using the Double and Simple Knots, there was no difference in tendon resistance when using the Modified Mason-Allen and Double stitches. On the other hand, we found that tendon resistance was higher when using Modified Mason-Allen stitches as compared to tendon resistance when using Simple stitches.

Keywords: Tendons. Suture techniques. Tensile strength.

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INTRODUCTION

The surgical treatment of rotator cuff tendon lesions through the arthroscopic route has been widely broadcast and popularized with the development of new techniques and materials.[1] The refinement of these is the topic of clinical and experimental research by several authors.[2-4]

The good clinical results obtained by means of this treatment method, signifying good joint mobility and motor force, depend on the reinsertion of the rotator cuff muscle tendons in their bone bed. For this purpose, it is necessary to achieve stabilization of the stump of the tendon sutured to the bone tissue until its total healing.[3,5,6]

Various studies have encountered high rates of re-rupture of the rotator cuff tendons in patients submitted to treatment through the arthroscopic route, citing as causes: loosening of the anchor, which may occur due to poor bone quality or technical error; snapping of the suture threads, both due to their resistance and in passage through the anchor orifice and fault in the tendon-suture interface, which is provided by the resistance of the tendon to the different types and methods of suture stitches.[3,5-7]

The repair of rotator cuff muscle tendons through the arthroscopic route is a technique that demands knowledge, skill and training on the part of the surgeon, with a long learning curve, due also to the inherent technical difficulties such as the positioning and the inclination of the anchors, the passage of the threads through the tendon and the suture with the different sorts of knot.[1]

Therefore, simple stitches, those in which one of the threads of the anchor passes once through the tendon, have been used with greater frequency, although studies have demonstrated that modified Mason-Allen stitches afford greater traction resistance in tendons. This probably occurs because the latter are technically harder to apply through the arthroscopic route.[7]

The aim of the study is to compare resistance among simple, mattress and modified Mason-Allen stitches, and thus to verify whether there is a significant difference that justifies the use of the modified Mason-Allen type stitch instead of the simple or mattress stitches.

MATERIAL AND METHODS

For the preparation of this study, biomechanical assays were conducted on supraspinous muscle tendons of 15 fresh human cadavers (30 shoulders) taken from the Coroner's Service of Santo André, an annex of Faculdade de Medicina do ABC. All the cadavers were of the male gender, with mean age 45 years and six months (25 to 75 years). (Table 1)

All the authors declare that there is no potential conflict of interest referring to this article.

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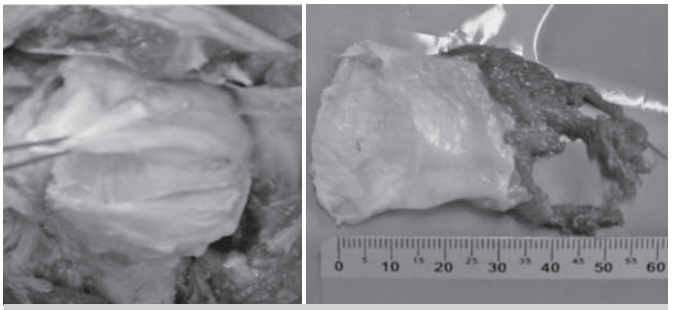
Table 1 – *Demographic data of the samples and results obtained in relation to the various types of stitch made.*

Sample	Gender	Age	Side	Size	Type of stitch	Resistance (N)	Displacement (cm)
1	M	38	R	40X35	Simple	106.82	1.4
1	M	38	L	40X30	Simple	112.7	2.5
2	M	40	R	40X35	Mattress	114.66	1.5
2	M	40	L	40X30	Mattress	138.18	1.9
3	M	36	R	40X35	M Allen	166.6	1.2
3	M	36	L	40X30	M Allen	188.16	1.3
4	M	48	R	30X40	Simple	108.78	1.4
4	M	48	L	40X40	Simple	155.82	2.2
5	M	52	R	30X40	Mattress	188.16	1.7
5	M	52	L	40X40	Mattress	156.8	1.9
6	M	56	R	30X40	M Allen	200.9	2.5
6	M	56	L	40X40	M Allen	191.1	1.9
7	M	27	R	45X35	Simple	102.9	1.5
7	M	27	L	35X30	Simple	110.74	2.5
8	M	30	R	45X35	Mattress	155.82	2
8	M	30	L	35X30	Mattress	166.6	1.8
9	M	25	R	45X35	M Allen	206.78	1.9
9	M	25	L	35X30	M Allen	186.2	2.5
10	M	75	R	35X40	Simple	98.98	1.5
10	M	75	L	40X35	Simple	109.76	1.8
11	M	70	R	35X40	Mattress	142.1	1.3
11	M	70	L	40X35	Mattress	123.48	1.6
12	M	65	R	35X40	M Allen	175.42	2.1
12	M	65	L	40X35	M Allen	183.26	1.9
13	M	35	R	45X30	Simple	199.92	2.5
13	M	35	L	40X35	Simple	168.56	1.5
14	M	40	R	45X30	Mattress	196	1.9
14	M	40	L	40X35	Mattress	252.84	2.2
15	M	45	R	45X30	M Allen	241.08	1.7
15	M	45	L	40X35	M Allen	245	1.8

Source : Coroner's Service of Santo André - SP
R – right, L - left, M - male, F - female, N – Newton
cm – centimeters, M Allen – modified Mason-Allen.

The pieces were removed, measured and stored in 0.9% saline (Figure 1), then sent to the analyses laboratory of SOGEFI (Filter Division do Brazil), where the tests were executed in the Kratos® 500/2000 series 5197 universal mechanical testing machine with load cell of 490 N and load application of 20 mm/minute. All the analyses were carried out in a period of less than four hours from the removal of the samples up to the performance of the tests. (Figure 2)



Source: Coroner's Service of Santo André – SP

Figure 1 – *Anatomic part of the shoulder demonstrating the removal of the sample*

Source: Analyses laboratory of SOGEFI (Filter Division do Brasil)

Figure 2 – *Photo of the Kratos 500/2000 series 5197 apparatus with 490 N load cell*

We used Durabraid® 2 suture (braided polyester) passed 1 cm from the free edge of the tendon. In the mattress and modified Mason-Allen stitches we sought to keep the thread passages 1 cm apart. (Figure 3)

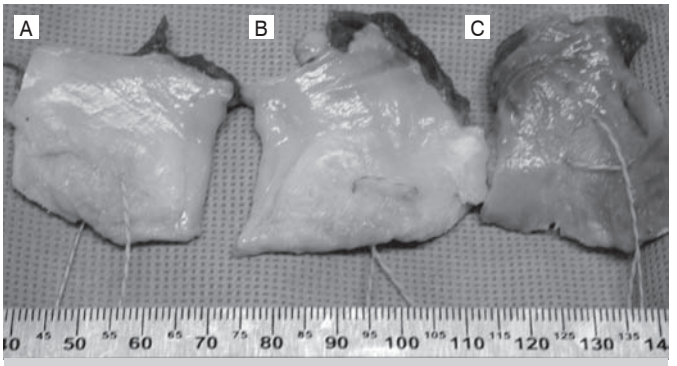


Figure 3 – *Different types of suture stitch: a) simple, b) mattress and c) modified Mason-Allen.*

We used the same type of suture stitch on both sides (right and left) of the same cadaver. We started with the simple stitches, used the mattress stitches in the second specimen and the modified Mason Allen type stitches in the third, and thus maintained the same sequence in the subsequent pieces.

The muscular part was fixed on the clip of the proximal portion of the apparatus, alongside the load cell, and the thread of the suture stitch was tied to the fixed bar, at the other end of the apparatus.

We quantified the degree of displacement of the tendon starting from the tension of 58.8 N, which corresponds to the moment when the thread and the tendon appeared tense.

We applied the paired statistical student's t-test to evaluate whether there was a statistically significant difference in comparing the measurements of size, displacement and resistance between right and left sides of the same cadaver.

The variance analysis (ANOVA) was used to evaluate whether there was a statistical difference in terms of the tendon resistance at the different types of stitch used and the multiple Bonferroni comparison to demonstrate in which kinds of stitch this difference occurred.

Pearson's correlation was used to evaluate whether the cadavers' age could influence tendon size (in mm^2), in its displacement and in the tendon resistance at the suture point, in each one of the types of suture performed.
All the tests were conducted at the significance level of 5%.

RESULTS

The mean size of the samples was 13.5750 mm^2 ± 1.6917 (11.9427 mm^2 to 15.2073 mm^2).
The mean displacement of the tendon on the right side was 1.74 cm ± 0.41 cm and on the left side 1.95cm ± 0.36 cm, averaging 1.85 cm ± 0.39 cm.
As regards the mean resistance of the tendon, on the right side we obtained the value of 160.65 N ± 46.04 and on the left side 165.95 N ± 44.27, averaging 163.30 N ± 44.46.
The student's t-test demonstrated that there was no statistical difference between right and left sides in relation to size (p=0.510), displacement (p=0.165) and resistance (p=0.451) with p>0.05 (Table 2).

Table 2 – *Comparison of the measurements between the right and left sides of the samples.*

Measurement	Side	Mean	SD	N	DF	Value t	p
Size	Right	13.850	124.21	15	14	0.68	0.510
	Left	13.300	195.30	15			
	Total	13.575	163.23	30			
Displacement	Right	1.74	0.41	15	14	-1.46	0.165
	Left	1.95	0.36	15			
	Total	1.85	0.39	30			
Resistance	Right	160.65	46.04	15	14	-0.77	0.451
	Left	165.95	44.27	15			
	Total	163.30	44.46	30			

Source: Coroner's Service of Santo André – SP.
SD- Standard Deviation, DF – degree of freedom.

As regards displacement, when we used the modified Mason-Allen stitch and the simple stitch, this was 1.88 cm on average with standard deviation of ± 0.43 cm for the former and of ± 0.49 for the simple stitch. When we used the mattress stitch, the result was 1.78 cm ± 0.26 cm on average.
Analyzing tendon resistance, in using the simple stitch, the mean value was 127.50 N ± 34.55, with the mattress stitch 163.95 N ± 41.18 and with the modified Mason-Allen the mean value was 198.45 N ± 26.13. (Figure 4)

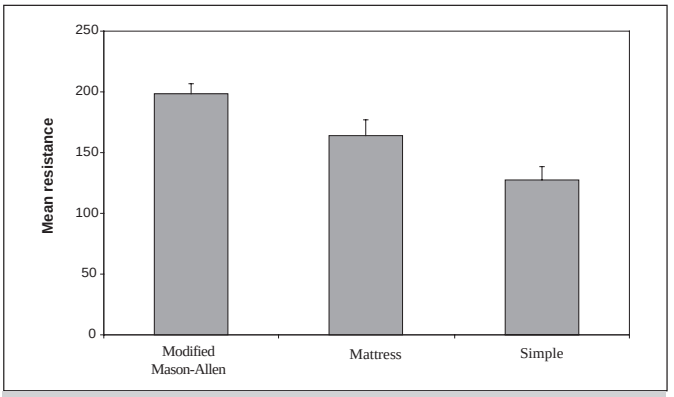


Figure 4 – *Mean resistances of the modified Mason-Allen, mattress and simple stitches.*

With the assistance of the ANOVA variance analysis, we verified that there was no statistically significant difference in terms of sample size (p=1.000) and tendon displacement (p=0.817) in relation to the stitches used. However, it could be noticed that the modified Mason-Allen stitch differs from the others in terms of resistance. (p=0.001). (Table 3)

Table 3 – *Comparisons of the measurements among the different types of stitch.*

Measurement	Type of stitch	Mean	SD	N	Value F	P
Size	M Allen	1357.50	169.17	10	0.00	1.000
	Mattress	1357.50	169.17	10		
	Simple	1357.50	169.17	10		
	Total	1357.50	163.23	30		
Displacement	M Allen	1.88	0.43	10	0.20	0.817
	Mattress	1.78	0.26	10		
	Simple	1.88	0.49	10		
	Total	1.85	0.39	30		
Resistance	M Allen	198.45	26.13	10	10.57	**<0.001**
	Mattress	163.95	41.18	10		
	Simple	127.50	34.55	10		
	Total	163.30	44.46	30		

Source: Coroner's Service of Santo André – SP
M Allen – modified Mason-Allen, SD – standard deviation, N - Newton

We used the multiple Bonferroni comparison for analysis of resistance among the different pairs of stitches in relation to one another and this demonstrated statistically significant difference between the modified Mason-Allen and simple stitches (p<0.001), but did not demonstrate any difference between simple and mattress (p=0.077), or between modified Mason-Allen and mattress (0.102). (Table 4)

Table 4 – *Multiple Bonferroni comparison among the different types of stitch.*

Comparison		Mean difference	Standard Error	P
M Allen	Mattress	34.50	15.43	0.102
M Allen	Simple	70.95	15.43	<0.001
Simple	Mattress	-36.46	15.43	0.077

Source: Coroner's Service of Santo André – SP
M Allen – modified Mason-Allen.

In the analysis of Pearson's correlations, we observed that only in the specimens sutured with mattress stitching, the higher the age, the lower the displacement undergone (p=0.047). Age had no influence in the other attempts at correlations (p>0.005) (Table 5).

DISCUSSION

Due to the high rate of rotator cuff re-rupture, particularly in cases of extensive lesions, as reported by some authors,[2,4,7-9] there is growing interest in the development of new techniques for improvement of the results of the treatments of these lesions.[4,10]
The ideal repair of the rotator cuff lesion should have considerable initial resistance force, not allowing mobility and contact failure be-

Table 5 – *Pearson's correlation between the age and the size-displacement-resistance of the samples obtained.*

Type of stitch	Measurements	Correlation	p	N
M Allen	Age X Size	0.241	0.503	10
	Age X Displacement	0.180	0.618	10
	Age X Resistance	-0.103	0.777	10
Mattress	Age X Size	0.203	0.573	10
	Age X Displacement	-0.639	**0.047**	10
	Age X Resistance	-0.282	0.43	10
Simple	Age X Size	0.183	0.613	10
	Age X Displacement	-0.285	0.425	10
	Age X Resistance	-0.276	0.441	10
Total	Age X Size	0.207	0.273	30
	Age X Displacement	-0.198	0.294	30
	Age X Resistance	-0.157	0.406	30

Source: Coroner's Service of Santo André – SP
M Allen – modified Mason-Allen, N – Newton.

tween tendon and bone. This serves to maintain mechanical stability until its complete healing, restoring the muscle-tendon-bone unit and favoring recovery of the muscular strength of the shoulder.[3,4,11]

To analyze the different kinds of stitch proposed, we excluded other repair failure factors related to the tendon-bone unit such as: poor bone quality, technical errors in the insertion of the anchors, loosening of these anchors and faults of the suture thread in the anchor orifice. The tissue was excised from the bone, thus allowing isolated evaluation of the stitch since most faults occur when the suture tractions the tendon.[4,12,13]

The suture material and the safety of the knot are also factors that influence repair. We used No. 2 (Durabraid®) braided polyester, which has been reported to be the most suitable choice in rotator cuff repairs.[14,15]

According to our results, there was no statistically significant difference between right and left sides in relation to sample size, displacement and tendon resistance. Analyzing the different kinds of stitch separately in terms of their resistance, we verified that the simple stitch is inferior to the other two. Gerber et al.[3] also arrived at the conclusion that the stitch used most often, the simple one, was the weakest in comparison to several other kinds of stitch. He also emphasized that this stitch, although weak, would not strangulate the tendon, allowing coaptation of the tendon to the bone in the absence of tension, proving useful for small rotator cuff lesions.[3]

The modified Mason-Allen stitch, like in literature, was superior in numerical terms to the simple and mattress stitches,[3,4,7,13] yet when compared separately with the mattress stitch, this difference was not statistically significant, and this significance was only confirmed between the simple and modified Mason-Allen stitches. This stitch, however, has the disadvantage of difficulty of its performance by the arthroscopic route, so the other two stitches are used much more frequently.[4] Moreover, Schneeberger, et al[10] showed that, arthroscopically, the modified Mason-Allen stitch did not improve the resistance of the rotator cuff tendon lesion repair when used together with anchors due to the fault of the anchor and of the stitch in its orifice. On the other hand, Scheibel and Habermeyer,[13] in 2003, obtained outstanding results using this kind of stitch, achieving excellent initial fixation strength and adequate mechanical stability, allowing tendon healing.

A limiting factor of this study was the non-performance of the cyclic force test, approximating the stitch tension to the real scenario. However, in other studies similar to this one, no statistically significant difference was observed in relation to displacement and elongation of the sample when this method was applied.[4]

Another fact to be emphasized is the need for greater casuistry, as the numerical values, in relation to resistance among the different stitches, exhibited a small difference, meaning that the only statistically significant connection was between the simple stitch and the modified Mason-Allen.

CONCLUSION

In absolute numbers the mean resistance with the Mason-Allen stitch is higher than the mattress stitch which, in turn, is higher than the simple stitch. Nevertheless, there is no difference of resistance in the tendon in terms of fault in the suture-tendons interface comparing the double stitch with the modified Mason-Allen suture and the simple stitch with the mattress suture, yet there is a difference when the simple and modified Mason-Allen stitches are compared.

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