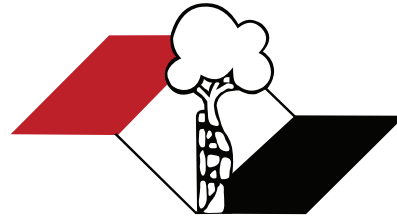


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ACTA ORTOPÉDICA BRASILEIRA

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(Reviewed January 2016)

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Type of Article	Abstract	Number of words	References	Figures	Tables	Maximum number of authors allowed
Original	Structured, up to 200 words	2,500 Excluding abstract, references, tables and figures	20	10	6	6
Update / Review*	Non-structured, up to 200 words	4,000 Excluding abstract, references, tables and figures	60	3	2	2
Editorial*	No abstract	500	0	0	0	1

*These contributions shall be published at the Editors' criteria, with due replica, when applicable.

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Link the conclusions with the goals of the study, but avoid statements and conclusions that are not supported by the data, in particular the distinction between clinical and statistical relevance. Avoid making statements on economic benefits and costs, unless the manuscript includes data and appropriate economic analysis. Avoid priority claim ("this is the first study of ...") or refer to work that has not yet been completed.

CONCLUSION: The conclusion should be clear and concise, establishing a link between the conclusion and the study objectives. Avoiding conclusions not based on data from the study in question is recommended, as well as avoiding suggest that studies with larger samples are needed to confirm the results of the work in question.

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Levels of Evidence for Primary Research Question^a

(This chart was adapted from material published by the Centre for Evidence-Based Medicine, Oxford, UK.

For more information, please visit www.cebm.net.)

Level	Types of study			
	Therapeutic Studies Investigating the Results of Treatment	Prognostic Studies – Investigating the Effect of a Patient Characteristic on the Outcome of Disease	Diagnostic Studies – Investigating a Diagnostic Test	Economic and Decision Analyses – Developing an Economic or Decision Model
I	High quality randomized trial with statistically significant difference or no statistically significant difference but narrow confidence intervals	High quality prospective study ^d (all patients were enrolled at the same point in their disease with ≥80% of enrolled patients)	Testing of previously developed diagnostic criteria on consecutive patients (with universally applied reference "gold" standard)	Sensible costs and alternatives; values obtained from many studies; with multiway sensitivity analyses
	Systematic review ^b of Level RCTs (and study results were homogenous ^c)	Systematic review ^b of Level I studies	Systematic review ^b of Level I studies	Systematic review ^b of Level I studies
II	Lesser quality RCT (eg, < 80% followup, no blinding, or improper randomization)	Retrospective ^e study	Development of diagnostic criteria on consecutive patients (with universally applied reference "gold" standard)	Sensible costs and alternatives; values obtained from limited studies; with multiway sensitivity analyses
	Prospective ^d comparative study ^e	Untreated controls from an RCT	Systematic review ^b of Level II studies	Systematic review ^b of Level II studies
	Systematic review ^b of Level II studies or Level I studies with inconsistent results	Lesser quality prospective study (eg, patients enrolled at different points in their disease or <80% followup)		
		Systematic review ^b of Level II studies		
III	Case control study ^d	Case control study ^d	Study of non consecutive patients; without consistently applied reference "gold" standard	Analyses based on limited alternatives and costs; and poor estimates
	Retrospective ^e comparative study ^e		Systematic review ^b of Level III studies	Systematic review ^b of Level III studies
	Systematic review ^b of Level III studies		Case-control study	
			Poor reference standard	
IV	Case series ^h	Case series		Analyses with no sensitivity analyses
V	Expert opinion	Expert opinion	Expert opinion	Expert opinion

^a A complete assessment of quality of individual studies requires critical appraisal of all aspects of the study design.

^b A combination of results from two or more prior studies.

^c Studies provided consistent results.

^d Study was started before the first patient enrolled.

^e Patients treated one way (eg, cemented hip arthroplasty) compared with a group of patients treated in another way (eg, uncemented hip arthroplasty) at the same institution.

^f The study was started after the first patient enrolled.

^g Patients identified for the study based on their outcome, called "cases" eg, failed total arthroplasty, are compared with patients who did not have outcome, called "controls" eg, successful total hip arthroplasty.

^h Patients treated one way with no comparison group of patients treated in another way.

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BIOMECHANICS OF BONE BLOCK GRAFT MODELS OF DIFFERENT GEOMETRY

BIOMECÂNICA DE MODELOS DE ENXERTOS ÓSSEOS EM BLOCO DE GEOMETRIAS DIFERENTES

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ABSTRACT

Objective: To evaluate the mechanical behavior of different geometry bone block grafts in wooden models. **Methods:** Constructs with rectangular (G1) and trapezoidal (G2) profile “grafts”, fixed with 3.5 mm 8-hole dynamic compression plates were submitted to non-destructive bending, with the load applied alternately on the same surface as that of the plate fixation (upper) and on the opposite surface (lower), and torsion tests. A 50 N maximum load for bending and a 5° maximum deformation for torsion were considered. Rigidity (N/mm) was recorded for the former and torque (N.m) was recorded for the latter. **Results:** Rigidity was consistently higher in G2 than in G1, but not significantly so for all comparisons. The exception was for the load applied on the same surface of plate fixation, significantly higher in G1 than in G2. Torque was higher in G1, but not significantly so. **Conclusion:** The two different-profile “grafts” present a similar mechanical behavior and can be indistinctly used in clinical practice. **Level of evidence V, specialist’s opinion based on basic studies.**

Keywords: Internal fixation of fractures. Bone transplantation. Complications. Pseudarthrosis.

RESUMO

Objetivo: Avaliar o comportamento mecânico de enxertos ósseos em blocos com geometrias diferentes usando modelos de madeira. **Métodos:** Montagens com “enxertos” de perfil retangular (G1) e trapezoidal (G2), fixadas com placas de compressão dinâmica de 3,5 mm e oito orifícios, foram submetidas a ensaios não destrutivos de flexão, com a carga aplicada alternativamente na mesma superfície de fixação da placa (superior), na superfície oposta (inferior) e de torção. Foram consideradas uma carga máxima de 50 N para a flexão e uma deformação máxima de 5° para a torção. Foram registrados o desvio (mm) e a rigidez (N/mm) para o primeiro e o torque (N.m) para o segundo. **Resultados:** A rigidez foi consistentemente maior em G2 que em G1, mas não significativamente para todas as comparações. A exceção foi para a carga aplicada na mesma superfície da fixação com a placa, significativamente maior em G1 que em G2. O torque foi mais elevado em G1, mas não significativamente. **Conclusão:** Os dois “enxertos” de perfis diferentes apresentam comportamento mecânico semelhante, podendo ser utilizados indistintamente na prática clínica. **Nível de evidência V; opinião de especialista baseada em matérias básicas.**

Descritores: Fixação interna de fraturas. Enxerto ósseo. Complicações. Pseudoartrose.

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INTRODUCTION

Despite the advances of the modern orthopaedic surgery, it is still a challenging issue to reconstruct and preserve limbs affected by the loss of a large portion of their frame. This is particularly true for the forearm bones, where massive bone loss of various causes compromises the delicate pronation-supination mechanism, with negative reflex over function.

Among other techniques, the bone block graft represents an adequate solution for the critical-sized defects of the forearm bones, since it provides both biological tissue and mechanical stability, two fundamental requirements for a good outcome. The bone block

graft is understood as the tricortiocancellous (TCC) graft from the iliac crest as described by Nicoll¹ and used with small modifications by many other authors.^{2,3} The TCC bone block graft completely takes up and heals in about four to six months.⁴

The use of the TCC bone block graft requires that the recipient site be adequately prepared, beginning with the removal of all devitalized bone and soft tissue. The recipient bone ends are usually regularized perpendicularly to the long axis, in order to provide full and easy adaptation of the graft, also prepared with contact surfaces perpendicular to its long axis. This seems to be the most adequate graft geometry for the situation, since it greatly

All authors declare no potential conflict of interest related to this article.

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resists to the axial compression forces through the defect site. However, there are situations in which oblique regularization of the bone ends should be preferred, in order to preserve healthy bone tissue and length, thus favouring the use of a smaller bone block. In such a case the graft must be fashioned also with oblique contact surfaces, with the hypothetical advantage of increasing the bony contact area at the same time that the graft can be securely wedged in place under pressure.⁵

Intermediate bone block grafts with oblique contact surfaces require a specific fixation technique, in order to block shearing forces, very much in the same way oblique diaphyseal fractures are fixed. It was then theorized that a bone block graft with two oblique converging contact surfaces and adequately fixed would resist shearing forces and behave just as well as the conventional rectangular profile grafts. The present study was designed to be carried out with wooden models simulating a diaphyseal bone such as the radius.

MATERIAL AND METHODS

Fourteen 250 mm-long 14 mm in diameter cylinders were made from ivory wood (*Balfourodendron riedelianum*), a native tree of South America (Argentina, Brazil and Paraguay) of compact and uniform structure, high density (0.69 and 0.73 g/cm³) and great resistance and flexibility. Its current use is in the production of fine furniture and tool handles.

The cylinders were sawed in three parts, being two 112 mm-long to represent the recipient bone stumps, and one, intermediate, 26 mm-long to represent the bone block graft. The wooden sets were distributed into two groups of seven, according to the configuration of the intermediate segment. In Group 1, the intermediate segment was sawed as a regular cylinder with a rectangular profile and two surfaces perpendicular to its long axis; in Group 2, the intermediate segment was sawed with a trapezoidal profile, with two converging oblique surfaces at 45° in relation to its long axis and the longest surface measuring 26 mm.

The wooden sets were then fixed with an 8-hole 3.5 mm DCP plate (Synthes Brasil®, Rio Claro SP, Brazil) and 14 mm-long (2.6 mm-long for the lag screw technique in Group 2) 3.5 mm in diameter cortical screws, according to AO technique. All plates were bent at 5° at its middle portion in order to provide pre-tensioning. For the constructs in Group 1, the first step was to fix the intermediate segment ("graft") below the pre-tensioned plate with two screws inserted in the neutral position (Figure 1). The two longer segments were then assembled below the plate in as close contact as possible between them and the intermediate segment and so maintained with the help of a vise, until the fixation was complete with three screws on each end. Axial compression was provided with two screws, one on each end of the construct, through the hole just next to the contact surfaces. The construct was released from the vise before definitively tightening the compression screws and the remaining screws were introduced in the neutral position (Figure 2). In Group 2, the constructs with the trapezoidal intermediate segment were mounted directly onto the vise with its longest surface looking up. Reduction was carefully checked by direct vision and maintained by hand until the vise was tightened. The pre-tensioned plate was then positioned and held in site by hand, while two inter-fragmentary 26 mm-long lag screws were inserted through the plate towards the contact surfaces of the greater segments. Likewise in Group 1, the construct was released from the vise before definitively tightening the two lag screws, after which the remaining screws were inserted in the neutral position.

Once ready, the constructs were identified by numbers according to group (11, 12, 13 and so on in Group 1; 21, 22, 23 and so on in Group 2) and then submitted to two non-destructive bending tests,

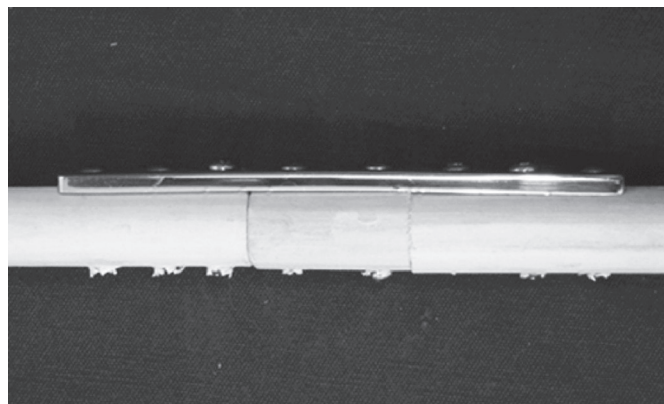


Figure 1. A model of rectangular profile graft fixed with a 3.5 mm DCP plate, under axial compression through the perpendicular contact surfaces.

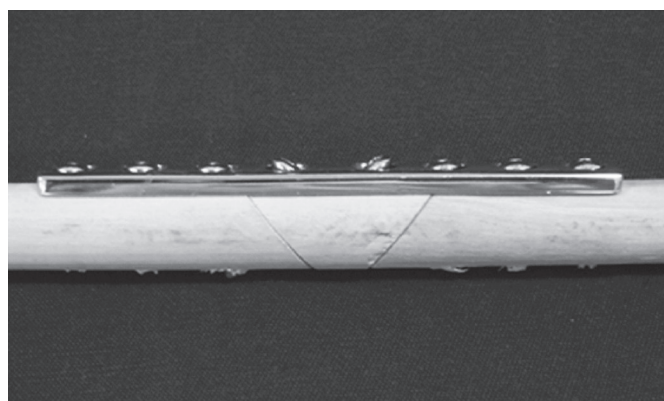


Figure 2. A model of trapezoidal profile graft fixed with a 3.5 mm DCP plate, under interfragmentary compression through the oblique contact surfaces.

according to the direction of load application in relation to the fixation plate (upper and lower bending) and a non-destructive torsion test. Bending tests: A universal testing machine (EMIC® model DL2000, Instron Brasil Equipamentos Científicos Ltda., São José dos Pinhais PR Brazil; www.emic.com.br), linked to a computer fed with specific software (TESC® Emic, v. 3.04) programmed for controlling and measuring the applied loads and for storing and interpreting the obtained data. The constructs were fixed onto the machine's vise by one end, comprising a 30 mm-long segment of its total length, so that a 220 mm-long portion of its length remained free. For the upper bending tests the constructs were fixed onto the universal testing machine with the fixation plate looking upwards while the load was applied on the opposite direction (downwards); for the lower bending tests, the construct was turned 180° and fixed onto the machine with the fixation plate looking downwards, while the load was applied in the same direction. The load was applied vertically from above below on the opposite free end, at a point 180 mm distant from the vise, by means of a rounded wedge-shaped accessory (Figure 3). Identical steps were followed for both upper and lower bending tests.

The non-destructive test consisted of load application up to a pre-determined limit (50 N in the present case) before any system failure occurred. The test began by applying a 5 N pre-load for 60 seconds for system accommodation. The actual load was then continuously applied at the rate of 5 mm/min, to the maximum predetermined load of 50 N. At this point, the resulting deformation

(displacement) was automatically measured (mm) and the system rigidity (N/mm) was automatically calculated, as well as graphs of both displacement and rigidity were supplied for each construct. All constructs were tested three times, not in a row but in separate sequences of the seven constructs of each group, according to numbering. After each test, the screws were tightened again and the construct was removed from the vise and reserved for the next sequence. The average of the three values obtained was used for the comparisons between groups. The rigidity data concerning both upper and lower bending tests were submitted to statistical analysis according to a mixed effect linear regression model using the *ProcMixed* procedure of the SAS v.9.0 software, at the 5% level of significance ($p \leq 0.05$).⁶

Torsion tests: An Instron 55MT (Instron Industrial Products, 900 Liberty Street, Grove City, PA 16127, USA) universal testing machine linked to a computer fed with specific software (PARTNER[®]) was used for the torsion tests. The constructs were fixed onto the machine by both ends, leaving a free 180 mm-long segment (lever arm), with the intermediate segment (“graft”) exactly in the middle (Figure 4). Torsion load was then applied at the rate of 5°/minute, up to a 5° deformation, when the torque (N.m) was then automatically measured. Similarly to the bending tests, all constructs were tested three times, not in a row but in separate sequences of the seven constructs of each group and the screws were equally re-tightened before removing the construct from the

machine, until the next sequence according to numbering. The average of the three values obtained was used for the comparisons between groups. The data concerning torque were recorded and submitted to statistical analysis by Student’s t test, using the PROC T TEST procedure of the SAS v.9.0 software, at the 5% level of significance ($p \leq 0.05$).⁶

RESULTS

Bending tests: The average displacement as measured on the free end of the construct was significantly ($p=0.01$) lower for the upper (3.99 mm) than for the lower (5.6 mm) plate position in Group 1 (rectangular profile “grafts”), while no significant difference ($p=0.06$) existed between upper (3.56 mm) and lower (4.67 mm) position in Group 2 (trapezoidal profile “graft”) (Table 1). Displacement was greater for Group 1 than Group 2 constructs, regardless of the plate position, but the differences between groups were non-significant for both positions ($p=0.45$ for the upper position; $p=0.12$ for the lower position) (Table 2, Figure 5).

The average rigidity was significantly ($p=0.04$) higher for the upper (13.75 N/mm) than for the lower (10.26 N/mm) plate position in Group 1. Likewise, the average rigidity was significantly ($p=0.03$) higher for the upper (15.27 N/mm) than for the lower (11.59 N/mm) in Group 2 (Table 3). However, for both the upper and lower plate position,

Table 1. Displacement (mm) on the bending tests according to plate position.

Group	Plate position	n	Average	CI (95%)		SD	Minimum	Median	Maximum
				LL	UL				
1	lower	7	5.6	4.24	6.95	1.46	3.99	4.95	7.76
	upper	7	3.99	2.88	5.1	1.2	2.73	3.9	6.05
2	lower	7	4.67	3.86	5.48	0.87	3.51	4.36	5.77
	upper	7	3.56	2.75	4.38	0.88	2.28	3.61	5.03

CI, confidence interval; LL, lower limit; UL, upper limit; SD, standard deviation.

Table 2. Statistics of the bending displacement according to plate position.

Effect	Estimate	LV	UV	p
Lower position (G1 - G2)	-0.9229	-21.027	0.2570	0.12
Upper position (G1 - G2)	-0.4300	-16.099	0.7499	0.45
G2 (lower - upper)	11.114	-0.06846	22.913	0.06
G1 (lower - upper)	16.043	0.4244	27.842	0.01

LV, lower value; UV, upper value.

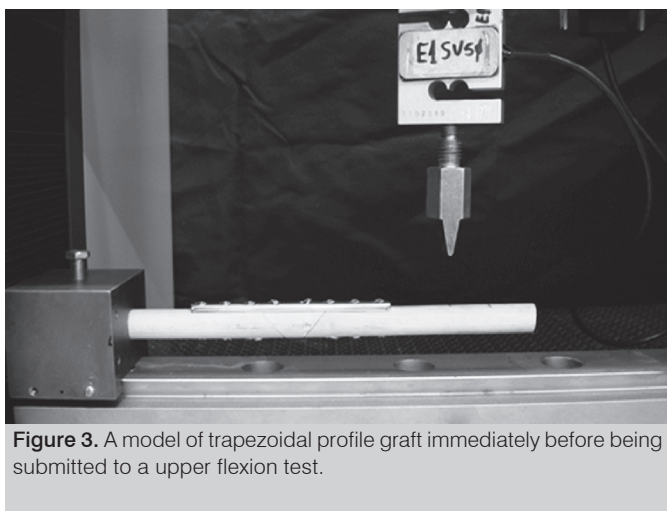


Figure 3. A model of trapezoidal profile graft immediately before being submitted to an upper flexion test.

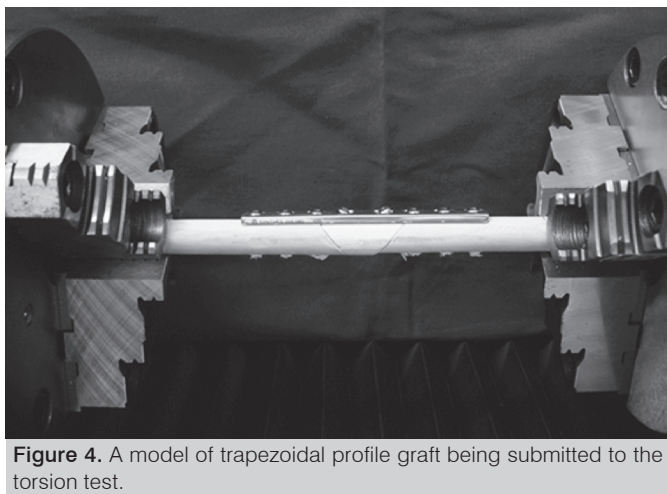


Figure 4. A model of trapezoidal profile graft being submitted to the torsion test.

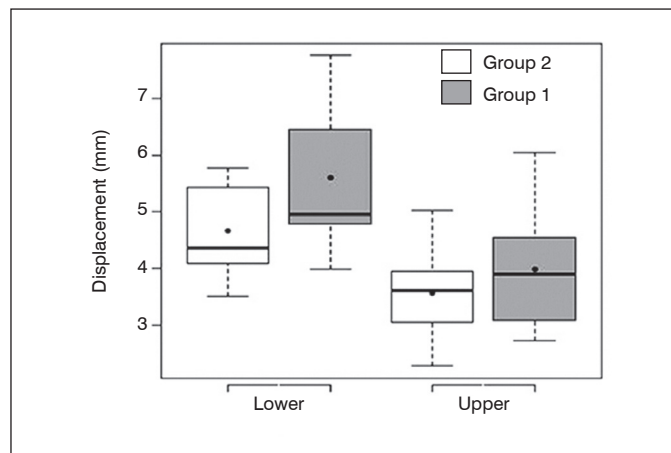


Figure 5. Box plot graph of the displacement during the flexion tests, according to group and plate position.

the average rigidity was higher in Group 2 than Group 1, although with non-significant difference between groups for both positions ($p=0.42$ for Group 2; $p=0.36$ for Group 1) (Table 4, Figure 6). Torsion tests: The average torque at 5° deformation was 2.38 N.m in Group 1 and 2.18 N.m in Group 2, with non-significant differences between groups ($p=0.0537$) (Table 5 and 6; Figure 7).

DISCUSSION

The treatment of diaphyseal critical-sized cortical bone defects often requires the use of some form of bone grafting associated with a very stable fixation. Specific surgical techniques for the treatment of

Table 3. Rigidity (N/mm) on the bending tests according to plate position.

Group	Plate position	n	Average	CI (95%)		SD	Minimum	Median	Maximum
				LL	UL				
1	lower	7	10.26	7.91	12.62	2.54	6.73	10.78	13.72
	upper	7	13.75	10.35	17.15	3.67	8.75	12.89	18.61
2	lower	7	11.59	9.20	13.98	2.58	8.89	12.00	15.83
	upper	7	15.27	11.52	19.02	4.05	9.86	14.76	22.77

CI, confidence interval; LL, lower limit; UL, upper limit; SD, standard deviation.

Table 4. Statistics of bending rigidity according to plate position.

Effect (G1 - G2)	Estimate	LV	UV	p
Lower position	13.214	-20.806	47.234	0.42
Upper position	15.200	-18.820	49.220	0.36
G2 (lower - upper)	-36.814	-70.834	-0.2794	0.03
G1 (lower - upper)	-34.829	-68.848	-0.08087	0.04

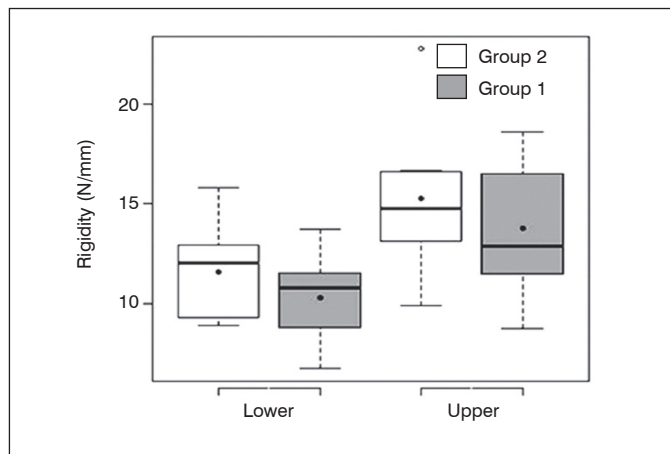


Figure 6. Box plot graph of rigidity (N/mm) according to group and plate position.

Table 5. Torque (N.m) at 5° torsion deformation, according to group.

Group	N	Average	CI (95%)		SD	Minimum	Average	Maximum
			LL	UL				
1	7	2.38	2.20	2.56	0.19	2.08	2.38	2.65
2	7	2.18	2.03	2.33	0.16	1.91	2.14	2.39

CI, confidence interval; LL, lower limit; UL, upper limit; SD, standard deviation.

Table 6. Statistics of the results of torque on the torsion tests.

Effect	Estimate	LV	UV	p
G1 - G2	-0.41	-0.203	0.0038	0.0537

LV, lower value; UV, upper value.

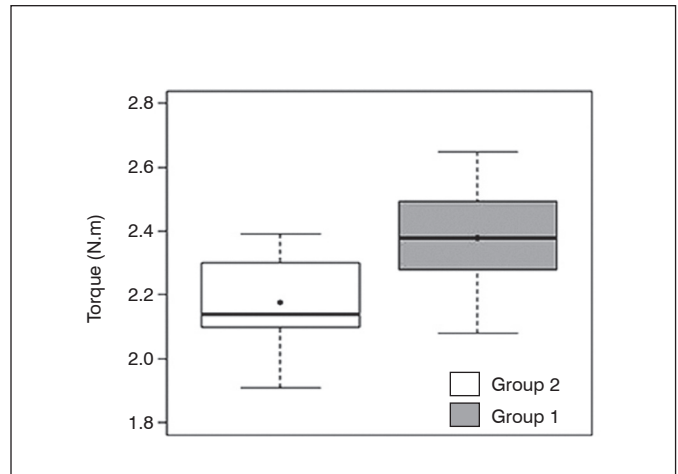


Figure 7. Box plot graph of torque (N.m) according to group (graph profile).

such defects of the forearm bones were introduced as early as the decade of the years 40 of the last century, involving different types of graft and resulting in variable outcome rates.⁷⁻⁹ The TCC bone block graft from the iliac crest was introduced shortly thereafter with very good results in 12 very complicated cases; in all of them, an intramedullary pin was used for fixation.¹⁰ A modification of the technique was later introduced, consisting of harvesting the graft already devoid of the upper and medial or lateral cortices, or both, and fixing it with plate and screws,¹ but with similar outcomes; for both techniques, the graft profile was rectangular from the very beginning. The TCC graft as described by Spira is the one we regularly use in our clinical practice, particularly for not too extensive but critical-sized defects,⁴ with regularly good results, as characterized by full integration and cortical transformation of the graft.

Despite the early description of fixation with intramedullary pins or conventional plate and screws, fixation with a compression plate became the most convenient model, particularly after the demonstration that absolute stability ("pressure-proof blocks") facilitates and accelerates graft integration^{4,11,12}. However, good results are also obtained with intramedullary pins, perhaps over a slightly longer period.^{2,3}

The main advantage of the TCC bone block graft from the iliac crest is the availability and relative easiness to do, at the reach of any well trained orthopaedic surgeon. Among other requirements (no infection, adequate recipient bed preparation), the shape and dimensions of the graft seem to play a major role for good results. The rectangular profile seems to be the most used since Nicoll's and Spira's description;^{1,10} it provides two contact surfaces perpendicular to the long axis of the recipient bone and, therefore, the ability to withstand axial compression and shearing forces imposed by motion. However, the trapezoidal profile ("keystone") more recently suggested provides two oblique wider contact surfaces, with the alleged advantage that healing would be quicker,⁵ but possibly with the disadvantage that the operative act would be considerably more difficult and time-consuming, not to mention that fixation with an intramedullary pin would be virtually impossible.

However, from a theoretical standpoint, the trapezoidal graft profile would favour a more economic bone resection in the preparation of the recipient bed and help reduce the defect length. Actually, a limiting factor for the use of the TCC bone block graft is the defect length, since wide defects require wide grafts, with an inevitable reflex over time of integration. Although this seems to vary among authors, it is our own experience that up to 5 cm long defects can

be corrected with the TCC graft. In the present study we limited the defect length to 26 mm, which roughly corresponds to 10% of the bone length (25 cm), thus characterizing a critical-sized defect, meaning that in a clinical situation it would not heal on its own or without the assistance of a surgical grafting procedure.

From a biological standpoint, the graft with oblique contact surfaces could even be superior to that with perpendicular surfaces, since the contact area is wider in the first case, thus contributing to speed up healing and integration. Assuming that both profile grafts would take up in approximately the same time, it was the mechanical behaviour of the trapezoidal profile graft that intrigued us. In the present investigation we decided to compare solely the biomechanical behaviour of both rectangular and the trapezoidal profile types of graft because the first is undoubtedly the most used, while the second has not yet been thoroughly addressed since its original description and the capability of which in solving clinical situations is not entirely known.⁵

For both profile "grafts", fixation of the experimental construct was done with a 3.5 DCP plate according to the AO technique in order to assure absolute stability against bending and rotational stresses. In order to make it work properly the plate installation must be adequately balanced, meaning that equal plate lengths are maintained above and below the defect.^{13,14} Also, the graft must be compressed against both recipient bone stumps, by means of axial (Group 1) or interfragmentary (Group 2) dynamic compression. Interfragmentary dynamic compression associated with a neutralizing plate is the most sensible indication for fixation of up to 45° oblique diaphyseal fractures of the forearm bones. In fact, the compression by the lag screw through the oblique surfaces is at least equivalent to the dynamic axial compression through the surfaces of perpendicular or not more than 30° oblique fractures. From this standpoint, the idea of using TCC bone block grafts

with oblique contact surfaces is also very attractive and was the reason why its mechanical behavior was compared with that of the perpendicular contact surfaces.

The present study was designed to be carried out with wooden models, according to a protocol of regular use in our department, for investigation on the fixation of several different bones, including spinal vertebrae.¹⁵ The wood used to make the models is of the kind recommended by engineers for mechanical studies. Obviously, it does not present the same biomechanical properties as the bones, but its compact and uniform structure, great density (~0.71 g/cm³, on average) and anisotropy account for uniform and reliable results, which theoretically can be translated to a real situation in living bones.

According to our results, the mechanical behavior of both profile "grafts" was very similar. Constructs in Group 1 (rectangular profile "grafts") were more flexible than those in Group 2, but not significantly so, meaning that both present identical mechanical resistance against bending stress. As expected, resistance against bending stress was significantly higher for the load applied on the same surface of the plate position, as confirmed by the rigidity figures. Rigidity was significantly higher for Group 2 constructs, probably indicating that the combination of a wedge shaped "graft" fixed by means of interfragmentary screws with a neutralizing plate should be preferred in a clinical situation whenever possible. Resistance against torsion was virtually the same for both Group 1 and 2 constructs.

CONCLUSION

The results presented above permit the authors to conclude that, from a biomechanical standpoint, both graft profile would behave similarly in a clinical situation. Therefore, the choice between one another would only depend on the surgeons' preference and on the defect geometry.

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TREATMENT OF SCAPHOID NONUNION WITH VOLAR LOCKED PLATE

TRATAMENTO DA PSEUDOARTROSE DO ESCAFOIDE COM PLACA BLOQUEADA VOLAR

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ABSTRACT

Objective: To assess and compare radiographic, tomographic and functional pre and postoperative parameters of patients submitted to treatment of nonunion of the scaphoid waist with locked plate for scaphoid. **Methods:** This is a case series of scaphoid waist nonunion, operated from March 2017 to March 2018 at the Institute of Orthopedics and Traumatology of HCFMUSP, using the technique of Fisk-Fernandez and osteosynthesis with locked plate for scaphoid APTUS®Hand from Medartis. The patients were submitted to radiographs, computed tomography and functional evaluation by the occupational therapy team in the pre and postoperative periods. **Results:** There was consolidation of the scaphoid waist nonunion in all cases, improvement in the parameters of carpal alignment in the imaging examinations, but functionally we observed reduction of the range of motion and grip strength in relation to the contralateral limb. **Conclusions:** The treatment of the scaphoid waist nonunion with locked plate was effective, with a high index of consolidation and improvement of the carpal alignment in the imaging tests, although with a reduction in the range of motion and grip strength in relation to the contralateral limb when evaluated with 12 weeks postoperatively. **Level of Evidence IV, Case series.**

Keywords: Pseudarthrosis/surgery. Scaphoid bone/injuries. Scaphoid bone/surgery. Fracture fixation, internal. Bone plates.

RESUMO

Objetivos: Avaliar e comparar parâmetros radiográficos, tomográficos e funcionais pré e pós-operatórios de pacientes submetidos ao tratamento de pseudoartrose do colo do escafoide com placa bloqueada para escafoide. **Métodos:** Esta é uma série de casos de pseudoartrose do colo do escafoide, operados no período de março de 2017 a março de 2018 no Instituto de Ortopedia e Traumatologia do HCFMUSP, utilizando-se a técnica de Fisk-Fernandez e osteossíntese com placa bloqueada para escafoide APTUS®Hand da Medartis. Os pacientes foram submetidos a radiografias, tomografia computadorizada e avaliação funcional pela equipe de terapia ocupacional no pré e pós-operatório. **Resultados:** Houve consolidação da pseudoartrose do colo do escafoide em todos os casos e melhora nos parâmetros de alinhamento carpal nos exames de imagem, porém, funcionalmente, observamos redução da amplitude de movimento e força de preensão em relação ao membro contralateral. **Conclusão:** O tratamento da pseudoartrose do colo do escafoide com placa bloqueada se mostrou efetivo, com elevado índice de consolidação e melhora do alinhamento carpal nos exames de imagem, embora com redução da amplitude de movimento e força de preensão em relação ao membro contralateral, quando avaliados com 12 semanas de pós-operatório. **Nível de Evidência IV, Série de casos.**

Descritores: Pseudoartrose/cirurgia. Osso escafoide/lesões. Osso escafoide/cirurgia. Fixação interna de fraturas. Placas ósseas.

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INTRODUCTION

Scaphoid fractures make altogether for 60 to 70% of all carpal bone fractures and they are second in frequency when it comes to wrist fractures, behind only distal radius fractures.¹ Nonunion occurs in 10 to 15% of scaphoid fractures and the risk of nonunion development becomes higher with treatment delays, inadequate immobilization time, early fracture deviation and carpal instability association.¹ When nonunion occurs at scaphoid waist level, the volar edges of proximal and distal fragments suffer from attrition, erosion and bone absorption, increasing the angular deformity due to distal

fragment flexing ("humpback" deformity). This scaphoid angular deformity together with bone absorption, causes a carpal collapse into a DISI (Dorsal Intercalated Segment Instability) pattern that must be corrected.²⁻⁴

There are consensus that the management of the scaphoid nonunion with angular deformity and carpal instability has three stages: open reduction with angular deformity correction (correction of intrascaphoid angle to about 20 degrees), restoration of length and form of scaphoid with autologous interpositional anterior wedge grafting and internal fixation by screw.³⁻⁷

All authors declare no potential conflict of interest related to this article.

Study conducted at the Hand and Microsurgery Group, Orthopedics and Traumatology Institute, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

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Although osteosynthesis with compression screw is considered nowadays the standard method of fixation⁸⁻¹⁴, osteosynthesis with plate and screws has theoretical advantage of fixation with divergent multiple screws leading to stability in multiple vectors, including torsion stability, providing better and more reliable internal fixation, capable of maintaining angular scaphoid deformity correction, which is required to restore wrist anatomy, biomechanics and kinetics.¹⁵⁻¹⁷

In this context, the present study is a series of 8 cases of scaphoid waist nonunion treated with "Humpback" deformity correction by interpositional anterior wedge grafting and internal fixation with scaphoid volar locked plate.

MATERIALS AND METHODS

A series of 8 subjects of male gender is presented, with ranging ages from 22 to 46 years old (average of 30 years old), diagnosed with scaphoid waist nonunion classified accordingly to Alnot (Table 1) as: IIA (1 case), IIB (6 cases) and IIIA (1 case), with pseudarthrosis diagnostic superior to 6 months, without any previous surgery or other upper limb lesions. None of the patients display advanced degenerative wrist condition (SNAC III/IV).

Epidemiological data of aforementioned patients are found summarized in Table 2.

After the approval of the USP Hospital das Clinicas ethics committee (CAAE: 81038417.4.0000.0068) and the filling of the free consent term, the patients were taken under surgery by the hand surgery and reconstructive microsurgery group of HCFMUSP from march/2017 to march/2018.

All patients were subject to preoperative functional evaluation and 12 weeks postoperatively, performed by the Hand Therapy team of HCFMUSP's orthopaedic and traumatology institute, including pain intensity analysis (analogic visual scale), range of movement (ROM), grip strength (Jamar), digital pinch strength (pinch test) and functional wrist score scales of DASH and MAYO.

The preoperative planning included comparative radiographs of both wrists in the standard scaphoid views: Front (posteroanterior), front with wrist ulnar deviation, lateral and oblique views.

The radiological segment was performed accordingly with radiographic views of the scaphoid routine in 3, 6 and 12 weeks postoperatively, and patients used immobilization through short arm thumb spica cast or brace, in continuum, for eight weeks, with changes in the immobilization time (more than eight weeks) set by the CT scan imagery evaluation performed at the eighth week postoperatively. Scaphoid bone healing, intrascaphoid angle, and carpal alignment (radiolunate and scapholunate angles) related data were evaluated over the entire study, with the aid of the various imagery exams performed throughout the research development. The imagery exams (radiographs) taken from non-damaged counter lateral wrists were used as standard control for pre and postoperative measures. Ambulatory postoperative appointments were performed within range of 1, 3, 6, 8 and 12 weeks, even after the bone healing evidence, the patients had ambulatory segment attendance. Good results parameters of treatment were considered as follow: absence of pain, radiological bone healing proof (radiographic evidence of bridging bony trabeculae across the graft), absence of implant looseness signs, intrascaphoid angle correction, non-existence of carpal instability and carpal collapse, recovery of range of movement and strength.

Surgical Technique

The subjects with scaphoid nonunion were positioned in supine and had anesthesia procedures (general or local anesthesia). An air intake pneumatic tourniquet was used bearing a pressure of 250 mmHg throughout the entire wrist surgery procedure. An anterior exposure was performed for the scaphoid (Russe approach) (Figure 1). A lengthways incision was performed in the wrist joint capsule for exposure of scaphoid palmar surface. The surgery exposure was distally extended until the scaphotrapezial joint, preserving the region's ligaments. With the exposure of the scaphoid, pseudarthrosis irregular edges were resected using a delicate osteotome, rongeur and curette until viable and well vascularized tissue was observed (Figure 2).

The scaphoid was reduced through the application of a traction force, ulnar deviation and wrist extension. After that reduction, the size of the necessary autologous bone graft was calculated. The tricortical graft was taken away from the iliac bone. The graft, in the shape of a wedge, was inserted in the scaphoid volar defect and temporarily fixed with K wire. Deformity corrections of scaphoid and DISI pattern of instability were evaluated by radiograph analysis (Figure 3). The scaphoid internal fixation was performed with a low-profile locked plate for scaphoid APTUS®Hand from Medartis (Figure 4). After the definitive internal fixation (osteosynthesis), radioscapoid joint was inspected, and the joint movement tested to verify plate impact with the bone borders.

RESULTS

There was scaphoid nonunion consolidation in all cases and no complications like infection and implant material fatigue or

Table 1. Alnot Classification of Scaphoid Waist Nonunion.

Grade I		Linear nonunion without altered scaphoid form, instability or intracarpal malalignment
Grade II	II A	Stable nonunion with incipient bone resorption at fracture line, without instability or malalignment
	II B	More or less mobile nonunion with anterior defect and proximal pole flexion on distal tubercle inducing DISI
Grade III	III A	More or less mobile displacement nonunion with instability or reducible malalignment with isolated styloscaphoid arthritis
	III B	More or less mobile displacement nonunion with instability or reducible malalignment with radial and/or intracarpal arthritis
Grade IV	IV A	Proximal fragment necrosis with malalignment
	IV B	Proximal fragment necrosis with radioscapoid and/or intracarpal arthritis

Table 2. Epidemiological Profile.

Patient	Dominance	Operated Side	Profession	Time since trauma	Mechanism of Trauma
1	Right-handed	Right	Driver	8 months	Wrist sprain
2	Right-handed	Left	Bakery manager	6 months	Fall from own body length
3	Right-handed	Right	Civil construction	1 year and 6 months	Fall from high surface (roof)
4	Right-handed	Left	Sales manager	2 years	Fall during sports activity (soccer)
5	Right-handed	Left	Machine operator	1 year and 2 months	Fall from motorcycle
6	Right-handed	Right	Glazier	1 year	Fall from own body length
7	Right-handed	Right	Transport assistant	2 years	Fall from motorcycle
8	Right-handed	Right	Stockist	6 months	Fall during sports activity (basketball)



Figure 1. Russe's anterior approach.



Figure 2. Scaphoid nonunion site after resection of devitalized bone edges.



Figure 3. Wedge shaped graft inserted in the scaphoid volar defect and temporarily fixed with K wire.

looseness were observed. However, in two of the patients, there was persistence of moderate pain complaint that worsened with wrist flexion, that complaint was due to an impact of a proximal region of the plate with the radius joint surface (Figure 5). All other patients had a decrease of pain after the surgery procedure.

As seen on Table 3, preoperative radiographs show that all patients had an increase of the scapholunate angle above 60° , which represents a carpal instability pattern of DISI type (preoperative scapholunate angle average of 74.87°). In all cases the scapholunate angle was reduced, with a postoperative average of 60.62° , however, two cases remained inside DISI indicative values.

An average preoperative value of 20.21° and postoperative value of 13.75° related to the radiolunate angle was observed, although two of the cases had an angle increase after surgery procedures. Intrascaphoid preoperative angle average was 43.12° , which represents a Humpback deformity (angle above 35°), but this value was corrected in the postoperative to an average of 17.37° .

Related to the patient's clinical evaluation, as summarized by Table 4, there was an average flexion/extension arc of the wrist of 53.12° preoperatively and 39.81° postoperatively, this value making a total of 59% of counter lateral limb range of movement for this patient's sample. The average radial and ulnar deviation of lesioned wrists is, preoperatively, respectively 15.25° and 16.87° and, postoperatively, 13.37° and 21° ; values that have a 61.13% and 68.02%, respectively, of all radial and ulnar contralateral deviations.

When data from the strength test with a dynamometer was analyzed, the average postoperative values for grip force, key pinch, three jaw chuck pinch and tip pinch was, respectively, 24.49 Kgf, 7.48 Kgf, 5.73 Kgf and 4.66 Kgf, with percentual correspondence related to non-affected contralateral side of 57.75%, 73.5%, 65.03% and 68.12% respectively. The average Mayo Wrist Score was, preoperatively, 57.5 and, postoperatively, 48.12, with a DASH Score of 38.83 and 30.68.

DISCUSSION

Scaphoid is the carpal bone most commonly fractured, 60 to 70% of all the carpal bone fractures, of which, 10 to 15% will evolve to nonunion due to the fact that the scaphoid is a bone with scarce blood supply and predominantly retrograde from branches of the radial artery.¹ The more proximal the fracture, greater the probability of the bone to become avascular and greater the risk of nonunion, which also increases when associated to delay in the beginning of the treatment, use of immobilization for unsuitable amount of time, when there is initial deviation of the fracture of more than 1mm and association with carpal instability.

Scaphoid nonunion tends to evolve with a distal fragment flexion of the scaphoid and a DISI pattern of carpal instability that can develop into a predictable wrist arthritis pattern know as SNAC (Scaphoid Nonunion Advanced Collapse). To prevent this adverse evolution of scaphoid nonunion is fundamental to achieve bone consolidation of an anatomically aligned scaphoid, with a lateral intrascaphoid angle lower than 35° , a scapholunate angle between 30° and 60° and a radiolunate angle ranging from 0° to $\pm 15^\circ$.

Use of plates for scaphoid nonunion treatment was described by Ender in 1977, using a hook plate after an iliac graft, which was fixed to the proximal fragment by a hook and to the distal fragment by screw, in a way of exerting compression to the graft placed in the pseudarthrosis site.¹⁸ Recently, buttress plates were developed for instable fractures or scaphoid nonunion with humpback deformities, to neutralize compression forces and axis angles that occur when a compression screw cannot guarantee stability,^{15,19} besides insuring greater rotational stability and having the additional advantage of the plate medium segment holding the wedge-shaped graft in an anterior position, preventing extrusion. Accordingly, to other literature related



Figure 4. Osteosynthesis with volar locked plate APTUS® Hand.



Figure 5. Wrist CT showing the impact of the proximal region of the plate with the radius joint surface.

case studies, a great consolidation rate was obtained (100% of cases) of scaphoid nonunion treated with volar plates, besides great improvement of carpal alignment, as seen through comparison of average preoperative scapholunate angles (74.87°) and postoperative (60.62°), and the average of radiolunate angles from 20.12° to 13.75° , postoperatively, with an improvement of scaphoid humpback deformity, clearly visible through comparison of pre (43.12°) and postoperative (17.37°) intrascaphoid angle. Concerning the clinical evaluation of patients was observed an improvement of pain after surgery, however, when compared to

objective clinical parameters like wrist range of movement, grip strength and pinch (key, tripod and tip), we confront a worsening, postoperatively. The average flexion/extension arc of the operated wrists corresponded to 59% of the average flexion/extension arc of the unaffected wrists, and, the average of radial and ulnar deviations postoperatively were of 61.13% and 68.02%, respectively, related to the contralateral wrists.

Grip strength and key, tripod and tip pinches were reduced after surgery. The average of the grip strength and key, tripod and tip pinches after surgery were of 57.75%, 73.5%, 65.03% and 68.12%, respectively, when compared to contralateral wrists.

This data is concurrent with the data observed by Esteban-Feliu et al.,²⁰ that in a retrospective series of 15 cases for the duration of 3 years, had observed a significant reduction of the affected wrist range of motion in relation to the contralateral (the mean ROM after surgery corresponded to 61% that of the opposite side), and a average grip strength which was 55% that of the unaffected side. However, Leixnering et al.¹⁸ published a series of 11 patients with scaphoid nonunion treated with volar plate in an average time segment of 13 months, where they had little and limited sequels to minor symptoms with a good ROM gain, also, Ghoneim¹⁶ published a series of 14 patients with a mean follow-up time of 11 months in which they achieved more than 70% ROM gain and grip strength relative to the unaffected contralateral limb.

We believe that part of the ROM and force limitations observed in our study, may be justified by the fact that postoperative physical evaluation was only performed 12 weeks after surgery, considering that in the long term segment there was a progressive improvement of ROM, grip strength and pinch of the operated wrist, although they still have limitations when compared to the contralateral side. As part of the functional evaluation of our patients, we also used the Mayo Wrist Score that divides the function degree of patient

Table 3. Radiographic evaluation.

Patient	Alnot classification	Scapholunate angle			Radiolunate angle			Intrascaphoid Angle	
		Preop	Posop	Contralateral	Preop	Posop	Contralateral	Preop	Posop
1	IIB	74°	52°	49°	5°	5°	7°	19°	11°
2	IIB	70°	54°	59°	15°	15°	0°	68°	12°
3	IIB	92°	86°	59°	40°	15°	13°	50°	35°
4	IIB	76°	70°	80° (Nonunion)	18°	30°	21°	40°	6°
5	IIIA	69°	54°	55°	29°	34°	0°	61°	29°
6	IIA	78°	51°	55°	31°	7°	4°	5°	5°
7	IIB	76°	63°	43°	7°	4°	9°	76°	31°
8	IIB	64°	55°	44°	16°	0°	0°	26°	10°

Table 4. Functional evaluation.

Patient	Dynamometry (Kgf)			Goniometry			Visual Analogue Scale		MayoWrist Score		Dash Score	
	(grip strength/key pinch/tripode pinch/tip pinch)			(Extension /Flexion/Ulnar Deviation/ Radial Deviation)			Preop	Posop	Preop	Posop	Preop	Posop
	Preop	Posop	Contralateral	Preop	Posop	Contralateral						
1	36/8/8/ 6.5	44,33/7,5/8,66/8	58/11/12/8	45°/65°/ 20°/20°	30°/80°/40°/22°	65°/85°/ 40°/35°	2	8	55	70	25	17.24
2	26/11 6/5.3	10/8 3.83/3.33	49/12.33 8.16/5.66	50°/60° 30°/15°	20°/20°/ 25°/10°	60°/75°/ 30°/25°	7	5	65	40	32.5	48.33
3	9.3/5.8 4/5.3	5.3/ 3.5 2.0/0.8	46.6/13 10.5/9.3	40°/50° 30°/15°	15°/15° 15°/10°	60°/65° 30°/20°	6	4	30	15	56.66	68.33
4	42/11 8/6	35/12 8/8	42/11 8/6	60°/80° 45°/15°	45°/45° 15°/10°	45°/60° 25°/15°	5	3	90	65	41.66	11.66
5	19.3/5.6 6/5.3	28/8 6/5	42/6.3 8/9.6	30°/40° 20°/12°	40°/50° 15°/10°	60°/75° 27°/15°	7	2	15	60	73.21	13.33
6	12/4/3/3	12/5.6 3.6/3	26/8/5/5	45°/35° 15°/10°	32°/50° 13°/10°	60°/50° 15°/10°	8	3	50	35	30.83	55
7	35/7.1 5.3/3.6	19.33/5.8 6.1/4.0	29/7.1 5.5/3.5	50°/60° 25°/20°	20°/35° 15°/20°	70°/80° 40°/25°	5	3	75	35	35	22.4
8	50/11 11/7.83	42/9.5 7.66/5.16	46.6/12.66 13.33/7.66	60°/80° 30°/15°	60°/80° 30°/15°	70°/90° 40°/30°	5	3	80	65	15.83	9.16

accordingly to the score as: excellent (90-100), good (80-90), satisfactory (60-80) and bad (<60); and a DASH (Disabilities of Arm, Shoulder and Hand) score, composed of 30 questions that evaluate patients accordingly to their physical function, symptoms and social function. In our casuistry, it was observed that the Mayo Wrist Score had an average of 57.5 preoperatively and 48.12 postoperatively, this worsening being justified by the reduction of ROM and grip strength. Possibly too because most of our patients execute occupational activities that request great wrist demand, being hard to return to their occupations with 12 weeks postoperatively. However, when we look to the DASH score, it is observed a clinical improvement of patients undergoing surgery procedures, with scores of 38.83 and 30.68, pre and postoperative respectively.

As complications of surgery procedures, it is observed the maintenance of pain even after consolidation of scaphoid nonunion in two of the patients, being that pain due to proximal plate portion impact with radius articular surface. As cited by Esteban-Feliu et al.,²⁰ maybe this is a problem that comes from the fact that there is only one design for scaphoid plate, in which no different shapes and sizes can be adapted.

However, in the great majority of our casuistry (75%) the patients had an improvement in pain after surgery and choose to not perform remotion of scaphoid plate.

CONCLUSION

From analysis of our cases series, we considered osteosynthesis with volar plate an effective alternative for scaphoid nonunion treatment, since there was a high rate of consolidation, with improvements in carpal alignment and in consequence a prevention against SNAC, in addition to a low rate of complications and clinical enhancement of DASH score, although there was a reduction of postoperative ROM and grip strength.

It is worth to emphasize that because our sample had a limited size and also the absence of a control group that had been treated with Herbert's screw for osteosynthesis, method still considered the gold standard procedure for scaphoid nonunion, the analysis of our work must be performed in a critical manner with more studies comparing the two osteosynthesis methods.

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CURRENT PANORAMA OF ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION SURGERY IN BRAZIL

PANORAMA ATUAL DA RECONSTRUÇÃO DO LIGAMENTO CRUZADO ANTERIOR NO BRASIL

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ABSTRACT

Objective: This study aims to establish the current panorama of the anterior cruciate ligament reconstruction surgery in Brazil. **Methods:** A survey that consisted of a 24-item questionnaire including surgeon's demographics, preferred technique, graft selection, graft positioning, use of braces, drains, antibiotic prophylaxis and most common complications was conducted at the last three editions of a national knee surgery event. **Results:** Six hundred eight questionnaires were analyzed. Brazilian knee surgeons are mostly male, with mean age of 42 years (26-68) and are affiliated to at least one orthopedic society. Thirty-six percent (36%) perform more than 50 reconstructions per year. The preferred graft is the hamstring tendons graft (64%). The frequency of use of anatomical technique increased approximately from 55% from 2011 to 2013, to 85.5% in 2015 ($p < 0.001$). From 2011 to 2015, there was a progressive reduction from 56.8% to 18.1% in the frequency of use of trans tibial femoral tunnel drilling ($p < 0.001$). **Conclusion:** Our findings show that Brazilian knee surgeons' preferences are evolving according to the current world practice. **Level of Evidence V, Economic and Decision analysis study.**

Keywords: Anterior Cruciate Ligament. Knee. Surgery. Reconstruction. Survey.

RESUMO

Objetivo: O presente estudo tem como objetivo estabelecer o panorama atual da cirurgia de reconstrução do ligamento cruzado anterior no Brasil. **Métodos:** Nas últimas três edições de um evento nacional de cirurgia do joelho, realizou-se uma pesquisa que consistiu em um questionário de 24 itens incluindo dados demográficos do cirurgião, técnica preferida, seleção do enxerto, posicionamento do enxerto, uso de órteses, drenos, profilaxia antibiótica e complicações mais comuns. **Resultados:** Seiscentos e oito questionários foram analisados. O cirurgião brasileiro de joelho é majoritariamente do sexo masculino, tem idade média de 42 anos (26-68) e é afiliado a pelo menos uma sociedade ortopédica. Trinta e seis por cento (36%) realizam mais de 50 reconstruções por ano. O enxerto preferido é o enxerto de tendões isquiotibiais (64%). A frequência de uso da técnica anatômica aumentou de 55% nos anos de 2011 e 2013 para 85,5% em 2015 ($p < 0,001$). Após 2011, também foi observada redução progressiva de 56,8% para 18,1% até 2015 na frequência de uso da técnica de perfuração do túnel femoral trans tibial ($p < 0,001$). **Conclusão:** Nossos achados mostram que os cirurgiões brasileiros de joelho estão evoluindo de acordo com a prática mundial atual. **Nível de evidência V, Análise econômica e de decisão.**

Descritores: Ligamento cruzado anterior. Joelho. Cirurgia. Reconstrução. Inquéritos e Questionários.

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INTRODUCTION

Rupture of the anterior cruciate ligament (ACL) of the knee is an extremely common sports injury, with an estimated number of 300,000 new cases every year in the United States alone.^{1,2} Surgical procedure for ligament reconstruction is one of the most performed orthopedic surgeries³ and is currently the standard of care, specially for active individuals who aim to return to high-level sports activity.²

Since its first description, ACL reconstruction surgery has evolved considerably, specially in the last three decades. First proposals of ACL repair by suture appeared at the beginning of the 20th century.⁴ The 1960's and 70's witnessed the extra-articular procedures, such as the Lemaire⁵ or Andrews⁶ procedures, with poor long term results. The attention, therefore, turned to ACL reconstruction, and the patellar tendon would soon become the gold standard graft.

All authors declare no potential conflict of interest related to this article.

This study was conducted at Núcleo de Estudos do Instituto Wilson Mello, at the address Rua José Rocha Bonfim, 214, Ed. Chicago, 10. andar, Condomínio Praça Capital, Jardim Santa Genebra, CEP 13080-650, Campinas, SP, Brazil
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The advent of arthroscopy revolutionized knee surgery, but also brought a new concept of isometric graft positioning, with transtibial femoral tunnel drilling.⁷ The arthroscopic isometric reconstruction became very popular in the last two decades of the 20th century, but often led to non-anatomic placement of femoral tunnels.⁸ The 21st century began with the introduction of the anatomical anterior cruciate reconstruction concept by Freddy Fu and coworkers.⁹ Since then, the pursuit of the ideal graft positioning has led to the so-called "anatomic" single-bundle reconstruction techniques, which can be accomplished by either by an anteromedial approach¹⁰ as well as an outside-in femoral drilling.¹¹

Today, there is still no consensus about the best ACL reconstruction technique. We present the current panorama of the anterior cruciate ligament reconstruction surgery in Brazil. We were also able to analyze the recent evolution of Brazil's knee surgeons preferences, since the present study includes data from the last 6 years.

MATERIALS AND METHODS

A survey was conducted at the last three editions of a national biannual knee surgery event that has the participation of most of the knee surgeons from all around the country. Local ethics committee waived the use of a consent term since there were no patients involved. Therefore, there was no consent form.

The survey was exactly the same in all three occasions and consisted of a 24-item questionnaire that was offered to all participants. (Appendix 1) It comprised questions about surgeon's demographics (gender, age, region of origin, year of graduation, titles and number of ACL surgeries per year), preferred technique, graft selection, graft positioning, femoral drilling technique, use of braces, drains, antibiotic prophylaxis and most common complications. The tunnel positioning was further analyzed by the use of figures. (Appendix 1) The questionnaires were filled independently by each surgeon, without any interference. No information was given and it should contain only the personal experience of each surgeon. The results were organized in an Excel (Microsoft Inc., California, USA) table. Data was presented in absolute frequency (n) and relative frequency (%). To analyze the frequencies and the association of categoric data it was used the Chi-square test or the Fisher's exact test when appropriate. Statistical analysis was conducted using the software PASW statistic 18.0 (SPSS Inc., Chicago, USA). Significance level (alpha) of 5% ($p < 0,05$) was adopted.

RESULTS

A total of 805 questionnaires were distributed in the three events, of which 608 were completed and returned (75% response). Surgeon's demographic are shown in Table 1. The vast majority of Brazilian knee surgeons that attended to the events were male (98,8%), with a mean age of 42 years old (26-68) and has specialist title and is affiliated to at least one orthopaedic society. Regarding the number of ACL procedures per year, 36% perform more than 50 reconstructions per year, 15% between 41 and 50 and 15% between 31 and 40 reconstructions. Of all surgeons, 97% perform arthroscopic surgery. The preferred graft is the hamstring tendons graft (64,4%). The patellar tendon is preferred by 10,4%, and 25,2% of the surgeons reported to use either hamstring or patellar tendon graft. The preferred femoral fixation device is interference screw followed by suspensory devices. Most of the surgeons use only interference screw for tibial fixation (79,3%). (Table 2) Forty six percent of the surgeons use antibiotic prophylaxis within the first 24 hours of the procedure, 26% only at anesthesia, 4,3% report antibiotic use within 48 hours, 19,8% use for more than 48 hours and 3,5 don't use antibiotic prophylaxis. The use of surgical drain fell from 40% to 25% from 2011 to 2015. ($p < 0.05$, Figure 1E)

Table 1. Demographics.

Characteristics	Values/ Occurrence	^a P-Value
Age [mean (range)] (anos)	42 (26-68)	-----
Gender [n (%)]		
Men	601 (98.8 %)	< 0.001
Women	7 (1.2 %)	
Member of at least 1 medical society [n (%)]		
Yes	581 (95.6 %)	< 0.001
No	27 (4.4 %)	
Number of ACL reconstructions per year [n (%)]		
01 to 10	52 (8.6 %)	< 0.001
11 to 20	84 (13.8 %)	
21 to 30	80 (13.2 %)	
31 to 40	68 (11.2 %)	
41 to 50	100 (16.4 %)	
> 50	224 (36.8 %)	

^ap-values for Chi-square tests. ACL: anterior cruciate ligament

Table 2 - Description of surgical preferences.

Characteristics	Values/Occurrence	^a P-Value
Surgical technique of preference [n (%)]		
Arthroscopic	590 (97.0 %)	< 0.001
Open	18 (3.0 %)	
Graft preference [n (%)]		
Hamstring tendons	391 (64.4 %)	< 0.001
Patellar tendon	63 (10.4 %)	
Either hamstring tendons or patellar tendon	153 (25.2 %)	
Femoral fixation device of preference [n (%)]		
Endobutton	139 (22.9 %)	-----
Ezloc	4 (0.7 %)	
Interference screw	244 (40.1 %)	
Interference screw and/or Endobutton	23 (3.8 %)	
Interference screw and or press-fit	2 (0.3 %)	
Transverse screw	147 (24.2 %)	
Transverse screw and or Endobutton	21 (3.5 %)	
Transverse and/or Interference screw and/or Endobutton	2 (0.3 %)	
Transverse and/or Interference screw	17 (2.8 %)	
Thight rope	1 (0.2 %)	
Transverse screw	5 (0.8 %)	
Other	2 (0.3 %)	
Tibial Fixation [n (%)]		
Agraaf	2 (0.3 %)	
Interference screw	482 (79.3 %)	
Interference screw and origin	2 (0.3 %)	
Interference screw and/or Agraaf	64 (10.5 %)	
Interference screw and/or AO cancellous screw	36 (5.9 %)	
Interference screw and/or Washerlock	11 (1.8 %)	
AO cancellous screw	3 (0.5 %)	
AO cancellous screw and/or Washerlock	4 (0.7 %)	
Thight rope	1 (0.2 %)	
Other	2 (0.3 %)	
Use of surgical drain [n (%)]		
Yes	237 (39.1 %)	< 0.001
No	369 (60.9 %)	
Use of Brace [n (%)]		
Yes	74 (12.2 %)	< 0.001
No	532 (87.8 %)	
Use of Antibiotics		
No	21 (3.5 %)	< 0.001
Yes at anesthetic induction	159 (26.2 %)	
Yes for 24 h	280 (46.2 %)	
Yes for 48 h	26 (4.3 %)	
Yes for more than 48 h	120 (19.8 %)	

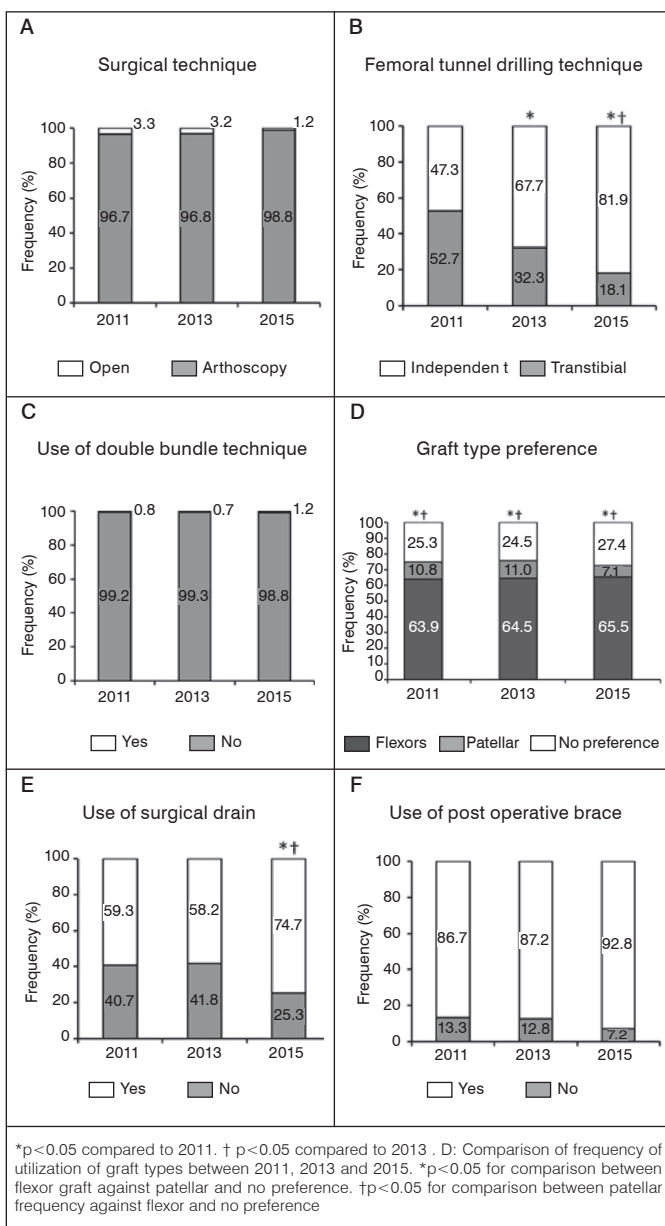
^ap-values for Chi-square tests.

In 2011, 2013 and 2015 there were a higher frequency of hamstring graft use compared to patellar tendon graft or use of either graft ($p < 0,05$), without a change over the years. (Figure 1D) The frequency of use of anatomical technique increased approximately 55% in the years 2011 and 2013, to 85.5% in 2015. ($P < 0.001$, Figure 2) After 2011 it was also observed progressive reduction from 56.8% to 18.1% by 2015 in the frequency of use of transtibial femoral tunnel drilling technique. ($P < 0.001$, Figure 1B)

No differences were observed between the frequency of use of open or arthroscopic technique, use of double-bundle technique, brace, and graft choice between 2011, 2013 and 2015. ($P > 0.05$, Figure 1A, Figure 1C, Figure 1D, Figure 1F)

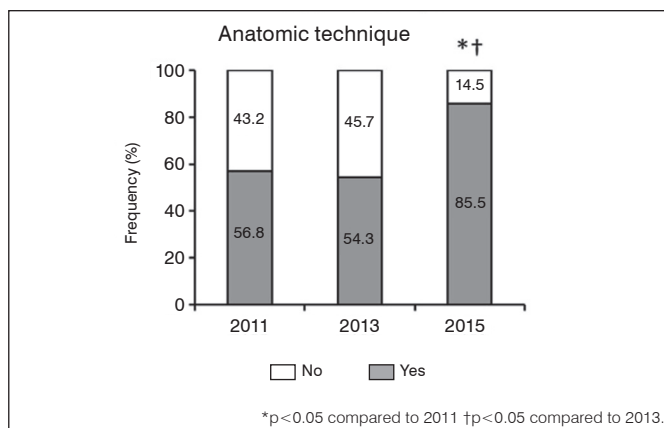
The preferred incision for harvesting hamstring tendons was the vertical longitudinal incision, followed by oblique and transverse incision. (Figure 3)

Association between ACL reconstruction frequency and other procedures with surgeon's age.



* $p < 0.05$ compared to 2011. † $p < 0.05$ compared to 2013. D: Comparison of frequency of utilization of graft types between 2011, 2013 and 2015. * $p < 0.05$ for comparison between flexor graft against patellar and no preference. † $p < 0.05$ for comparison between patellar frequency against flexor and no preference

Figure 1. Comparison of frequency of utilization of medical procedures between 2011, 2013 and 2015.



* $p < 0.05$ compared to 2011 † $p < 0.05$ compared to 2013.

Figure 2. Frequency of utilization of the anatomic technique in 2011, 2013 and 2015.

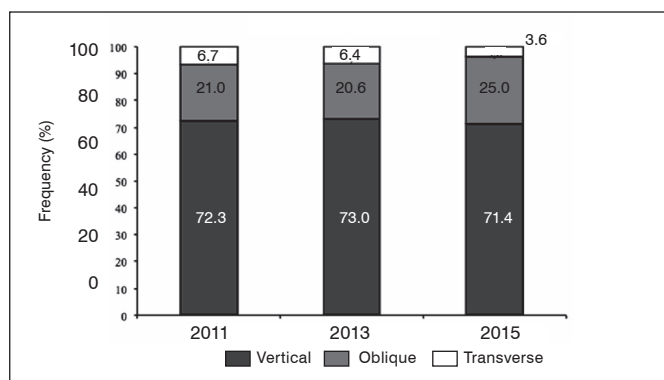


Figure 3. Type of hamstrings harvest incision.

A significant association between ACL reconstruction frequency per year and surgeon's age ($P < 0.001$) was identified. (Table 3) Professionals aged 35 to 60 had the highest number of ACL reconstructions/year, followed by professionals under the age of 35 years and above 60 years. Additionally, a significant correlation between the use of antibiotics ($P = 0.002$) was observed. (Table 3) The most common antibiotic prophylaxis regimen adopted was within 24 hours from anesthesia, followed by the use above 48h, between 24 and 48h and no antibiotic use. There was no significant association between the frequency of ACL reconstruction/year and the femoral tunnel drilling technique used ($P = 0.381$). (Table 3) Association Between the Report of using Anatomical Technique and Procedure Actually Used.

We compared the report of the use of anatomical technique and the tunnel positioning demonstrated in the questionnaires' figures. Only 84.5% of the professionals who reported use of anatomical technique demonstrated proper tunnel positioning technique. It was observed that 98.6% and 85% of all professionals demonstrated proper positioning of the tibial tunnel and femoral tunnel, respectively ($P < 0.001$). In addition, 24% of the surgeon's that are using the transtibial technique claim that they are using anatomical reconstruction technique, and 27.8% of them believe that they are achieving the anatomical femoral positioning. (Table 4)

Complications After ACL Reconstruction.

The most common reported complications after ACL reconstruction using the transtibial and anatomical techniques were anterior pain (34.8% and 32.4%, respectively), persistent muscle atrophy (28.8% and 40.5%, respectively) and difficulty in achieving full flexion

Table 3. Multiple association.

	Number of ACL reconstructions per year												P - Value
	1 a 10		11 a 20		21 a 30		31 a 40		41 a 50		> 50		
	n	%	n	%	n	%	n	%	n	%	n	%	
Femoral drilling technique													
Transtibial	26	50.0%	32	38.1%	31	39.2%	21	30.9%	41	41.4%	82	36.6%	P = 0.381
Anatomic	26	50.0%	52	61.9%	48	60.8%	47	69.1%	58	58.6%	142	63.4%	
Surgeon's age													
< 35 yo.	36	69.2%	35	41.7%	14	17.5%	30	44.1%	26	26.0%	37	16.5%	P < 0.001
35 > 60 yo.	15	28.8%	44	52.4%	65	81.3%	35	51.5%	64	64.0%	177	79.0%	
> 60 yo.	1	1.9%	5	6.0%	1	1.3%	3	4.4%	10	10.0%	10	4.5%	
Use of Antibiotics													
No	4	7.7%	0	0.0%	0	0.0%	1	1.5%	2	2.0%	14	6.3%	P = 0.002
Yes at induction	4	7.7%	23	27.4%	18	22.8%	25	36.8%	30	30.3%	59	26.3%	
Yes for 24 h	32	61.5%	40	47.6%	37	46.8%	36	52.9%	39	39.4%	96	42.9%	
Yes for 48 h	4	7.7%	2	2.4%	4	5.1%	2	2.9%	3	3.0%	11	4.9%	
Yes for more than 48 h	8	15.4%	19	22.6%	20	25.3%	4	5.9%	25	25.3%	44	19.6%	

Table 4. Association between the report and actual use of anatomic technique.

	"I use anatomic technique"				P - Value
	Yes		No		
	n	%	n	%	
Tibial tunnel positioning					
1 or 2 (anatomic position)	356	98.6%	168	68.6%	P < 0.001
3 (non-anatomic position)	5	1.4%	77	31.4%	
Femoral tunnel positioning					
2 ou 3(anatomic position)	307	85.0%	102	41.6%	P < 0.001
1,4 ou 5 (non-anatomic position)	54	15.0%	143	58.4%	
Femoral drilling technique					
Transtibial	56	15.5%	177	72.2%	P < 0.001
Anatomic	305	84.5%	68	27.8%	

Table 5. Complications.

Complications	Femoral Drilling Technique			
	Transtibial		Anatomic	
	n	%	n	%
Persistent muscle atrophy	67	28.8%	151	40.5%
Difficulty to achieve total extension	24	10.3%	28	7.5%
Difficulty to achieve total flexion	27	11.6%	15	4.0%
Anterior pain	81	34.8%	121	32.4%
Hemarthrosis	0	0.0%	8	2.1%
Persistent instability	10	4.3%	10	2.7%
Stiffness	2	0.9%	4	1.1%
Thromboembolism	0	0.0%	1	0.3%
None	17	7.3%	19	5.1%

(11.6% and 4.0% respectively) followed by difficulty in full extension, extension gain, flexion gain, hemarthrosis, stiffness and persistent instability, which alone did not exceed 10% of cases. (Table 5) Additionally, a single case (0.3%) of thromboembolism was reported after ACL reconstruction of anatomical access. Only 7.3% and 5.1% of professionals using the transtibial and anatomical approach, respectively, reported having not observed any complications after ACL reconstruction. (Table 5)

DISCUSSION

The present study defined the current panorama of the anterior cruciate ligament reconstruction surgery in Brazil. To the best of our knowledge, this is the first study that analyzed the evolution of the Brazilian knee surgeon's preferences.

Our results shows that most of Brazilian knee surgeons are performing an adequate number of ACL procedures each year, in accordance to the opinion that a surgeon should perform at least 30 procedures per year to be considered a "high volume" surgeon and ensure lesser complication incidence and better cost-effectiveness.^{12,13} A recent similar study from Croatia found that almost 75% of respondents performed four or less ACL reconstructions per month, meaning less than fifty ACL reconstructions per year.¹⁴ The preferred choice of graft (hamstring tendons) is in accordance to the graft's choice observed around the world.¹⁵ The semi-tendinosus tendon with or without the gracilis tendon, started to gain popularity in the 80's and has become the more commonly used graft for years now. Nevertheless, patellar tendon graft is still considered

the gold standard by several surgeons.¹⁶ Although the double bundle technique can't be considered a new approach to the ACL reconstruction, it's use among Brazilian surgeons was reflected to be predominantly nonexistent for all the time points. We believe that aspects such as technique learning curve and costs are the main reason why we see this scenario in Brazil. This finding was somewhat expected as the popularity of the double bundle technique has never been large among Brazilian surgeons.

The most important finding of the present study is the trend to the gradual abandonment of the isometric positioning technique that use transtibial approach for femoral drilling. We observed a progressive reduction in the frequency of use of transtibial femoral tunnel drilling technique and a higher frequency of the single-bundle anatomic technique with independent drilling, either through the anteromedial portal or outside-in technique, which also is in accordance to the world trend. Despite the fact that the discussion is far from over, there is a crescent number of studies showing that anatomic reconstruction could restore ACL function more closely to the native ligament, with better biomechanical and clinical results, specially regarding knee rotation.⁷ Another interesting finding was the misconception of the so-called "anatomic technique". Only 84.5% of the professionals who reported use of anatomical technique demonstrated proper tunnel positioning technique using the questionnaire's figures. Moreover, 24% of the surgeons reporting the use of transtibial femoral drilling technique also reported to be using anatomic reconstruction technique. It is known that transtibial femoral tunnel drilling results in non-anatomic placement of the femoral tunnels.^{8,17} Literature also shows a confusion

regarding the proper report of the chosen ACL reconstruction technique among articles. Van Eck et al., examined 74 studies that claimed to use "anatomic technique" for ACL reconstruction and found a gross under-reporting of specific operative technique data.¹⁸

When harvesting the hamstrings tendons we found a preference for longitudinal incision. It is known that iatrogenic injury to the infrapatellar branch of the saphenous nerve is a common complication during ACL reconstruction with hamstrings tendon.¹⁹ A recent systematic revision concluded that the available studies suggest less neurological damage if an oblique incision is used.²⁰ Our finding on the use of post-operative brace after ACL reconstruction suggest a low indication of brace which have diminished over time and had never been greater than 14% of all the respondents of our survey. Our results may be justified by evidence²¹ that suggest that the use of post-operative brace have poor effect on pain control during the post-operative phase. However, different surgeons indicate the use of brace for different reasons such as protection and range of motion control. Perhaps a more interesting question would be to those who indicate bracing, what are the main reasons for prescribing this intervention.

Our study has some limitations. First of all, it is based on a survey. The answers may not reflect the real practice of each surgeon. Secondly, we did not investigate results, rehabilitation protocols, return to sports criteria or some other information that could be interesting. Thirdly, the vast majority of responders were male, which do not reflect totally the gender distribution of knee surgeons through our country. Still, it is in fact a predominantly male speciality in Brazil. However, our strength rely on the high number of responders and specially on the fact that data from 3 different events were analyzed, which made possible to observe shifts in preference trends through the past 6 years.

CONCLUSION

The current panorama of the anterior cruciate ligament surgery in Brazil shows that Brazilian knee surgeons preferences are in accordance to the current world practice, with recent substitution of isometric graft positioning through transtibial femoral tunnel drilling technique for anatomic positioning through independent femoral tunnel drilling technique.

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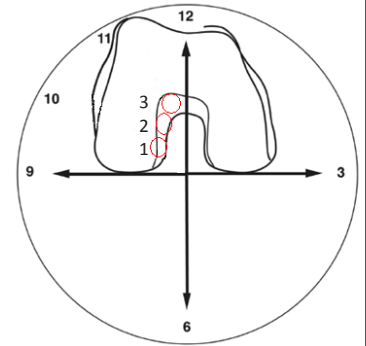
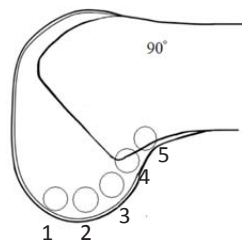
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Appendix 1. Questionnaire.

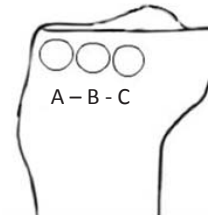
1. Gender
 Male
 Female
2. Age: _____
3. In which region of Brazil do you work?
 North
 Northeast
 Central West
 Southeast
 South
4. Do you have any title from Orthopedic Societies?
 Yes () No ()
5. Which one(s)? If necessary, you can choose more than one alternative.
 Brazilian Society of Orthopedics and Traumatology (SBOT)
 Brazilian Society of Knee Surgery (SBCJ)
 Brazilian Society of Sports Medicine (SBME)
 Others: Which one(s)?

6. Do you do ACL reconstruction surgery?
 Yes () No ()
7. How many ACL reconstructions do you do per year, approximately?
 1 to 10
 11 to 20
 21 to 30
 31 to 40
 41 to 50
 more than 50
8. Year of graduation: _____
9. Year of completion of residence: _____
10. Have you completed your knee residence?
 Yes () No ()
11. Year of completion of knee R4: _____
12. Which technique do you use for ACL reconstruction?
 Arthroscopy
 Open - Arthrotomy
13. What is your preferred graft for ACL reconstruction? If you wish, you can tick more than one option:
 Patellar
 Flexor
 Quadriceps
 Allograft
14. What is your femoral fixation of choice for the graft chosen above?
 Transverse pin
 Interference screw
 Endobutton plaque
 Ezloc
 Other: _____
15. What is your tibial fixation of choice for the graft chosen above?
 If you wish, you can tick more than one option.
 Interference screw
 Post (bolt + washer)
 Washerlock screw (lock washer)
 Agraf
 Other: _____
16. To remove the flexor tendons, which access route do you use?
 Longitudinal
 Cross-sectional
 Oblique
 Other: _____

17. What is your femoral tunnel making technique?
 Through the tibial tunnel (Transtibial)
 Through the accessory medial portal (Medial transportal)
 Guidewire "Outside-in"
 Other: _____
18. How do you do ACL reconstruction?
 Single band
 Double band
19. What is your preferred location for your femoral tunnel in the figures below? Tick one location. If you do double band, tick two locations:



20. What is your preferred location for your tibial tunnel in the figure below? Tick one location.



21. Do you use the anatomical ACL reconstruction technique?
 Yes () No ()
22. Do you use a suction drain in the postoperative period?
 Yes () No ()
23. Do you use postoperative bracing?
 Yes () No ()
24. Do you use any prophylactic antibiotic therapy?
 No
 Only in anesthesia induction
 For 48 h
 For more than 48 h
25. Which complications do you commonly observe in the follow-up of your patients after ACL reconstruction?
 Anterior pain
 Persistent muscular atrophy
 Infection
 Persistent instability
 Full extension gain difficulty
 Full flexion gain difficulty
 Thromboembolism
 Stiffness

PRIMARY LEIOMYOSARCOMA OF BONE: CLINICOPATHOLOGIC AND PROGNOSTIC FACTORS ANALYSIS IN A SINGLE INSTITUTION

LEIOMIOSSARCOMA PRIMÁRIO ÓSSEO: ANÁLISE CLINICOPATOLÓGICA E DOS FATORES DE PROGNÓSTICO EM UMA ÚNICA INSTITUIÇÃO

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ABSTRACT

Objective: Primary leiomyosarcoma of bone (PLB) is a rare type of malignant bone tumor considered as a variant of the spindle cell sarcomas (SCS). The objective of this study was to analyze the clinicopathologic and the prognostic factors of patients with PLB treated at a single institution. **Methods:** We retrospectively reviewed the records of 22 patients with pathologically confirmed PLB. The data collected were: age, sex, tumor size and location, grade and stage of the disease and histopathologic features. Mean age was 45.5 years (range, 17 to 73 y). Location was: upper limb (27.3%), lower limb (68.2%) and pelvis (4.5%). Patients had high grade in 90.9% of the reports. Margins were negative in 77.3% of the cases. Histological reports describe spindly sarcomatous cells arranged in fascicles with increased vascular formation without osteoid or chondroid matrix production. On immunohistochemistry, smooth muscle actin and desmin were positive in all cases. **Results:** Mean follow-up time was 73.5 months (range, 5.3 to 331.1 m). We found 22.7% of local recurrence (LR). Distant metastasis (DM) was reported in 9 (40.9%) patients. Lung metastasis was the only DM affected site. Overall survival (OS) rate in 5 years was 59.1%. Predictors of OS were LR and DM. **Conclusions:** PLB is an extremely rare malignant bone tumor that has a higher rate of DM and similar OS prognosis compared with other bone sarcomas. **Level of Evidence IV, Case Series.**

Keywords: Sarcoma. Leiomyosarcoma. Surgical margins. Recurrence. Neoplasm metastasis.

RESUMO

Objetivos: O leiomiossarcoma primário do osso (LPO) é um tumor ósseo maligno raro, considerado uma variante do sarcoma de células fusiformes (SCF). O objetivo deste estudo foi fazer uma análise clínico-patológica e dos fatores de prognóstico dos pacientes diagnosticados com LPO tratados em uma instituição única. **Métodos:** Foram analisados retrospectivamente os prontuários de 22 pacientes com diagnóstico confirmado de LPO. Os dados coletados foram: idade, sexo, tamanho e localização do tumor, grau histológico, estágio da doença e as características histopatológicas. A média de idade foi 45,5 anos (de 17 a 73 a). A localização foi: membro superior (27,3%), membro inferior (68,2%) e pelve (4,5%). Os pacientes apresentaram alto grau em 90,9% dos relatos. As margens foram livres em 77,3% dos casos. Os relatos histológicos descrevem células sarcomatosas finas e compridas, arranjadas em fascículos, com aumento da vascularização e sem produção de matriz osteoide ou condral. No estudo imuno-histoquímico, a actina do músculo liso e a desmina foram positivas em todos os casos. **Resultados:** O tempo médio de seguimento foi 73,5 meses (de 5,3 a 331,1 m). Dos pacientes, 22,7% apresentaram recorrência local (RL). Metástase à distância (MD) foi reportada em 9 (40,9%) pacientes. O único local de MD foi o pulmão. O tempo médio de sobrevida em 5 anos foi de 59,1%. Os fatores preditivos de sobrevida global foram: RL e MD. **Conclusão:** O LPO é um tumor ósseo maligno extremamente raro que tem uma taxa maior de MD, com uma sobrevida global similar aos outros sarcomas ósseos. **Nível de Evidência IV, Série de Casos.**

Descritores: Sarcoma. Leiomiossarcoma. Margens de Excisão. Recorrência. Metástase neoplásica.

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INTRODUCTION

Leiomyosarcoma (LMS) is a rare tumor that usually affects middle-age persons. Some authors have described cases of LMS in young adults and even in children. It has predilection

for female rather than male.¹ The World Health Organization (WHO) defines it as a malignant tumor with distinct features of smooth muscle cells.² The most common location of LMS is the retroperitoneum (including the pelvis). It is also predominant in

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some large blood vessels, specially the inferior vena cava and the pulmonary arteries. When the tumor is in the upper portion of the inferior vena cava, it obstructs the hepatic veins producing the Budd-Chiari syndrome. It is less common but it can also arise from subcutaneous, intramuscular and bone tissues.^{2,3} The last one is known as PLB and was first described by Evans and Sanerkin in 1965. The origin of LMS (all types) still remains unclear or partially unknown. Some authors believe that there is some kind of hormonal influence, based on the predilection of the tumor for female when compared with male.⁴ All LMSs usually presents the same initial clinical feature: a mass lesion that produces moderate pain. The other clinical symptoms depend on the location of the tumor rather than in the group.^{4,5} The classic histological pattern is: compactly cellular with fibrous and myxoid changes, observing marginal spindle cell groups with focal storiform, palisaded or haemangiopericytoma-like arrangement. Also, larger tumors present hypocellular zones with coagulative necroses.⁶ Differential diagnoses of PLB are made especially with Dermatofibrosarcoma, Fibrosarcoma of Bone and Myxofibrosarcoma.^{2,7} Surgery continues to be the gold standard treatment for PLB. Chemotherapy (CT) can be used, as adjuvant or neoadjuvant setting, but the definitive role is not totally defined. They can be also used as a palliative therapy for metastatic patients.⁶⁻⁸ Given the lack of randomized trials for the creation of treatment guidelines, the outcomes and prognostic factors for PLB, remain uncertain. They exhibit a relatively better OS rate than the other bone sarcomas, even though publications show that DM is higher.⁸ No large publications have yet totally investigated or defined PLB, then, in an effort to improve the understanding of the clinical outcomes and the prognosis, we conducted a retrospective study, evaluating a series of patients, with the purpose of understanding better this bone tumor.

MATERIALS AND METHODS

A retrospective study was performed after we obtained the approval from the ethical committee review board from our institute. We identify the clinical records from every patient diagnosed with PLB that underwent surgery, in the division of orthopedic oncology, in the last 10 years. A total of 22 patients with PLB were included in this study (Table 1). All the patients with incomplete data in the medical files and that didn't received surgery as treatment, were excluded from our investigation. Diagnoses were performed by the pathology division of our institute, based on the WHO classification of Soft Tissue Sarcomas (STS). Demographic data including: sex, age, tumor location, surgery and number of surgeries, surgical margins, histologic grade, adjuvant or neoadjuvant therapy, LR and time to develop LR, DM and time to develop DM, follow up and oncologic status were collected. Histologic grade was determined based on French Federation of Cancer Centers (FNCLCC). The decision on using CT for each patient was studied in multidisciplinary meetings. Of these patients, 10 (45.4%) were female and 12 (54.6%) were male, with a mean age of 45.5 (range, 17-73years). Most of the tumors, in 12 (54.6%) patients, appeared on the left side of the body. The distal femur was the most affected anatomical location with 7 (31.7%) cases, followed by the proximal femur with 6 (27.3%) cases, proximal humerus and distal ulna with 3 (13.7%) cases each, proximal tibia 2 (9.1%) cases and pelvis 1 (4.5%) case. The size of the tumor was divided in four groups in accordance with the American Joint Committee on Cancer (AJCC) staging system. Group II had 12 (54.6%) patients, group I and IV had 3 (13.7%) patients each and group III had 4 (18%) patients. Seventeen (77.2%) patients received tumor wide resection surgery, while 5 (22.8%) patients underwent limb amputation. Margins were

Table 1. List of patients included in the study.

Case	Diagnosis	Grade	Local	Follow-up*	Surgery
1	PLB	III	proximal tibia	42.1	resection
2	PLB	III	pelvis	62.5	resection
3	PLB	III	proximal tibia	48	resection
4	PLB	III	proximal femur	331.1	amputation
5	PLB	III	proximal femur	37.4	resection
6	PLB	III	distal femur	56.8	resection
7	PLB	III	distal femur	217.3	amputation
8	PLB	III	proximal femur	191.4	resection
9	PLB	III	proximal humerus	48.9	resection
10	PLB	III	distal femur	67.7	resection
11	PLB	III	distal femur	66.6	amputation
12	PLB	III	distal ulna	136.1	resection
13	PLB	III	proximal humerus	120.3	resection
14	PLB	I	proximal femur	24.7	resection
15	PLB	III	proximal humerus	28.8	resection
16	PLB	I	proximal femur	29.1	resection
17	PLB	III	distal ulna	31	amputation
18	PLB	III	distal ulna	30.6	resection
19	PLB	III	distal femur	16.9	amputation
20	PLB	III	proximal femur	18.1	resection
21	PLB	III	distal femur	6.4	resection
22	PLB	III	distal femur	5.3	resection

* follow-up time in months.

microscopically positive in 5 (22.8%) cases and negative in 17 (77.2%) cases. Most cases, 20 (90.9%), had grade 3 (FNCLCC) tumor report. LR was found in 5 (22.8%) cases, all of these patients underwent multiple surgical procedures (MSP). Also, we had 9 (40.9%) reports of DM, being the lungs the affected organ in every case. Fifteen (68.1%) patients received neoadjuvant CT. Mean follow up in this study was 73.5 months (range, 5.3 to 331.1 m). The OS rate in 5 years was 59.1%. All the demographic data is summarized in Table 2. Pathology reports of surgical margins, LR and OS were considered the principal objectives of this study. Time for LR, single or multiple, was calculated from the first surgical procedure. OS was estimated using the Kaplan-Meier method. The relation between single surgical procedure (SSP), LR, DM and oncologic status were investigated using the log-rank test for categorical variables. Differences of the $p < 0.05$ were considered statistically significant. Also, we calculated the OS, time to LR and disease free overall survival (DFOS) using Kaplan-Meier functions and log-rank tests to compare the outcomes of the qualitative variables. The influence of age on the outcomes of the patients was tested using the Cox bivariate regression. The not adjusted HR with their respective confidence interval of 95%, were calculated using the Cox bivariate regression. All the variables, that in the bivariate tests presented significant level of 0.10 ($p < 0.1$) with the use of multiple Cox regression, were tested in multiple models. The selected variables that when together presented significant level of 5% in the final model, were tested in multiple models also. For all the statistical analyses, we used the IBM-SPSS software for Windows version 20.0. For tables and charts, we used the Microsoft Excel 2008 version software. All the tests were realized with a significant level of 5%.

Table 2. Patient demographics and clinical characteristics.

Variable	Description (n=22)
Age	
mean	45.5(range 17-73years)
Sex	
female	10(45.4%)
male	12(54.6%)
Follow up (months)	
mean	68.4 (range 5.3-331.1 months)
Grade, n (%)	
I	2(9.1%)
II	0 (00%)
III	20(90.9%)
Local, n(%)	
distal femur	7 (31.7%)
proximal femur	6 (27.3%)
proximal humerus	3 (13.7%)
distal ulna	3 (13.7%)
proximal tibia	2 (9.1%)
pelvis	1 (4.5%)
Size, n(%)	
< 5cm	3(13.7%)
5cm to 9.99cm	12(54.6%)
10cm to 14.99cm	4(18%)
>15cm	3(13.7%)
Side, n(%)	
right	10(45.4%)
left	12(54.6%)
Surgery, n(%)	
resection	17(77.2%)
amputation	5(22.8%)
Margins, n(%)	
negative	17(77.2%)
positive	5 (22.8%)
Adjuvance, n(%)	
yes	15(68.1%)
no	7(31.9%)
Local Recurrence, n(%)	
yes	5(22.8%)
no	17(77.2%)
Multiple Surgeries, n(%)	
yes	6(27.3%)
no	16(72.7%)
Distant Metastasis, n(%)	
yes	9 (40.9%)
no	13 (59.1%)
Local for Distant Metastasis, n(%)*	
lung	9 (100%)
Overall Survival, n(%)**	
mean	59.1% in 5 years

*For the 9 patients with distant metastasis.

RESULTS

LR was statistically influenced by tumor margins, MSP and DM ($p < 0.001$). DFOS was statistically influenced by tumor grade (FNCLCC), tumor margins, MSP and DM ($p < 0.05$). LR suffered statistical influence by MSP alone or by tumor margins and DM together. Patients with MSP had 21.06 times a higher risk of LR than patients that had a single procedure. Positive microscopically margins with DM had 3.73 times a higher risk of LR than negative microscopically margins. Patients with DM had 8.34 times a higher risk of LR than patients without metastasis. DFOS was statistically influenced by MSP and DM. Patients with MSP had 2.64 times a higher risk of diminished DFOS, and patients with reports of DM had 7.93 times a higher risk of diminished DFOS. OS was statistically influenced by tumor grade (FNCLCC), LR, MSP and DM ($p < 0.05$). DM is probably the most important prognostic factor to explain OS in patients with PLB, but we were not able to use this variable since none of the patients without metastasis died. Histological reports describe spindly sarcomatous cells arranged in fascicles with increased vascular formation without osteoid or chondroid matrix production in every case. On immunohistochemistry, smooth muscle actin and desmin were positive in all the reports.

DISCUSSION

PLB is a rare malignant bone tumor, considered most frequent in middle age patients. It is usually reported as a high-grade tumor, with an important potential of DM.⁹ The reasons of the high rates of DM are not completely understood. Some authors believe that PLB cause an extensive invasion on the neighbor tissues, fact that is not visible during surgery.⁴⁻¹⁰ Some facts, described in few studies, can be considered to be important for the prognosis of PLB: tumor grade, surgical inadequate or positive margins, LR and DM.^{7-11,12} To our knowledge, this is the first study that describes PLB as a unique entity, in a Latin American hospital, and the casuistry in this case series, is among the largest found in the investigated literature. In our study, 22 patients with pathologically confirmed diagnosis of PLB, and a mean follow up of 73.5 months presented: 28.8% had positive surgical margins, 90.9 % had high grade tumors, 28.8 % had reports of LR and 40.9% presented DM. This study had a number of limitations. First, the lack of studies describing the disease as a unique entity and the publications focused on specific subjects instead of describing general information were a major difficulty on the research for information on PLB. Second, there are limitations for the applicability of this retrospective study. The information represents those of a single institution, and although it's the only documented paper of PLB in Latin America, we found a limited capacity of describing prognostic factor with narrow confidence intervals. And third, the information on the medical files is not always complete or understandable, which makes the number of cases included less representative. Clinically, PLB tend to have higher rates of DM when compared with other bone sarcomas.¹³ The present study reports a DM rate of 40.9%, corresponding to the reports of other papers. It seems that DM has a direct relation with tumor grade, surgical margins and LR.^{6,14} Most of the pathological reports for PLB are high grade tumors (FNCLCC).^{2,8,15} In a series of three different studies, we found that high grade PLB was predominant.^{7,12,14} In our study, high grade tumors were also predominant, but with 90.9%, which is a much higher percentage when compared to the reported in other studies. As for DM, most of the studies report high rates with a range varying from 20% to 25%. The most common affected organ is the lung.^{2,15} Not in accordance to the findings in literature, our rate of DM was 40.9%, again, a considerable

higher percentage. Nevertheless, and in accordance with the publications, we also have the lung as the predominant affected organ for DM. Although, the prognostic factors for PLB haven't been totally defined, there are some facts about the disease that have a direct connection with OS.^{3-5,16} Authors agree that tumor grade and surgical margins have a close relation with LR, being grade III tumors and reports of positive or not adequate margins, important factors for increasing the rates of LR.^{9,14} Another important fact is that the LR also increases the potential for DM, which has a direct effect on follow up time and consequently OS.^{16,17} In our study, we identified that high grade tumors and

positive margins, alone or together, directly increase the rates of LR. Also, we observed that LR has a principal role on the DM appearance. Interestingly, these facts separately don't seem to affect directly the OS of the patient with PLB. Anyhow, future studies are needed, to see whether these results are similar or not to the new information obtained.

CONCLUSION

In this institutional series we conclude that PLB is an extremely rare malignant bone tumor that has a higher rate of DM and a similar OS prognosis when compared with other bone sarcomas.

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ARTHROSCOPIC TREATMENT FOR LATERAL EPICONDYLITIS: OUTCOMES IN 104 CASES OF A SINGLE INSTITUTION

TRATAMENTO ARTROSCÓPICO PARA EPICONDILITE LATERAL: RESULTADOS EM 104 CASOS DE UMA ÚNICA INSTITUIÇÃO

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ABSTRACT

Objective: To evaluate the outcomes of patients that underwent arthroscopic surgery for lateral epicondylitis (LE), after failed conservative treatment. **Methods:** One hundred four patients with LE treated with arthroscopic debridement of the extensor carpi radialis brevis (ECRB) tendon were enrolled in this retrospective study. They were evaluated using Disabilities of the Arm, Shoulder and Hand (DASH) score, Visual Analogue Scale (VAS) and Short Form Health Survey (SF-36) scale. Mean age at surgery was 46.9 years. Duration of symptoms was 2.1 years (range: 6 m to 10 yrs.). Mean follow-up was 34.4 months (range: 6 to 68 m). **Results:** Mean postoperative scores were: 20.67 points on the DASH; 1.8 points on the VAS at rest, with 48 cases (46%) without pain, 40 (38%) with mild pain, 13 (13%) with moderate pain and 4 (4%) with severe pain; 4.7 points on the VAS in activity, with 21 (20%) without pain, 21 (20%) with mild pain, 35 (34%) with moderate pain and 27 (26%) with severe pain; and SF-36 was 66.8 points. Of the 23 patients who practiced sports regularly or with higher physical demand from the upper limbs, 17 (74%) were able to return to the same activity at the same level. No significant complications were observed postoperatively, except for 3 (2.8%) cases of postoperative superficial infection. **Conclusion:** Surgical treatment with arthroscopy for recalcitrant LE is effective and safe, presenting positive outcomes in the studied patients. **Level of evidence IV, Case Series.**

Keywords: Lateral Epicondylitis. Tennis Elbow. Elbow Joint. Arthroscopic Surgery. Tendon Injuries. Rehabilitation.

RESUMO

Objetivo: Avaliar os resultados dos pacientes submetidos a tratamento cirúrgico artroscópico da epicondilite lateral (EL) refratária depois da falha no tratamento conservador. **Métodos:** Estudo retrospectivo que incluiu 104 pacientes submetidos a desbridamento artroscópico do tendão extensor radial curto do carpo (ERCC) para tratamento de EL. Os pacientes foram avaliados pelo escore de DASH, pela classificação visual analógica de dor (EVA) e pelo Short-Form 36 (SF36). A média da idade foi de 46,9 anos (variação de 30 a 69 anos). O tempo de sintomas foi de 2,1 anos (variação de 6 meses a 10 anos). O seguimento médio foi de 34,4 meses (variação de 6 – 68 meses). **Resultados:** A média dos escores pós-operatórios foi de: 20,67 pontos no DASH; 1,8 pontos no EVA de repouso, sendo 48 (46%) sem dor, 40 (38%) com dor leve, 13 casos (13%) com dor moderada e 4 (4%) com dor intensa; 4,7 pontos no EVA em atividade, sendo 21 (20%) sem dor, 21 (20%) com dores leves, 35 (34%) com dores moderadas e 27 (26%) com dores intensas; e SF-36 de 66,8. Dos 23 pacientes em prática constante de esporte ou com maior demanda física nos membros superiores, 17 (74%) conseguiram retornar ao mesmo nível. Não observamos complicações significativas exceto por 3 (2,8%) casos de infecção pós-operatória superficial. **Conclusão:** O tratamento artroscópico para EL recalcitrante do cotovelo é eficaz e seguro, apresentando resultados positivos. **Nível de Evidência IV, Série de Casos.**

Descritores: Epicondilite Lateral. Cotovelo de Tenista. Articulação do Cotovelo. Artroscopia. Traumatismos dos Tendões. Reabilitação.

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Study conducted at Hospital Orthoservice, São José dos Campos, SP, Brazil and at the Orthopedics and Traumatology Institute, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.

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INTRODUCTION

Lateral epicondylitis (LE) is the most common elbow-related pain complaint, affecting up to 3% of the adult population annually.¹ Despite the classical description of tennis elbow, only 10% of the patients that present LE are tennis players, being the majority of the cases related to occupational activities.² Tendons are relatively hypovascular in the area close to the insertion. This hypovascularity predispose the tendons to hypoxic degeneration and has been implicated as a possible cause of LE. The most common primary pathology is tendinosis of the ECRB, 1-2 centimeters (cm) from its fixation on the lateral epicondyle, with the development of the characteristic angiofibroblastic invasion.³ It is a self-limited pathology, with the majority of the patients improving with conservative treatment. However, some factors such as duration of the symptoms, prior infiltration, prior orthopedic surgery, and workers' compensation, are known factors of poor prognosis, increasing the probability of surgical intervention as treatment.⁴ Recurrence of LE has been described in 8.5% of the cases. Patients with over six months of pain, approximately 6% of all the cases⁵, have a greater chance of being symptomatic for longer periods, commonly requiring surgery as the definitive treatment. Surgical intervention can be very effective for recalcitrant cases of LE, with a large percentage of individuals reporting improvement.⁶ Several surgical procedures have been described for this condition.⁷⁻⁹ The majority of the techniques releases or debrides the ECRB tendon. Some factors, especially female patients and a common extensor tendon injury bigger than 6 millimeters (mm), diagnosed by magnetic resonance, have been associated with poor prognosis after surgical intervention.¹⁰ Arthroscopic surgical treatment of lateral epicondylitis has advantages when compared with open surgery. The most important are: the ease for debriding the lower surface of the tendon without invading the common extensor aponeurosis (Figure 1), complete access to assess any intra-articular pathology and shorter rehabilitation time.¹¹

MATERIALS AND METHODS

This is a retrospective study of 104 patients that underwent arthroscopic debridement of the ECRB to treat LE. Included patients had unsatisfactory or no improvement at all with the conservative treatment. Conservative treatment consisted of six months of physical therapy with the proper orthosis, two intramuscular infiltrations with corticosteroids and pain medications. Patients with chondral lesions, signs of arthrosis and previous elbow surgery were excluded from the study. The function of all the patients was evaluated using DASH, VAS and SF-36 scales in the pre-operative period and in the post-operative follow-up.

Operative technique

The operative technique used was based on published descriptions^{1,7} with certain adaptations. The patient was positioned in

the opposite lateral decubitus of the injured elbow, under general anesthesia. A brachial plexus block was also performed. An elbow support was also used, to allowed a 90° flexion and full extension of the elbow during the procedure. Also, a pneumatic tourniquet placed at the proximal region of the arm was used. Surgical landmarks of the olecranon, the epicondyles, the head of radius, and the ulnar nerve were drawn. The elbow articulation was inflated with 40 milliliters (ml) of saline solution, through a puncture in the middle of the imaginary triangle formed by the lateral epicondyle, the head of radius, and the olecranon, to facilitate the entry of the arthroscope in the intra-articular space. We preferentially used the anterior superomedial and anterior superolateral portals, beginning with the former, through which the trocar and scope is placed. The second portal was made using a needle under intra-articular visualization to optimize its positioning. A complete analysis of the anterior compartment of the elbow joint was performed, including the articular and capsule surfaces. Then, a partial capsulotomy of the lateral region was performed to allow the visualization of the origin of ECRB tendon, which is extra-articular. With a radio frequency device, the ECRB tendon was removed from the humerus. Thereafter, the tendon was debrided with an arthroscopic shaver and the lateral region of the humerus with a bone shaver, with the intention to cause bleeding and cellular migration to the region. The ECRB was not reinserted. The collateral ligament can be damaged if the resection of the ECRB is performed without direct visualization, because of the collapse of the anterior soft tissues; therefore, we used an infusion pump to keep the joint inflated.

Post-operative

During the first five post-operative days, the patients used an arm sling for comfort and pain control. Movements were allowed depending on pain. No extraordinary efforts with the operated limb were allowed during this period. Frequently, the normal range of motion of the elbow was achieved after two weeks of physiotherapy. After achieving the normal range of motion, muscular isometric strengthening exercises for approximately four weeks were prescribed. Exercises with resistance were initiated six weeks after surgery and were indicated for six weeks. Unrestricted movements of the limb were allowed after this 12 weeks of therapy.

RESULTS

Of the 104 patients, 71 (69%) were male and 33 (31%) female. The mean age at surgery was 46.9 years (range from 30 to 69 yrs). The duration of the symptoms prior to surgery was approximately 2.1 years (range from 6 m to 10 yrs). The mean follow-up time was 34.4 months (range from 6 to 68 m). A total of 72 right and 32 left elbows were operated. The dominant arm was affected in 67% of the cases. The mean postoperative scores were: 20.67 points on DASH; 1.8 points on the VAS at rest, 48 (46%) without pain, 40 (38%) with mild pain, 13 (13%) with moderate pain, and 4 (4%) with severe pain; and 4.7 points on the VAS in activity, 21 (20%) without pain, 21

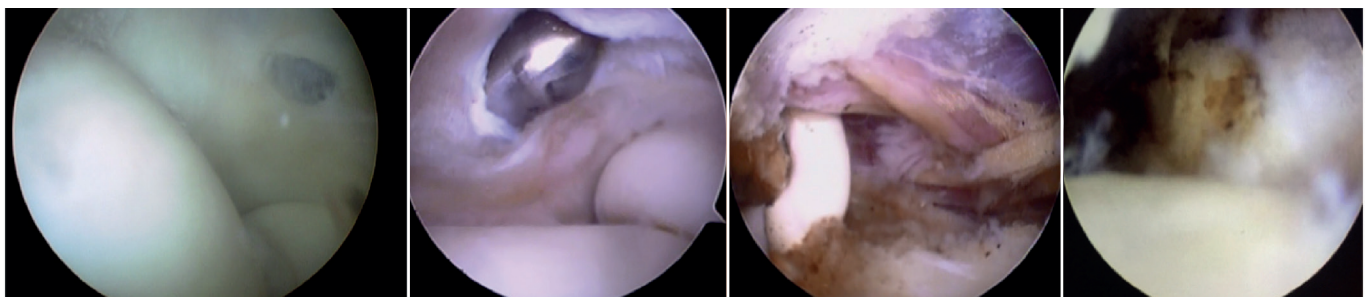


Figure 1. Results of DASH and VAS scores.

(20%) with mild pain, 35 (34%) moderate pain, and 27 (26%) with intense pain (Table 1). The mean SF-36 score was 66.8 (Table 2). Of the 23 patients with demanding physical activities including sports, 17 (74%) were able to return to the same activity at the same level. Sixteen patients were receiving welfare benefits and when we analyzed their results using VAS score, we noticed that this tend to worsen their results when compared to patients without benefits, but this difference was not statistically significant (Table 3). Five patients did not present any improvement in the scores evaluated. We did not observe any significant complications with the arthroscopic procedure, except for 3 (2.8%) cases of superficial postoperative infection. The results of the SF-36 are subdivided and detailed in Table 2. The statistical analysis was performed by comparing the pre and post-operative measures with the Student *t*-test. Two-tailed and paired tests were used in all cases, and those having *p* values <0.01 were considered statistically significant. The statistical program SPSS was used in the analysis.

DISCUSSION

LE is the most common elbow-related pain complaint in adults. Also, it frequently responds well to conservative treatment. Surgical intervention is required, eventually, when symptoms are unsatisfactory or do not improve at all, after at least six months of physiotherapy; this occurs in approximately 16% of the cases.⁵ A similar rate was observed in our study. We evaluated the functional response and pain in this group of patients with refractory conservative treated epicondylitis, who submitted to arthroscopic debridement of the ECRB tendon. A significant improvement was observed in almost all the evaluated scores. The results obtained with VAS scores are in agreement with the literature, with a slight improvement when measured in the patients at rest.¹² In a publication that compares arthroscopic versus percutaneous techniques for the treatment of LE, DASH score was assessed preoperatively and postoperatively, showing significant improvement in the results (*p* < 0.05). It went from 72 to 48 points in the arthroscopic cases and from 70 to 50 points in the percutaneous cases.¹³ Patients in this study, had a

Table 1. Results of DASH and VAS scores.

	DASH	VAS
Pre-operative	48.9 ± 21 (3.33-90)*	7.6 ± 1.9 (1-10)*
Post-operative at rest	21.24 ± 20.6 (0-63.3)*	1.8 ± 2.2 (0-3)*
Postoperative in activity	---	4.8 ± 3.3 (0-10)*
<i>p</i> value	<0.001	<0.001

*Mean and the standard deviation, with the range between parentheses.

Table 2. Comparative pre and postoperative results of the SF-36.

	Functional capacity	Limitation by physical aspects	Pain	Overall health status	Vitality	Social aspects	Limitations by emotional aspects	Mental health
Pre-op	63.7 ± 25.1 (15-100)*	20.1 ± 33.8 (0-100)*	32.9 ± 17.1 (0-80)*	62 ± 19.6 (10-100)*	65 ± 26.2 (1-100)*	69.4 ± 24.6 (0-100)*	32.9 ± 43.6 (0-100)*	70 ± 21.7 (8-100)*
Post-op	76.4 ± 21.5 (5-100)*	48.1 ± 48 (0-100)*	61.1 ± 25.8 (0-100)*	57.7 ± 14.5 (5-85)*	82.3 ± 17.1 (40-100)*	64.3 ± 14.6 (37.5-100)*	62.8 ± 47 (0-100)*	83 ± 14.5 (48-100)*
<i>p</i> value	<0.01	<0.01	<0.01	0.25	<0.01	0.18	<0.01	<0.01

*Mean and the standard deviation, with the range between parentheses.

Table 3. Results of the VAS comparing patients with and without welfare aid.

	Pain at rest	Pain in activity
Patients without welfare benefits	1.5 + 2.7 (0-8)*	4.3 + 3.4 (0-10)*
Patients with welfare benefits	2.7 + 2.8 (0-8)*	5.7 + 2.9 (2-9)*
<i>p</i> value	0.17	0.22

* Mean and standard deviation values, with the range between parentheses.

DASH mean score of 21.2 points, showing a better outcome when compared with literature. Nonetheless, our preoperative DASH mean score was also better if compared with other publications. Emphasis has been placed on the psychological aspects that are associated with patients who develop recalcitrant LE.¹⁴ Although we did not measure these aspects directly through specific questionnaires, we noticed by the SF-36 analysis, that there was a statistically significant improvement in these parameters, which mean that even psychological factors can be improved after appropriate treatments. Some studies suggest that, regardless of the technique, the results of surgery for LE are not uniform. Verhaar et al.¹⁵ reported a 66% rate of satisfaction at 1 year follow-up, with 30% of the patients returning to their daily activities. In our study, 46% of the patients remained without pain after 1 year follow-up, but only 20% returned to their activities. An advantage of the arthroscopic treatment for LE is the possibility of early rehabilitation. Owens et al.⁹ reported 16 patients who improved after arthroscopic release, with a mean return to work with no restrictions of six days after surgery. In our study, despite immediate movement after the procedure, patients only returned to their normal activities after 12 weeks of the surgery. Baker et al.¹⁶ published the results of a long-term cohort study, reporting that patients who were well after 2 years follow-up, maintained their level of function, without worsening of pain. Despite the good results demonstrated in publications, we must note that approximately 26% of the patients who practiced sports, with emphasis in the upper limbs, were not able to return to the level at which they were practicing. In some cases the result was a change of the sport practiced. Also, 5% of the patients in our study didn't achieve any improvement with the surgical treatment. We also observed, as other publications,¹⁷ that patients who have welfare benefits tend to worsen their outcomes. Nevertheless, we believe that there is benefit with the surgical treatment in patients with chronic symptoms, although studies show similar results between surgical approach and placebo.¹⁸

CONCLUSION

Surgical treatment through arthroscopy for recalcitrant LE is effective and safe, presenting positive outcomes in the studied patients.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. ATN (0000-0003-3044-959X)*, GKC (0000-0002-9830-754X)*, PBR (0000-0001-5089-1022)*, JPZ (0000-0001-5941-7714)*, OPC (0000-0002-1128-7292)*, were the main contributors in writing this work. ATN participated in: research, design, writing and data collection; GKC participated in: concept, research, writing and data collection; PBR participated in: concept, research, writing and data collection; JPZ participated in: writing, concept, design, and analysis; OPC participated in: concept, writing and analysis. *ORCID (Open Researcher and Contributor ID).

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EVALUATION OF SURGICAL TREATMENT OF ROTATOR CUFF ANTEROSUPERIOR TEARS ARTHROSCOPICALLY

AVALIAÇÃO DO TRATAMENTO CIRÚRGICO DAS LESÕES ANTEROSSUPERIORES DO MANGUITO ROTADOR POR VIA ARTROSCÓPICA

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ABSTRACT

Objective: To evaluate the functional result of arthroscopic treatment in anterosuperior rotator cuff tears. **Methods:** Fifty-six patients submitted to arthroscopic repair of anterosuperior rotator cuff tears were evaluated. The follow-up time was five year and five months. All the tears were diagnosed by detailed physical and imaging examination. Statistical analysis was used to compare the preoperative and postoperative results of range of motion and the UCLA score, with Wilcoxon signed-rank test, 5% significance level ($p \leq 0.05$), the relationship between the subscapularis tear and postoperative results using the Mann-Whitney test, and between the pain length and the UCLA scale using Spearman's correlation. **Results:** A statistically significant improvement ($p < 0.001$) was found, comparing the range of motion and the UCLA preoperatively and postoperatively. 39% of the cases were classified as excellent, 33.9% as good, 23.7% as regular and 3.4% as bad results. A statistically significant relationship was found between the subscapularis tear type and the functional state, the pain length and the postoperative UCLA scale. Five complications, four reruptures and one adhesive capsulitis were found. **Conclusions:** The arthroscopic treatment for anterosuperior tears presented satisfactory results, with 8.5% of complications. **Level of Evidence IV, Case series.**

Keywords: Rotator cuff. Retrospective studies. Shoulder.

RESUMO

Objetivo: Avaliar o resultado funcional do tratamento artroscópico das lesões anterossuperiores do manguito rotado. **Métodos:** Avaliação de 59 pacientes com lesão anterossuperior submetidos a tratamento cirúrgico. O tempo de seguimento foi de 5,5 anos. As lesões foram diagnosticadas por exame físico e de imagem. A análise estatística comparou os resultados pré e pós-operatórios de amplitude de movimento e da escala da UCLA, com teste de pontos sinalizados de Wilcoxon, nível de significância de 5% ($p \leq 0,05$), a relação entre a lesão do subescapular e o pós-operatório pela aplicação do teste de Mann-Whitney, e entre o tempo de dor e a escala da UCLA pela correlação de Spearman. **Resultados:** Houve melhora estatisticamente significativa ($p < 0,001$) comparando-se a amplitude de movimento e a escala da UCLA nos períodos pré e pós-operatórios. 39% dos casos foram classificados como excelentes resultados, 33,9% bons, 23,7% regulares e 3,4% ruins. Houve relação estatisticamente significativa entre o tipo de lesão do subescapular e o resultado funcional, entre o tempo de dor e a escala da UCLA pós-operatória. Registramos cinco complicações, quatro re-rupturas e uma capsulite adesiva. **Conclusão:** O tratamento artroscópico das lesões anterossuperiores apresentou resultados satisfatórios, com 8,5% de complicações. **Nível de Evidência IV, Série de Casos.**

Descritores: Manguito rotador. Estudos retrospectivos. Ombro.

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INTRODUCTION

Associated subscapular and supraspinal tendon tears are less frequent than other types of rotator cuff tears, such as posterior superior tears and isolated supraspinal tendon tears. Anterior superior tears usually have a worse prognosis than the above mentioned tears. Therefore, their treatment is a challenge for shoulder and elbow surgeries, and there is little national literature on this subject.¹

With the advent of arthroscopy, partial subscapular tears are diagnosed with more precision than previously.² Also, through arthroscopy, some tears that would require extensive surgical exposure can now be repaired by minimally invasive procedures.³ The objective of this study was to evaluate the clinical and functional outcome of arthroscopy of anterior superior rotator cuff tears.

All authors declare no potential conflict of interest related to this article.

This study was conducted at two institutions: FMABC and Hospital Ipiranga, São Paulo, SP, Brazil.

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MATERIAL AND METHODS

From August 2002 to February 2008, 1,056 shoulder arthroscopies were performed to repair rotator cuff tears, of which 59 (5.6%) were performed to repair anterior superior tears. Thirty-nine patients were females and 20 were males aged 39 to 76 (mean of 57 years). The right side was the affected side in 45 patients (76.27%) and the left side was the affected side in 14 patients (23.73%). The dominant side was affected in 47 patients (79.66%) and the non-dominant side was affected in 12 patients (20.34%). The mean time of preoperative pain was 36 months (2 to 180 months).

The tears were diagnosed through physical examination, radiography and magnetic resonance imaging (MRI). (Figure 1) The study was authorized by the Ethics Committee on Research of Faculdade de Medicina do ABC under number 357/2009. All patients in the study signed an informed consent form.

In the preoperative period, the patients were evaluated for range of motion — elevation, lateral rotation to the side of the body, using a goniometer and medial rotation based on the vertebral level. They were also evaluated by the Functional Scale of the University of California, Los Angeles (UCLA). Besides, the tests of Neer, Hawkins, Yokum, Jobe, lift-off, abdominal grip, Cancela and Patte, Speed, O'Brien and Yergason were performed.

The surgeries were performed in the beach chair position, with arthroscopic repair of the tears with metal or bioabsorbable anchors. Mean postoperative follow-up time was 18.88 months (12 to 57 months). In the latter evaluation, the patients were examined by evaluators who were unaware of their pre and intraoperative data. Statistical analysis was performed by comparing the pre and postoperative results of elevation, medial rotation, lateral rotation and the UCLA scale score using the Wilcoxon signed-rank test, with a significance level of 5% ($p < 0.05$). The Mann-Whitney test was used to evaluate the relationship between the type of subscapular tear and its association with the postoperative functional result by the UCLA scale. The Spearman rank correlation coefficient was used to study the relationship between time of preoperative pain and postoperative functional result by the UCLA scale.

RESULTS

Pre-operative evaluation

With regard to range of motion, the elevation ranged from 85° to 160° (mean of 135°). Medial rotation ranged from T5 to gluteus (mean at L1). Lateral rotation ranged from 10° to 80° (mean of 46°). The UCLA functional scale score ranged from 8 to 25 points (mean of 18.2 points).

In 50% of the cases, physical examination was not able to confirm subscapularis tear and 70% of the patients presented pain or positive maneuvers for biceps tear.

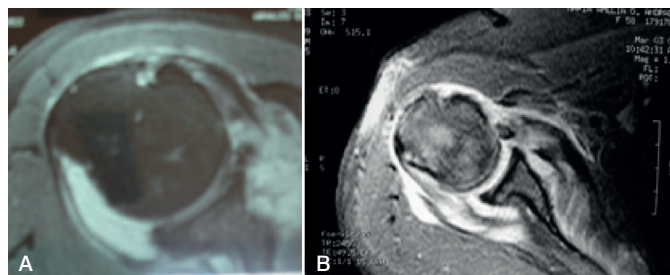


Figure 1. A and B. Magnetic resonance imaging of the shoulder (axial section) showing, in both cases, subscapular tear and dislocation of the long head of biceps

Intraoperative evaluation

The number of anchors to repair the tears ranged from one to five, and in 15 cases, tendon-to-tendon stitches were required. (Figures 2-A and 2-B). The following were performed: 40 tenotomies and six biceps tenodeses (Figures 3-A and 3-B). Of the patients presenting acromion-clavicular pain, all were submitted to the mini-Munford procedure. Of the 59 cases, 44 had partial subscapular tendon tears and 15 had total subscapular tendon tears.

Pre-operative evaluation

As for the range of motion, the mean final elevation was 158° (100° to 180°). In the final medial rotation, the patients were able to reach mean T10, minimum gluteal region and maximum T5. The mean final lateral rotation was 58° (0° to 90°).

Regarding elevation, there was a mean improvement of 23° ($p < 0.001$). As for medial rotation, a mean gain of three vertebral levels was found ($p < 0.001$). In lateral rotation, there was a mean improvement of 12° ($p < 0.001$). (Table 1)

The mean UCLA functional scale score in the postoperative period was 30.71 points (minimum 17 and maximum 35). Therefore, a mean increase of 12.52 points was found ($p < 0.001$). (Table 1) Twenty-three

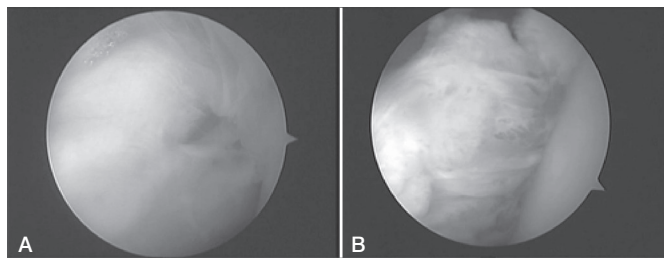


Figure 2. A) Subscapular tendon tear. B) Repair.

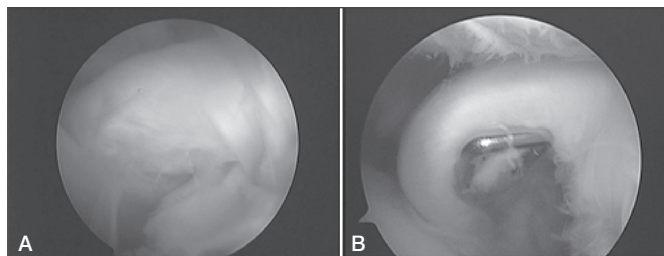


Figure 3. A) Long head of biceps tear and B) tenotomy.

Table 1. Wilcoxon signed-rank test results.

Pair of variables	N	Mean	Standard deviation	Minimum	Maximum	Significance (p)
Pre-operative evaluation	59	135	23.46	80	160	<0.001
Post-operative evaluation	59	158	13.43	100	180	
Pre-operative external rotation	59	46	14.37	10	80	<0.001
Post-operative external rotation	59	58	14.57	0	90	
Pre-operative internal rotation	59	5.73	3.81	0	13	<0.001
Post-operative internal rotation	59	8.44	3.97	0	13	
Pre-operative UCLA	59	18.19	4.17	8	25	<0.001
Post-operative UCLA	59	30.7	4.89	17	35	

Source: SAME, FMABC.

cases (39%) were classified as excellent results, twenty (33.9%) as good, fourteen (23.7%) as regular and two cases (3.4%) as bad. Comparing the 44 cases with partial subscapular tendon tears and the 15 cases of total tears, we found that the mean UCLA functional scale in the postoperative period were 31.70 and 27.80, respectively ($p < 0.035$). (Table 2) By evaluating only those cases with total subscapular tear, we found statistically significant improvement after surgery ($p = 0.002$). (Table 3)

Regarding the preoperative pain time, whose mean was 35.59 months (minimum 2 months and maximum 180 months), a statistically significant relationship was found with the postoperative functional UCLA outcome ($p = 0.001$ and $r = -0.423$). (Table 4)

We also found five complications (8.5%): four rotator cuff re-ruptures and one case of adhesive capsulitis. The re-ruptures were diagnosed when we performed magnetic resonance imaging in five patients with persistent pain for more than 6 months postoperatively.

DISCUSSION

The term "anterior superior tears" was introduced by Warner et al¹ to describe associated lesions of the subscapular and supraspinatus tendons. This type of tear occurs less frequently than the associated supraspinatus and infraspinatus tears and may be underdiagnosed.² Information on the surgical treatment of subscapular tear associated with supraspinatus tear is limited.^{1,3}

Warner et al. report that only 4% of their cases of rotator cuff tears were anterior posterior tears.¹ Frankle and Cofield presented in 24 cases of anterior posterior tears out of 301 cases of rotator cuff tears.⁴ Bigliani et al. described the results of 61 cases of lesions of at least two rotator cuff tendons, of which only 11 were anterior posterior tears.⁵ Geber et al. presented an incidence of 5.5% of subscapular tears isolated or associated with supraspinatus tears.³ In our study, these tears represented only 5.6% of rotator cuff tears. Regarding etiology, a potential cause of subscapular and supraspinatus tendon tear would be trauma to the affected shoulder on lateral rotation and abduction.⁴ In our study, 35% of the tears were of traumatic origin. Another potential etiology would be impact with coracoid process caused by reduced space between the coracoid process and the minor tubercle, with normal values ranging from 9 mm to 11 mm, although some authors believe that this decreased coracoid-humerus space is a consequence of the rotator cuff tear, not the cause.^{4,5}

Subluxations of the long head of the biceps tendon (LBT) may be one of the possible causes of partial subscapular tears, as well as subscapular tendon overload after supraspinatus tear.⁶ The association of some degree of LBT injury is commonly found in rotator interval tears.^{2,6} However, it is still unknown whether cuff tears cause any LBT tears or vice versa.³ According to Habermeyer et al., biceps pulley tears may be caused by degeneration or trauma. According to this author, pulley tears can also be caused when the

Table 4. Spearman's correlation results.

Variable	Statistics	Time of Pain (months)
PO UCLA	Coefficient of Correlation (r)	-0.423
	Sig. (p)	0.001
	n	59

SOURCE: SAME, FMABC.

pitching movement is abruptly stopped.⁷ Gerber was the first one to describe the anterior posterior impact that may cause LBT pulley and subscapular tear.⁸ In our study, in 78% of the cases, LBT tear was confirmed on surgery.

In his study, Bennett reports that 18 of 19 patients had biceps tears.² LBT subluxation caused by biceps pulley tear generates loss of anterior humeral head stability over the glenoid which, associated with biceps subluxation, is the initial event of anterior posterior impact.⁹

Isolated or combined subscapular tendon tears can be difficult to diagnose. In cases of total tears, physical examination detects the tear, as well as MRI.^{4,5} Lesions of the uppermost portion of this tendon represent a problem. Physical examination is often incapable of detecting the tear and MRI is difficult to interpret.^{1,5} In our study, we found that in 50% of the cases, physical examination was not able to detect subscapular tendon tear. These patients did not present any increase in lateral rotation and the lift-off and abdominal-press tests were negative. In addition, MRI was not conclusive for tendon tears. During surgery, high subscapular tears were observed, most of which involved the LBT pulley.

Burkhart¹⁰ reports that isolated supraspinatus or associated tears may function as if biomechanically and functionally intact, but associated supraspinatus and subscapular tears alter normal shoulder kinematics. Several authors have described that the superior portion of the subscapular tendon insertion is the most important portion, with 14 to 16 mm of thickness in general.¹¹⁻¹³ Therefore, in our opinion, it is important to redo this insertion to restore the shoulder mechanics, even when we encounter partial tears.

In the analysis of Gerber et al. outcomes from 56 cases of anterior superior tears, worse functional results were found compared to that of the posterior-superior rotator cuff tears.¹⁴ Frankle and Cofield reported that postoperative elevation was, on average, 134 degrees, but 25% of patients had significant weakness and pain.⁴ Warner et al. reported similar results to those of the European experience.¹

In our study, the mean interval between onset of symptoms and surgery was 36 months, with four cases of rotator cuff re-ruptures, representing 6.8% of the total cases operated and 75% of the complications. Two of the cases had a time interval between the onset of symptoms and surgery of 12 months and two of 24 months. We evaluated whether there was any relationship between the time of preoperative pain and the functional results analyzed by the UCLA functional scale and found a statistically significant relationship.

Table 2. Mann-Whitney Test Results.

Sub tear	n	Mean	Standard deviation	Minimum	Maximum	25 percentile	Median	75 percentile	Sig. (p)
partial	44	31.70	3.86	23.00	35.00	29.00	33.00	35.00	0.035
total	15	27.80	6.43	17.00	35.00	22.00	31.00	35.00	
Total	59	30.71	4.89	17.00	35.00	28.00	33.00	35.00	

Source: SAME, FMABC.

Table 3. Wilcoxon signed-rank test results.

Pair of variables	n	Mean	Standard deviation	Minimum	Maximum	25 percentile	Median	75 percentile	Sig. (p)
PRE UCLA	15	18.47	3.46	12.00	25.00	17.00	18.00	21.00	0.002
POST UCLA	15	27.80	6.43	17.00	35.00	22.00	31.00	35.00	

Source: SAME, FMABC.

According to a few reports of arthroscopic treatment, this technique allegedly has important advantages over open repair, since it requires using the deltopectoral route and a bigger extension to mobilize and repair the supraspinatus tendon,⁵ which leads to many more adhesions and fibrosis and impairs rehabilitation. Bennett et al. reports that arthroscopic treatment of anterior posterior lesions provides improved internal rotation and pain relief, and patients return to functional activities more rapidly. In their study, Ide et al.¹⁵ reported that 13 of 20 patients with a minimum follow-up of two years had an intact repair. Similarly, Burkhart and Tehrany¹⁶ report good or excellent results in 23 of 25 patients who underwent arthroscopic vision repair of subscapular tear associated with supraspinatus tear. In our study, there was statistical significance improvement of all parameters analyzed. In our opinion, this fact is mainly due to the

type of arthroscopic vision repair and proper treatment of the high subscapular tears, which were the majority. Even in the cases of total subscapular tear, there was a significant improvement (mean of 27.80 points). However, comparing the outcomes of patients whose subscapular tears were partial tears with cases of total tears, we found a statistically superior outcomes ($p < 0.035$) in cases of partial tears.

CONCLUSION

Treatment with arthroscopic vision for the repair of anterior superior tears produced satisfactory results (72.9%), 39% of which were classified as excellent and 33.9% were classified as good, with improved range of motion and UCLA functional scale, in addition to low rates of complications.

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PROXIMAL HUMERUS FRACTURE WITH LOCKING PLATE: FUNCTIONAL AND RADIOGRAPHIC RESULTS

FRATURAS DO ÚMERO PROXIMAL COM PLACA BLOQUEADA: RESULTADOS FUNCIONAIS E RADIOGRÁFICOS

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ABSTRACT

Objective: To correlate the functional outcome and radiographic indices of proximal humerus fractures treated with locking plate. **Methods:** Seventy patients with proximal humerus fractures treated with locking plate, with mean follow-up of 30 months. These patients were analyzed for the score of the University of California, Los Angeles (UCLA) for the operated shoulder, range of motion measurements and radiography of both shoulders. After that, a graphical correlation was established between the radiographic measurements and the functional outcomes. **Results:** 78% good and excellent results according to the UCLA score, with mean 130° elevation; 45° lateral rotation; and thumb-T10 medial rotation. The type of fracture according to the Neer classification and age had a significant correlation with the range of motion. An association was found between the lowest mean elevation and the UCLA score when the neck-shaft angle variation in the antero-posterior plane was greater than 15° varus ($p < 0.001$). **Conclusion:** The variation of the neck-shaft angle measurement in the anteroposterior plane showed significant correlation with the range of motion and can be one of the predictors of functional results in proximal humerus fractures treated with locking plate. **Level of evidence III, Retrospective Study.**

Keywords: Humeral fractures/surgery; Fracture fixation, Internal; Humeral fractures/radiographic evaluation.

RESUMO

Objetivo: Correlacionar os resultados funcionais e os índices radiográficos das fraturas do úmero proximal tratadas com placa bloqueada. **Métodos:** Examinou-se 70 pacientes com fraturas do úmero proximal tratados com placa bloqueada, com seguimento médio de 30 meses. Esses pacientes foram submetidos à análise do escore da Universidade da Califórnia de Los Angeles (UCLA) no ombro operado, avaliação do arco de movimento e a exames radiográficos de ambos os ombros. Estabeleceu-se, então, a correlação gráfica entre as medidas radiográficas e os resultados funcionais. **Resultados:** Obtivemos 78% de bons e excelentes resultados conforme o escore da UCLA, com médias de: 130° de elevação; 45° de rotação lateral; e polegar-T10 de rotação medial. O tipo de fratura segundo a classificação de Neer e a idade teve significativa correlação com o arco de movimento. Encontrou-se associação entre menor média de elevação e escore UCLA quando a variação do ângulo cervicodiafisário na incidência anteroposterior foi maior que 15° em varo ($p < 0,001$). **Conclusão:** A variação da medida do ângulo cervicodiafisário na incidência anteroposterior mostrou significativa correlação com o arco de movimento, podendo ser um dos preditores dos resultados funcionais nas fraturas do úmero proximal tratadas com placa bloqueada. **Nível de Evidência III, Estudo Retrospectivo.**

Descritores: Fraturas do úmero/cirurgia; Fixação interna de fraturas; Fraturas do úmero/avaliação radiográfica.

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INTRODUCTION

Proximal humeral fractures are relatively frequent; they account for 5–10% of all fractures.¹ Their incidence is 6.6 cases for every 1000 people every years², 70% in patients above 60 years old. They are the second most common upper limb fracture and the third most common in patients above 75 years old. The most common mechanism of injury is fall from standing protected by the extended hand.³

Approximately 80% of these fractures have no displacement or are minimally displaced and stable, resulting from low-energy trauma, and can be treated non-surgically⁴ with good prognosis. Surgical treatment is reserved for patients with fractures that are displaced, unstable, open, associated to vascular injury, or in polytrauma patients.

According to the literature, there is no unique treatment method that is effective for all types of proximal humeral fractures. The

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most commonly used surgical techniques are: closed reduction and fixation with pins or percutaneous screws, open reduction and internal fixation with plate and screws or with tension band, intramedullary nails, and hemiarthroplasty.^{1,5}

Internal fixation of the proximal humerus with locking anatomic plate favors the maintenance of the reduction obtained during surgery, allowing for earlier passive mobilization and thus facilitating post-operative rehabilitation.⁶

However, this technique is not free from complication. The most common among them are: limitation of range of movement, avascular necrosis, loosening of the synthesis material, articular penetration of screws, and/or varus fixation of the humeral head.⁷

This study aimed to evaluate the correlation between functional outcomes and radiographic indices of proximal humeral fractures treated with locking anatomical plate.

METHODS

This was a retrospective study conducted by the Shoulder and Elbow Group of the Orthopedics and Traumatology Service of the hospital, from february 2006 to May 2010, with 143 patients who suffered fracture of the proximal humerus and underwent surgical treatment (open reduction and internal fixation) with locking anatomic plate (PHILOS – Synthes®).

The following patients were excluded: 5 patients with bilateral fractures; 6 individual for pre-senting infection (re-operated for removal of the synthesis material); 4 in which loss of fixation were replaced by hemiarthroplasty and 58 due to loss of follow-up.

Of the 70 patients available for study, 44 fractured the right side and 26 on left side; 41 the dominant side and 29 the non-dominant; 50 were female and 20 male. The average age of patients was 67 years ranging from 21 to 92 years and the mean follow-up time was 30 months, ranging from 13 to 64 months. The most common mechanism of injury was fall from standing in 72% of de cases (Table 1).

The classification used in this study was described by Neer⁸ in 1970, based on displacement of the four main fragments, which were firstly identified by Codman in 1934⁹: humeral head, greater tuberosity, lesser tuberosity, and diaphysis. According to Neer,⁸ multiple parts are considered when there are deviations greater than 1 cm or 45° between fragments. For the greater tuberosity, a distance greater than 5 mm makes it a displaced part.

For diagnosis and preoperative classification, X-rays in the true shoulder anteroposterior, scapular Y, and Velpeau views were used, as well as CT scan when there was doubt regarding articular involvement. Of the 70 studied fractures, 20 were classified as two-part, 37 as three-part, and 13 as four-part.

To assess the functional results, patients with a minimum of 12 months of follow-up were included. The degree of flexion and rotation (lateral and medial) of both shoulders was measured and the University of California in Los Angeles (UCLA) score was applied.

Postoperative radiographic evaluation was standardized with a 100 cm distance from the X-ray apparatus to the film in the anteroposterior incidence (AP), with correction of anteverision of the glenoid cavity and limb in neutral rotation; scapular Y made with the patient standing in the posteroanterior position with 45° anteriorly and the X-ray apparatus toward the scapula; and Velpeau view a modification of axillary profile for patients with upper limb immobilization. Radiographs were always made on the same day by the same previously trained staff, at least 18 months after surgery.

The radiographic measurements assessed were the cervico-diaphyseal angle (formed by the intersection between a line perpendicular to the anatomical neck and a line parallel to the axis of the humeral diaphysis), compared to the non-operated side in true shoulder anteroposterior view¹ (Figure 1), and scapular Y (angle between a line passing through the anatomical neck and a line parallel to the diaphysis of proximal humerus (Figure 2), and distance between the proximal end of the plate and the apex of the greater tuberosity on the true shoulder anteroposterior view. The presence of pseudoarthrosis, avascular necrosis, and osteolysis was investigated.

Subsequently, the correlation between changes in radiographic measurements and functional results was calculated.

In the statistical analysis, the relationship between quantitative variables was chosen by Spearman's correlation. In studies of the variations we used the Kolmogorov-Smirnov test Lilliefors correction to verify the normality of the data. If it were not rejected the normality of the data was used the Student t test.

Table 1. Epidemiology.

Genre	
Male	20
Female	50
Member	
Right	44
Left	26
Affected dominant side	41 (59%)
Mean follow-up	30 (18-64) months
Average age	67 (21-92) year
Trauma mechanism	
Fall from standing	49 (72%)
Running over	6 (8%)
Motorcycle accident	6 (8%)
Car accident	6 (8%)
Drop in height	3 (4%)
Neer classification	
2 part	20 (29%)
3 part	37 (53%)
4 part	13 (18%)

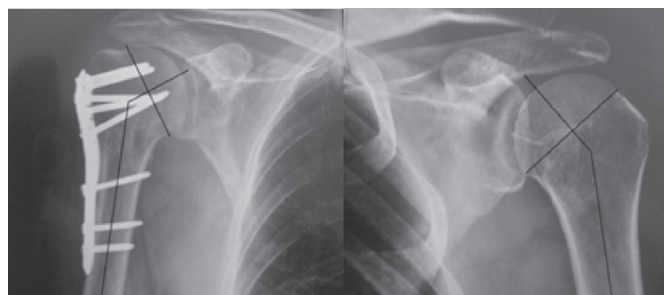


Figure 1. Measurement of cervicodiaphyseal angle in the anteroposterior incidence of both shoulders.

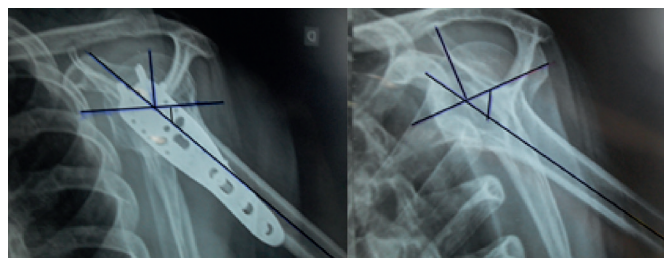


Figure 2. Measure the angle in the scapular Y incidence of the both shoulders.

RESULTS

Functional results

For the 70 patients analyzed, the mean elevation of the operated limb was 130° (30°-170°), with a loss of 21% compared to the contralateral side (164°), the mean of external rotation (ER) was 45° with 30% reduction compared to the opposite side (64°) and the mean of internal rotation (IR) was thumb-T10, with its contralateral side mean was thumb-T7.

In the UCLA score, we obtained 51 patients with excellent and good results (72.9%), 12 regular (17.1%) and 7 with poor results (10.0%). Of these, 67 had to be satisfied (95.7%) and 3 unsatisfied (4.3%). In 37 patients had three-parts fractures, 29 presented excellent and good results (78.38%), six patients was regular results (16.22%) and two with poor results (5.40%). The mean of range of motion losses compared to the contralateral side were: 31° elevation (163°-132°), 20° external rotation (64°-44°) and three internal rotation vertebrae (T7-T10). The worst scores of the study were in fractures classified as four-parts, four cases with excellent and good results (30.77%), four regular (30.77%) and five with poor results (38.46%). In the assessment of range of motion, the mean for elevation was 89° with a decrease of 45% compared to contralateral shoulder (162°). The external rotation loss was 28° with 45% reduction of motion (60°-32°). The average internal rotation-L1 was thumb with opposite side thumb-T9 (Table 2).

Results statistically significant ($p < 0.05$) when comparing the UCLA score and elevation, with age and number of parts of the Neer classification. The higher the age and the number of parts, the worst the flexion and UCLA score. (Figure 3 and 4).

Radiographic evaluation

In radiographic evaluation, five (7.14%) patients had avascular necrosis is therefore not possible to estimate the pre-established measures for the study (all classified as Neer fractures in 4 parts preoperatively).

Of the 65 patients studied, the mean of cervicodiaphyseal the anteroposterior was: 131° on the operated side (82°-210°) and 138°

Table 2. The mean of range of motion the operated side (OS), the contralateral shoulder (CL) and UCLA score.

Neer classification	Elevation OS	Elevation CL	RE OS	RE CL	RI OS	RI CL	UCLA Mean
2 part (20 patients)	152°	163°	51°	62°	T8	T7	32.65
3 part (37 patients)	132°	163°	44°	64°	T10	T7	31.10
4 part (13 patients)	89°	162°	32°	60°	L1	T8	22.84

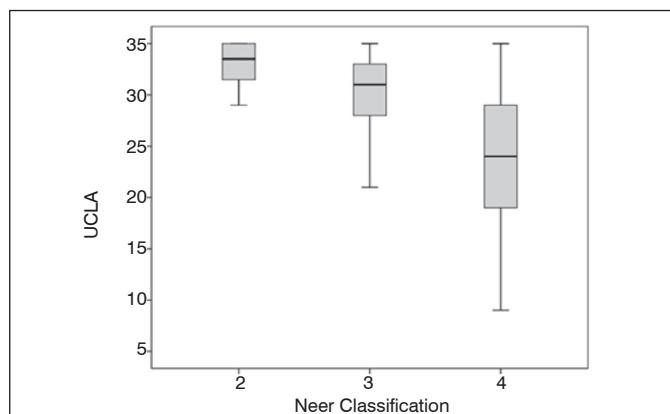


Figure 3. Relationship between Neer classification UCLA score ($p < 0.0001$).

the contralateral shoulder (126°-152°), the mean in the scapular Y view was 60°, and opposite side measuring 57°. The greatest differences were observed in four-parts fractures, specifically in the anteroposterior view that showed a difference of 17° compared to non-operated side (Figure 5).

When measuring the distance between the proximal end of the plate and the apex of the greater tuberosity, a mean of 6 mm (range: 0–1.6 mm) was obtained and in two cases is greater tuberosity of osteolysis.

Correlation between radiographic and functional outcomes

The worst functional outcomes were observed in cases where the difference between the operated and contralateral side was greater than or equal to 15° varus in the anteroposte-rrior incidence. In such cases, the patients had lower mean flexion (105,40°) and worse UCLA score (26,40). Patients who had variations lower than 15° had mean flexion of 151° and mean UCLA score of 32,85. These results were statistically significant in the present study. (Figure 6) (Table 3).

For analysis of the distance between the proximal end of the plate and the apex of the greater tuberosity, patients were divided into two groups: the first, with values lower than 8 mm, and the second, with values greater than or equal to 8 mm. By comparing the results of bending between the two groups was not statistically significant (Table 4).

We did not obtain statistically significant results, to correlate the radiographic measurements for scapular Y view with functional outcomes and UCLA.

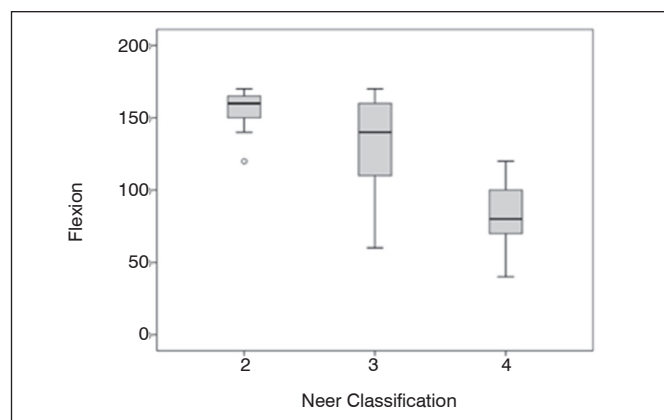


Figure 4. Relationship between Neer classification with flexion ($p < 0.0001$).

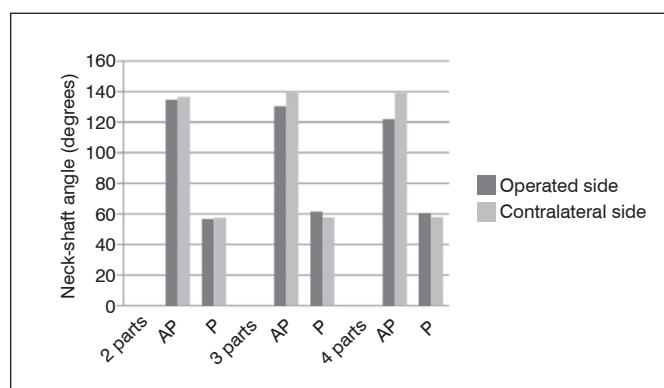


Figure 5. Cervicodiaphyseal in the anteroposterior (AP); and scapula profile (P).

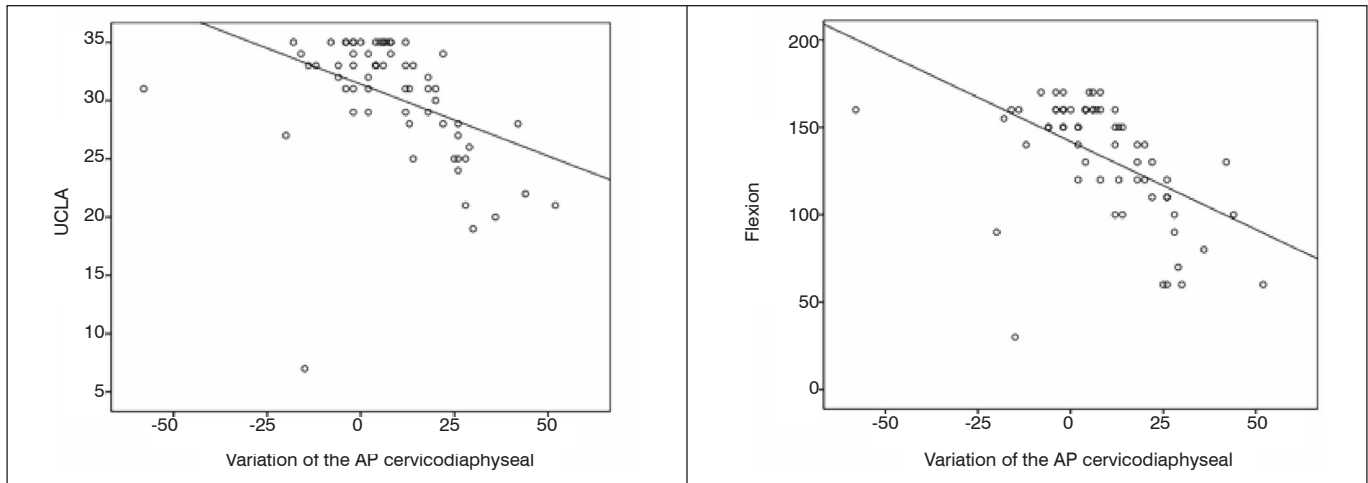


Figure 6. Correlation between UCLA and bending with changes in the cervicodiaphyseal anteroposterior (AP).

Table 3. Correlation between the variation in cervicodiaphyseal anteroposterior with UCLA and elevation ($p < 0.001$) (SD = standard deviation).

	Variation of the angle cervicodiaphyseal					
	<15			≥ 15		
	Mean	Median	DP	Mean	Median	DP
UCLA	32.85	33.00	2,359	26.40		6,035
Elevation	151.00	160.00	17.802	105.40	M	35.176

Table 4. Correlation between the elevation and the distance of the end of the plate relative to the apex of the greater tuberosity (TMP).

	TMP						p-value
	<0.8			≥ 0.8			
	Mean	Median	DP	Mean	Median	DP	
Elevation	133.46	140	30.718	134.4	150	39.59	.5531

DISCUSSION

In the present study, it was observed that deviations greater than 15° varus relative to contralateral shoulder in anteroposterior view are not well tolerated by the patient and lead to with flexion loss and a worse UCLA score.

Solberg et al^{10,11} reached a similar conclusion. In their study, the authors divided the results according to the obtained alignment relative to the contralateral shoulder. They considered less than 5° of varus angulation of the humeral head as a good reduction. In turn, a satisfactory reduction ranged from 5° and 20° of varus deformity of the humeral head. The authors concluded that patients with good or satisfactory reductions had better outcomes than patients with varus deformity greater than 20°, who presented flexion loss and worse functional outcome.

Herbert Resch,¹² in a 2011 review article, also considered these parameters to be important, and proposed a classification based on varus and valgus deviations. Brunner et al¹³ observed inferior results when the reduction of the fracture had cervicodiaphyseal angle with an increased varus; however, their results were not statistically significant.

Although the surgical technique recommend that the distance of the plate relative to the greater tuberosity should be 8 mm and lower distances lead to a deficit of abduction and flexion due to impact of the plate on the acromion¹⁴, in our study we showed no difference

statistically significant difference between the groups with plate < 8 mm plate compared with ≥ 8 mm below the apex of the greater tuberosity. In the functional evaluation, three patients were not satisfied with the treatment, according to the UCLA score, seven patients were considered poor results. Five cases were fractures in four parts and evolved into avascular necrosis (7,14%). Brunner et al¹³ reported a number, with 8% necrosis in a multicenter study of 158 fractures. Patients with avascular necrosis present the worst functional results. However, elderly patients, who have lower functional demand, tolerate this complication better.¹⁵

The 72,9% excellent and good results observed in the present study are accordance levels reported in the literature. In 2011, Hirschmann et al¹⁶ published a study with 64 patients with a minimum follow-up of four years, treated with locking plate, and reported 75% excellent and good results. They also concluded that these results continued to improve even one year after the surgery. Rose et al¹⁷ found 75% consolidation and excellent results.

In the present study, the higher the age of the patient and the number of parts of the fracture, the worst the flexion and the UCLA score. These results were statistically significant ($p < 0.003$). Yang et al¹⁸ found that the higher number of fracture parts and the lack of medial support (calcar comminution) were determiners of the functional outcome. Koukakis et al¹⁹ also had worse outcomes related to age. In the present study, the cervicodiaphyseal angle was used as a comparative radiographic parameter with the contralateral shoulder for correlation with functional outcomes. However, there is no universal standardized method to measure this angle.

Other biases in the results of this study which were not analyzed are the co-morbidities of patients, prior and late postoperative integrity of the rotator cuff, the extremes of the age. Further studies with greater emphasis on such factors are needed to complement the present findings.

CONCLUSION

This study indicates that the variation of the cervicodiaphyseal angle in the anteroposterior view was significant correlation with the range of motion. This radiographic parameter can be one of the predictors of functional results in fractures of the proximal humerus treated with locking plates.

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this study. RSBP (0000-0001-8520-5643)*: writing; data analysis; active participation in the discussion of results and intellectual concept. FRR(0000-0003-4516-751X)*: surgeries; writing; revision and intellectual concept. ACTJ(0000-0001-8601-4734)*: surgeries and data analysis. CSFJ (0000-0002-5385-788X)*and RBF (0000-0001-5362-8211)*: surgeries and active participation in the discussion of results. DCDM and WNSC: writing and active participation in the discussion of results. . *ORCID (Open Researcher and Contributor ID).

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SLAP IV IN OVERHEAD SPORTS PRACTICE

SLAP IV EM ATLETAS DE SUSPENSÃO

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ABSTRACT

Superior labral tear from anterior to posterior (SLAP) is the most common disease in overhead sports practice. Objective: to evaluate the functional outcome after tenodesis of long head biceps tendon (LHBT) in high-performance patients with isolated SLAP lesion refractory to conservative treatment. Methods: Patients underwent the same open repair procedure, using an interference screw. Results: Both patients presented good clinical results and returned to the sport with performance similar to that prior to the injury. Conclusion: The results favor the surgical treatment of these athletes with SLAP IV. **Level of Evidence IV, Série de Casos.**

Keywords: SLAP lesion, Tenodesis, Sport injuries, Gymnastics, Mountaineering.

RESUMO

A lesão labral superior anteroposterior (SLAP) é a doença mais comum em atletas em suspensão do solo. Objetivo: avaliar o resultado funcional após tenodese do TCLB (tendão do cabo longo do bíceps) nos pacientes atletas em suspensão de alta performance com lesão SLAP isolada refratária ao tratamento conservador. Métodos: Os pacientes foram submetidos ao mesmo procedimento de reparo por via aberta, com uso de parafuso de interferência. Resultados: Ambos os pacientes apresentaram bons resultados clínicos e retornaram ao esporte com performance semelhante ao prévio à lesão. Conclusão: Os resultados favorecem o tratamento cirúrgico desses atletas com SLAP IV. **Nível de evidencia IV, Series of Cases.**

Descritores: Lesão SLAP. Tenodese. Traumatismo no esporte, Ginástica. Montanhismo.

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INTRODUCTION

Climbers, gymnasts and circus acrobats are athletes who perform maneuvers with the body suspended from the ground, requiring great physical effort. The appearance of osteoarticular lesions is one risk even with adequate physical exercise, with higher incidence in the upper limbs.

Shoulder injuries are superior to the suspension movements, such *Superior Labral Anterior and Posterior* Lesion (SLAP). The disease is secondary to the mechanism of compression and traction of the upper whole-labral body with the shoulder in hyperextension, and in some cases through maneuvers with the abducting arm associated with a flexion movement¹. In the problem of conservative treatment, the surgical options are: arthroscopic repair of the labral lesion, tenodesis of the long head of biceps tendon (LHBT) or LHBT tenotomy.

The objective of this study was to evaluate the functional outcome after LHTB tenodesis with supraperioral interference screws in high performance patients with SLAP lesions isolated refractory to conservative treatment.

MATERIALS AND METHODS

This is a retrospective study involving patients in suspension with SLAP IV² lesion isolated refractory to conservative treatment

submitted to LHTB tenodesis in the period from 2014 to 2015. The study was approved by the Research Ethics Committee of Plataforma Brasil (INVITARE clinical research) under protocol CAAE 70129317.5.0000.8098.

Individuals of both gender who failed to undergo the surgical treatment were included and underwent an open tenodesis of the LHBT at a reference center for shoulder and elbow surgery in São Paulo - SP. Through the evaluation of medical records, four patients underwent this surgery, and one patient operated bilaterally (total of five shoulders). Our sample consisted of: two athletes, female gender, circus acrobats (athlete A with 24 years and right and left shoulder injury (bilateral), athlete B with 26 years old and left shoulder injury). The third athlete (C) is male, professional gymnast in rings, 26 years old, right handed and with left shoulder injury. The fourth athlete (D) is male, mountaineer, 26 years old, left-handed and left shoulder injury. All athletes are professional practitioners in their modalities, with an intense training profile (average of 5 hours/day, six days a week), with no previous history of injuries or shoulder surgeries.

The clinical presentation was similar in all cases, with pain in the anterior region of the shoulder when performing limb maneuvers and lateral rotation or lateral rotation elevation, always associated with the soil suspension (Table 1, Figure 1) with time the onset of symptoms 2 months ago. On physical examination they presented O'Brien test

All authors declare no potential conflict of interest related to this article.

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positive for SLAP lesion, with negative surprise test and relocation test. Magnetic resonance imaging showed superior labral lesion (only SLAP lesion),¹ without evident biceps involvement. (Figure 2) The patients were submitted to conservative treatment with physiotherapy and anti-inflammatory / analgesic medication, but without significant improvement. The in-office evaluation involved the Visual Analogue Scale (VAS), which ranges from 0 to 10 with increasing intensity of pain; UCLA Shoulder Score ranging from 0 to 35 points, with good / excellent result ≥ 27 and bad if < 27 points; and the American Shoulder and Elbow Society (ASES) rating Scale that is graduated from 0-100 points, being considered good / excellent if > 85 points. In addition to measuring the range of motion (ROM),^{3,4} All four indicators were submitted to the same surgical technique of LHBT tenodesis, open surgery, above the insertion of the tendon of the pectoralis major muscle. The patients were placed in a beach chair under anesthesia, performed arthroscopy of shoulder with the

diagnosis of SLAP lesion (type IV in all cases, differing from MRI findings), accomplished LHBT tenotomy, and away other lesions associated. (Figure 3) Then the arm (about 3 to 4 cm) was accessed on the left and anterior sides of the anterior axilla, identified as LHBT (medial to the insertion of the pectoral muscle) and determining the size required for a good tensioning. Made in the form of Krackov at the end of the tendon, perforated humerus (cis cortical only) proximal to the insertion of the major pectoralis muscle (according to the diameter of the tendon), LHBT tensioning was performed, and tenodesis was performed with the interferences screw. (Figure 4)

All followed the same protocol of rehabilitation. Maintained limb immobilization for three weeks, followed by progressive gain of movement (active and passive) of the operated shoulder and training of the sports gesture. Muscular strengthening was started after 8th week. The return to the sport was possible after 3 months of surgery. The four athletes were reassessed and discharged after 12 months of surgery, but both were reassessed after 24 months of surgery for late post-surgical feedback. Both were exercising their sports activities without pain, without limitation, with a level of performance similar to that prior to injury. Statistical Package for the Social Sciences (SPSS) version 20.0 for determination of distribution by gender, age, upper limb dominance, time of return to work and sports activities, range of motion and scores of VAS, UCLA and ASES. Descriptive statistics were used to determine frequencies; measures of central tendency and measures of dispersion related to the clinical, demographic characteristics and functional scores of the shoulder in the studied patients.

Table 1. Demographic data of professional overhead sports athletes. SLAP (Superior Labral Tear from Anterior to Posterior)¹.

Patient	A	B	C	D
Sex	Female	Female	Male	Male
Age (years)	24	26	26	26
SLAP (type)	IV	IV	IV	IV
Sport	Circus gymnast	Circus gymnast	Climber	Gymnast (rings)
Brain dominance	Right	Right	Right	Left
Operated shoulder	Right and left	Left	Left	Left



Figure 1. High performance athletes in physical activity with the body suspended from the ground. A. Gymnast in rings. B, D e E. Circus acrobat; C. Mountaineering.

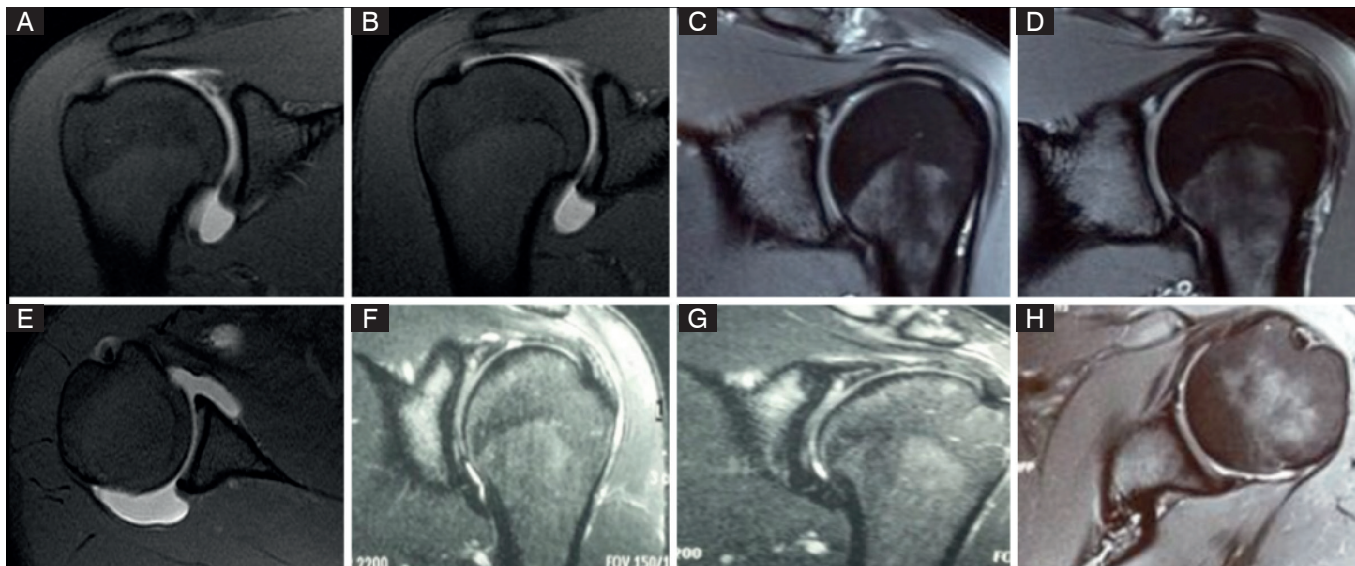


Figure 2. Magnetic resonance imaging (MRI) of the shoulder at T2. A, B, C, D, F e G. Coronal section of the MR showing SLAP lesion (only in arthroscopy can be concluded that it was SLAP IV). E e H. Axial cut shows tendinopathy of LHTB, without other concomitant lesions.

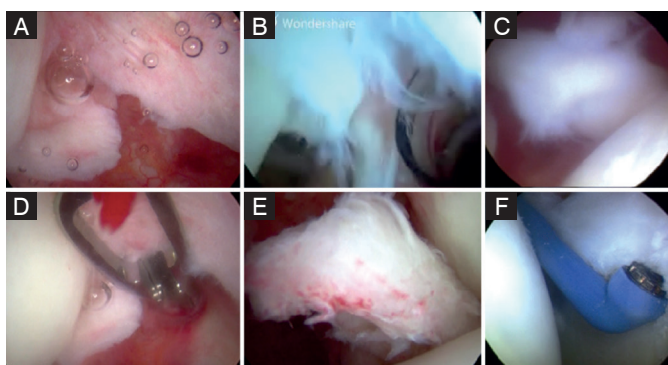


Figure 3. Images of shoulder arthroscopy (glenohumeral space). A, B, C. SLAP lesion type IV (progression of the lesion to the LHTB); D. LHTB tenotomy; E. Tenotomized biceps; F. Debridement of upper anterior-posterior posteral residual lesion.

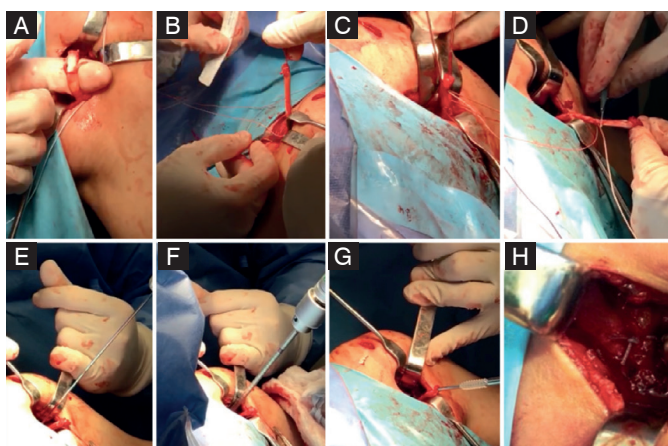


Figure 4. Images of the surgical stage open for suprapectoral tenodesis. A. Super-lateral incision to the axillary fold and identified LHTB; B. Measurement of LHTB length and diameter; C. Suture made of Krackov type after adequate measurement; D. Distracted pathological distal portion of the LHTB; E. Positioning guide wire; F. Passed cannulated drill according to tendon diameter; G. Made LHTB tenodesis with cannulated interference screw; H. Image after suprapectoral tenodesis.

The categorical variables were expressed by absolute number (valid percentage) and the quantitative variables expressed by means and standard deviation, in case of normal distribution. Quantitative variables with non-Gaussian distribution were expressed in medians and interquartile range. Significant $\alpha < 0.05$ was considered significant. The Wilcoxon test was used to evaluate the VAS, UCLA, ASES, and ROM scores because they were unpaired data. To evaluate the qualitative variables, the Mann-Whitney test was used.

RESULTS

All four patients presented SLAP lesion type IV according to the Snyder's classification², and mean age of 25.5 ± 1 and median 26 years, with two lesions in the dominant limb. The postoperative follow-up was 24 months (Table 1).

The patients returned to the sport with three months. After 12 months of returning to the sport, 100% of the functional status of the limb was reported as having a functional level equal to or greater than that prior to SLAP lesion (onset of pain). The four patients were evaluated in the pre- and postoperative period (six postoperative months) for ROM for upper limb elevation, VAS, and UCLA / ASES scores. The shoulder ROM for preoperative elevation was on average $147.2 \pm 8.4^\circ$ and in the postoperative period of $175 \pm 9.2^\circ$, with $p < 0.001$. No loss of lateral rotation was observed postoperatively. Regarding the evaluation of the pain scale (VAS) in the preoperative period presented a mean of 3.4 ± 0.54 points and in the postoperative period of 0 points, with $p < 0.001$. As to the scores for evaluating shoulder function with SLAP, UCLA presented a mean of 26 ± 1.22 points in the preoperative period and in the postoperative period of 35 points, with $p < 0.001$. While ASES had a preoperative mean of 80.6 ± 7.9 points and in the postoperative period of 96 ± 4.6 points, with $p < 0.001$. (Table 2)

After a 24-month follow-up, the results of the EVA and the ASES and UCLA scores maintained a maximum score.

DISCUSSION

The brachial biceps muscle has great importance in supination of the forearm (primary) and elbow flexion (secondary), accounting for 40% and 30%, respectively. In relation to the shoulder, the LHTB has the following functions: static (since positioned anatomic) and dynamic

Table 2. Escores funcionais ASES (*American Shoulder and Elbow Society Rating Scale*) e UCLA (*University of California at Los Angeles*) e escala visual analógica (EVA) pré e pós-operatório com 6 meses.

Patient	A*	A†	B	C	D
ASES pre	73.3	93	80	74	80
ASES post	100	100	100	100	100
UCLA pre	24	27	27	26	26
UCLA post	35	35	35	35	35
VAS pre	4	3	3	4	3
VAS post	0	0	0	0	0

A*. Ombro direito do paciente A; A†. Ombro esquerdo do paciente A; B. Paciente B; C. Paciente C; D. Paciente D.

humeral head depressor, as well as glenohumeral stabilizer during pitches and when the shoulder is positioned in abduction and external rotation.⁵ The SLAP lesion has a strong relationship with throwing athletes. Subsequently, Burkhart et al., observed that the SLAP lesion in this profile of athletes presented evolutionary pathophysiology resulting from the association of kinetic chain disorders and scapular dyskinesia.¹ Gymnasts, circus acrobats and mountaineering are not subjected to high angular velocity at the shoulder as the pitchers but are exposed to long periods of overload in external rotation and traction extension of the body weight maintained in suspension.⁶ Caraffa et al. published an electromyographic study with overhead sports practice and observed that the most painful moments were restricted to late periods of the maneuvers and positions that the musculature presented low activity, but with high shoulder overload (favorable position for SLAP injury).⁶

Kibler et al. demonstrated in a systematic review for surgical treatment of the SLAP lesion there is no consensus in the literature regarding the best conduct due to the lack of consistency and accuracy of the published studies.⁷ The scarcity of published studies for the treatment of this lesion with suspended athletes makes it difficult to choose the best option for each case.

The main points to be questioned in the treatment chosen are: resolution of pain and level of return to the sport. Ide et al. reported that 60-75% of their patients undergoing SLAP repair were able to return to the sport with the same level of performance prior to

injury.⁸ Boileau et al. reported that 87% of cases returned to previous sports level with tenodesis,⁹ similar to the results found in our study (all returned to previous performance level).

The preferred localization of LHBT tenodesis is also controversial in the orthopedic community. Tendon tenosynovitis may extend beyond the intra-articular portion and have an inflammatory component that extends through the proximal portion of the bicipital groove. To eliminate the possibility of this pathology causing persistent pain in the anterior region of the shoulder, some researchers have recommended positioning the site of tenodesis distal to the groove.¹⁰⁻¹² Some evidence suggests less persistence of pain and revision rates for open distal tenodesis sites compared to proximal sites using a fully arthroscopic approach.¹⁰ Other works state that there is no difference in functional scores, residual pain or complications.^{11,12} In our study we opted for suprapeitoral fixation by surgeon preference, and an excellent result was obtained as suggested in the most recent literature. In a study performed only with climbers by Schoffl et al., An excellent post-tenodesis functional result with mini-open interference screw and a 6-month follow-up (ASES score 97.3) were observed.¹³ The level of function of the shoulder and athletic ability of the athlete presented with 96.8% of normality.¹³ No studies were found with surgical treatment for SLAP injury in gymnasts (suspension) or circus acrobats in the BIREME, Pubmed and Scielo platforms database. The treatment for SLAP injury in overhead athletes is still based on clinical experience of authors in the recent literature. The type of injury, age of the patient, concomitant lesions, functional demand and level of sports activity should be considered.

CONCLUSION

This study demonstrated the excellent functional outcome after surgical treatment of the SLAP lesion type IV in high performance athletes who practice sports with the body suspended from the ground (overhead). Both were submitted to open suprapectoral LHBT tenodesis. Patients evolved with resolution of pain, with no signs of instability or aesthetic deformity, with a return to sports performance similar to that prior to injury.

The suprapectoral tenodesis, with an open screw, was a safe and effective option for the treatment of SLAP IV injury in athletes with high functional demand of the shoulder.

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PROXIMAL HUMERAL FRACTURES TREATED WITH OSTEOSYNTHESIS USING THE ANTEROLATERAL APPROACH

FRATURA DO ÚMERO PROXIMAL TRATADAS COM OSTEOSSÍNTESE PELA VIA DE ACESSO ANTEROLATERAL

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ABSTRACT

Objective: The main surgical approach in proximal humeral fractures is the deltopectoral approach. Many surgeons avoid the anterolateral approach, fearing its complications, especially axillary nerve injury. The objective of this study is to evaluate shoulder function and complications in patients with proximal humeral fractures treated using an anterolateral approach with direct observation of the axillary nerve. **Methods:** Retrospective study with postoperative radiological and functional evaluations (Constant and DASH scores) and review of the complications. The associations between fracture classification and the difference in Constant scores among the subjects and the final angle of consolidation were analyzed using Fisher's test or analysis of variance (ANOVA). The Constant scores were compared among the shoulders using the paired t-test. **Results:** The study evaluated 35 patients. Shoulder function was decreased, compared with the contralateral side ($p < 0.005$). The only factor related to functional worsening was the Neer IV fracture. The main complication was malunion. There were no clinical changes related to the axillary nerve. **Conclusion:** The treatment using the extended anterolateral approach produced good functional results, although the function was decreased (Neer IV fractures). The main complication was malunion. There were no side effects due to exposure of the axillary nerve. **Level of evidence III, Retrospective Study.**

Keywords: Humeral Fractures, Surgery, Complications, Osteosynthesis fracture.

RESUMO

Objetivo: A via de acesso mais utilizada na osteossíntese das fraturas de úmero proximal é a deltopectoral. A via anterolateral sofre resistência, pois muitos temem suas complicações, principalmente lesão do nervo axilar. **Objetivo** é avaliar a função do ombro e as complicações nas fraturas de úmero proximal, tratados pela via anterolateral com observação direta do nervo axilar. **Métodos:** Estudo retrospectivo com avaliação radiológica e funcional (Constant e DASH scores) pós-operatórios e complicações. A associação entre a classificação da fratura e a diferença dos escores entre os membros, bem como o ângulo final de consolidação, foram analisados pelo Teste de Fisher ou Anova. A comparação dos escores Constant entre os membros foi conduzida pelo teste t pareado. **Resultados:** foram avaliados 35 pacientes. Houve diminuição da função do ombro em relação ao contralateral ($p < 0,005$). O único fator relacionado à piora funcional foi fratura Neer IV. A principal complicação foi consolidação viciosa. Não se observou alterações clínicas relacionadas ao nervo axilar. **Conclusão:** A osteossíntese das fraturas do úmero proximal realizada pela via de acesso anterolateral estendida, apesar da diminuição da função do ombro (fraturas Neer IV), evoluiu com bom resultado funcional e mostrou-se segura na proteção do nervo axilar. **Nível de evidência III, Estudo Retrospectivo.**

Descritores: Fixação interna de fraturas, fraturas do úmero proximal, complicações, cirurgia.

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INTRODUCTION

Fractures of the proximal humerus are more prevalent in elderly patients with osteoporosis, and the incidence of these lesions has increased with the aging population.¹ Neer classified fractures of the humerus based on the deviation of the fragments. Fractures in two to four parts are preferably treated with osteosynthesis when they

require surgical treatment.² For fractures affecting the humeral head or fractures in four parts associated with osteoporosis and advanced age, arthroplasty may be the surgical treatment of choice.^{2,3} Osteosynthesis underwent a major evolution with the introduction of fixed-angle locking plates, which provide better fracture stabilisation

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Study conducted at the Shoulder Group, Outpatient Service, Orthopedics and Traumatology Department, Faculdade de Ciências Médicas, UNICAMP, Campinas, SP, Brazil.
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in osteoporotic bones compared with conventional plates and have become the implant of choice in osteosynthesis.¹

The approach most commonly used for the surgical treatment of proximal humerus fractures is the deltopectoral approach due to its ease and reduced proximity to the axillary nerve.^{1,4} Gardner described the anterolateral approach for proximal humerus fractures.⁵ It is performed between the anterior and middle portions of the deltoid, with better exposure of the lateral humerus. Therefore, the anterolateral approach provides better access to the greater tuberosity and the lateral side of the humerus, which facilitates placement of the locking plate as the implant has a fixed angle.⁵ The major risk of the anterolateral approach is damaging the axillary nerve, which runs perpendicular to the humerus, located 5 cm above the acromion. Therefore, the axillary nerve must be dissected when this approach is used.⁶⁻⁸

There are numerous articles on the minimally invasive plate osteosynthesis (MIPO) technique using the anterolateral approach, without axillary nerve isolation, with good functional results.^{4,9} However, few studies have evaluated the safety and function of the shoulder in proximal humeral fractures treated surgically with a locking plate via the anterolateral approach with direct axillary nerve isolation.^{5,10} Therefore, this study evaluated the function of shoulders with proximal humeral fractures treated with osteosynthesis with a locking plate via the extended anterolateral approach and examined its complications.

MATERIALS AND METHODS

This study was approved by the local ethics committee (approval no. 41229014.2.0000.5404).

This retrospective study enrolled patients with proximal humeral fractures classified as Neer 2, 3, or 4 requiring surgical treatment. Patients were excluded if they had fractures associated with dislocations, opposite shoulder injuries that did not allow comparison, or fractures with indications for arthroplasty, or if they refused to participate in the study. All participants have signed a consent form. Osteosynthesis was performed with a locking plate via the extended anterolateral approach. The patients were positioned in a beach chair. A 10-cm incision was made, beginning at the anterolateral edge of the acromion and extending distally parallel to the axis of the diaphysis. (Figure 1) The anterior and middle portions of the deltoid were separated by blunt dissection, the axillary nerve was identified and protected, and the plate was placed below it. (Figure 2)

The bone consolidation and angulation were evaluated with radiographs from three views using the reference values described by Sohn et al.,^{11,12} including the true anteroposterior view (20° of external rotation) for evaluating the head-shaft angle and the axillary view for evaluating anteroposterior angulation. A varus deformity was defined as an angle of less than 120°, and a valgus deformity was defined as an angle greater than 140°. The anterior or posterior tilt of the humeral head was evaluated in the axillary view. Positive values exceeding 5° were considered anterior tilt, and negative values exceeding 5° were considered posterior tilt. Values between -5° and +5° were considered adequate. (Figure 3) The reduction of the greater tuberosity was assessed by measuring the distance between the articular surface and the lateral superior aspect of this structure. The height of the plate was evaluated by measuring the distance from the upper border of the greater tuberosity and the apex of the plate. (Figure 3) The consolidation was considered complete when there was callus formation in all three views. The radiographic evaluation was performed independently by two independent surgeons who met to resolve any discrepancy in the evaluations.

Shoulder function was evaluated using the Constant and DASH scores.¹³ The scores of the operated and contralateral sides were compared. The axillary nerve function was evaluated by testing

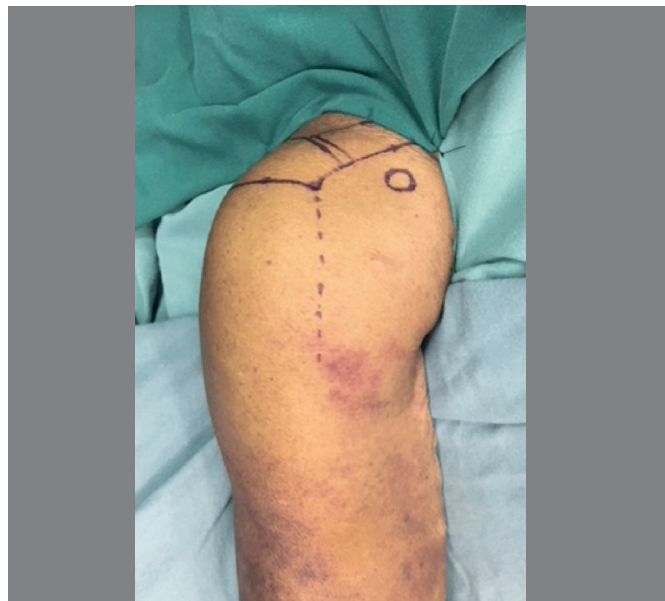


Figure 1. Antero lateral Skin Incision.



Figure 2. Final plate position.

sensation in its dermatome. The evaluations were performed at least 12 months postoperatively.

Factors that could affect shoulder function in these patients were evaluated using multiple linear regression with the stepwise method. The following variables were included in the model: age, gender, fracture classification, affected side, fracture consolidation angle, plaque height and osteonecrosis, and Constant and Dash scores. The fracture classification was treated as a dummy variable. The significance criterion for entering a variable in the model was 5% in the F-test, and it was 5.1% significance for its removal. The associations between the fracture classification and the difference in the Constant scores among the subjects and the final angle of consolidation were analysed using Fisher's test or analysis of variance (ANOVA). The Constant scores were compared between the limbs using the paired *t*-test. All analyses were conducted in PASW Statistics 18.0 (SPSS, Chicago, USA), and a significance level of 5% ($P < 0.05$) was adopted.

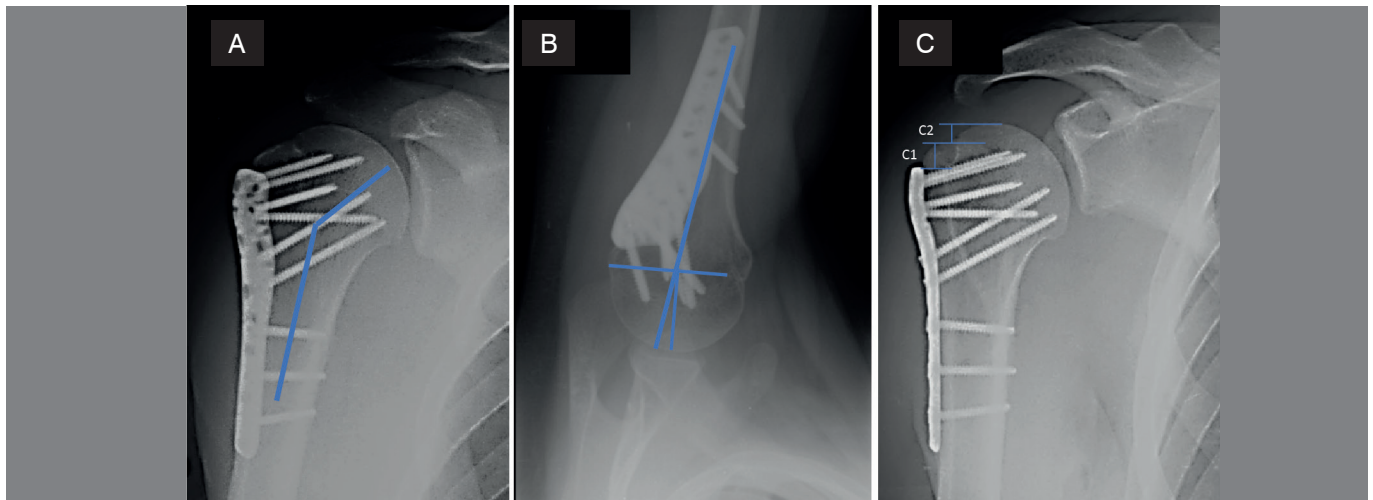


Figure 3. Head-Shaft angle (A) ; Anteroposterior tilt(B); Plate Height (C1); Greater Tuberosity Reduction (C2).

RESULTS

We evaluated 45 patients. Ten patients were excluded after they were lost to follow up. There was a predominance of females (54%). The mean patient age was 53.6 ± 16.9 years. The left side (57%) was most commonly affected. The dominant side was the right in 97% of the cases.

Of the patients analysed, 11, 13, and 11 were classified as Neer IV, III, and II fractures, respectively. The mean follow-up period was 31.1 ± 20.3 months. Consolidation occurred at an average of 3.1 ± 1.1 months. There was no case of pseudarthrosis. Table 1 summarises the patients' demographic data.

The final postoperative radiological evaluation showed a head–shaft angle of $133.4 \pm 10.1^\circ$, and the anteroposterior angulation was $-8.34 \pm 11.23^\circ$. The greater tuberosity was 0.93 ± 5.19 mm below the articular surface, and the plate was 8.7 ± 5.19 mm below the apex of the greater tuberosity. (Table 2) The cases of malunion (14 cases/40%) involved valgus (3 cases/8.6%), varus (2 cases/5.7%), posterior deviation (12 cases/34.3%), or anterior deviation (1 case/2.9%). There was no statistical relationship between post-operative angulation and type of fracture. (Table 2) The reduction of the greater tuberosity was adequate in 75% of the cases (Neer III and IV fractures) and the plate height was adequate in 91.4% (one case developed impingement and required plate removal). There was no statistical difference in the quality of tuberosity reduction or plate height among the different fracture types. (Table 3)

In one case, the intra-articular screw migrated secondary to osteonecrosis, and the implant was removed. There were no cases involving joint screws in the immediate postoperative period.

One patient developed a superficial infection that was treated with oral antibiotics. Partial osteonecrosis of the humeral head occurred in two patients (one each Neer III and IV). However, neither patient required arthroplasty. In one case, the implant was removed. No patients had decreased sensation in the dermatome corresponding to the axillary nerve.

The mean Constant and DASH scores were 72.1 ± 16.2 and 12.1 ± 15.7 , respectively. The functional evaluation showed a significant

Table 1. Demographic characteristics of patients.

Variable	Value
Age [Mean (SD)] (years)	53.6 ± 16.9
Consolidation time [mean (SD)] (months)	3.1 ± 1.0
Follow-up time [mean (SD)] (months)	31.1 ± 20.3
Gender [No. (%)]	
Male	16 (45.7%)
Female	19 (54.3%)
Neer Classification [Number. (%)]	
II	11 (31.4%)
III	13 (37.2%)
IV	11 (31.4%)
Side [Number. (%)]	
Right	15 (42.9%)
Left	20 (57.1%)
Dominant side [No. (%)]	
Right	34 (97.1%)
Left	1 (2.9%)

Table 2. Numerical variables (mean \pm SD; median [min-max]).

	All cases	Neer classification			p-value
		Type II	Type III	Type IV	
Head-Shaft angle ($^\circ$)	$133,4 \pm 10,1$ 135 [94 – 156]	$134,6 \pm 5,1$ 136 [125 – 142]	$132,6 \pm 9,4$ 135 [111 – 148]	$133,2 \pm 14,7$ 135 [94 – 156]	0,924 ^a
Anterior/posterior ang ($^\circ$)	$-8,34 \pm 11,23$ -3 [-38 – 8]	$-6,91 \pm 11,42$ -3 [-28 – 5]	$-7,69 \pm 12,73$ -2 [-38 – 8]	$-10,55 \pm 9,78$ -4 [-24 – 0]	0,375 ^a
Major tuberosity reduction (mm)	$-0,93 \pm 4,05$ 0 [-9 – 8]	NA	$-0,59 \pm 3,07$ 0 [-8 – 3,8]	$-1,34 \pm 5,11$ 0 [-9 – 8]	0,664 ^b
Plate height (mm)	$-8,70 \pm 5,19$ -9,7 [-20 – 2]	$-9,91 \pm 3,37$ -10 [-16,4 – -5,03]	$-9,55 \pm 6,38$ -10,8 [-20 – 2]	$-8,70 \pm 5,19$ -9,7 [-20 – 2]	0,231 ^b

^aKruskal-Wallis test; ^bANOVA.

($P < 0.005$) decrease in the Constant score relative to the contralateral limb (Constant 85.8 ± 6.1).

In the multiple linear regression analysis, Neer IV fractures explained 30.7% ($P = 0.001$) and 17.9% ($P = 0.013$) of the variation in the Constant and DASH scores, respectively. Age, sex, affected side, occurrence of osteonecrosis, fracture consolidation angle, and plate height were not significantly associated with these scores. The presence of a Neer IV fracture led to a 19 point decrease in the Constant score ($P = 0.001$) and a 13.6 point increase in the Dash score ($P = 0.013$) postoperatively. (Table 4)

DISCUSSION

The incidence of proximal humerus fractures has increased in recent decades with the increasing elderly population. Consistent with the literature, we observed a higher incidence of fractures in patients over 50 years and in women.¹⁴

Consolidation with a change in the head–shaft angle occurred in 15% of the patients in comparison with a reported incidence of 0–21%.^{15–17} However, we observed a greater frequency of valgus than varus consolidation. The postoperative varus collapse of the humeral head in patients undergoing osteosynthesis with a locking

plate is related to both medial comminution of the humerus and to the absence of screw placement in the humeral calcar region.^{11,17,18} Therefore, we believe that we observed less varus consolidation compared with most reports in the literature because of our routine use of inferior screws in the humeral head, which was our practice even when it was necessary to put the plate more inferiorly. Metha *et al.* observed greater biomechanical stability with the plates placed more inferiorly,¹⁸ which also resulted in a lower incidence of secondary impingement compared with most reports in the literature.¹⁹ The higher incidence of valgus consolidation may also have occurred because reduction with a greater cervical–diaphyseal angle was used to facilitate the placement of the medial and inferior screws in the head, as we did not use implants with polyaxial screws.²⁰

There were 12 cases of consolidation with posterior deviation of the head. The evaluation of postoperative anteversion / retroversion in proximal humerus fractures is poorly described in the literature. However, our results are similar to those using the anterolateral approach using the MIPO technique or the deltopectoral approach, and we relied on the posterior/anterior tilt of the humeral head as a means of evaluating the cephalic version in the axillary radiological view.^{11,12} The reduction of the greater tuberosity was above the surface of the humeral head in six patients (25%) with Neer III and IV fractures. However, two cases were secondary to humeral head varus consolidation. Therefore, adequate reduction of the tuberosity was achieved in 83.3% of our cases. Malunion of the greater tuberosity should be avoided, as it may lead to secondary impingement and decreased shoulder function.¹²

In agreement with the literature, there was no statistical difference in the postoperative angulation according to the type of fracture as classified by Neer.^{12,19} However, the anatomical reduction of proximal humerus fractures remains challenging, regardless of the approach, and functional worsening of the shoulder occurs when reduction is not attained.¹⁹ Arthroplasty may be an option for elderly osteoporotic patients in whom adequate fracture reduction cannot be achieved.¹² The reported incidence of osteonecrosis secondary to proximal humeral fracture ranges from 0 to 68%.⁹ There is a positive correlation between fracture type (Neer IV) and an increased chance of progression to osteonecrosis.¹¹ Partial humeral head necrosis occurred in two of our patients (one each Neer IV and III). However, there was no correlation between the presence of osteonecrosis and a worse functional outcome. Head collapse and migration of the screw to the articular region result in a worse prognosis, but this occurred in only one patient, which could explain the absence of the influence of osteonecrosis on the functional evolution. However, our mean follow-up time was 31 months, and some authors report that the evolution to osteonecrosis occurred 36 months after treatment.⁹ Another limitation of the study was that it did not evaluate the influence of the Hertel criteria or medial comminution on osteonecrosis.

Pseudarthrosis has an incidence of 1–10%, which is influenced by the type of fracture and smoking.¹⁹ We did not observe any pseudarthrosis.

Table 3. Categorical variables (frequency).

	All cases (n=35)	Neer classification			p-value
		Type II (n=11)	Type III (n=13)	Type IV (n=11)	
Head-Shaft angle					
Varus (< 120°)	5.7% (2/35)	0% (0/11)	7.7% (1/13)	9.1% (1/11)	0.908
Normal (120° to 140°)	85.7% (30/35)	90.9% (10/11)	84.6% (11/13)	81.8% (9/11)	
Valgus (> 140°)	8.6% (3/35)	9.1% (1/11)	7.7% (1/13)	9.1% (1/11)	
Anterior/posterior angulation					
Posterior (< -5°)	34.3% (12/35)	27.3% (3/11)	30.8% (4/13)	45.5% (5/11)	0.628
Normal (-5° to +5°)	62.9% (22/35)	72.7% (8/11)	61.5% (8/13)	54.5% (6/11)	
Anterior (> +5°)	2.9% (1/35)	0% (0/11)	7.7% (1/13)	0% (0/11)	
Greater tuberosity reduction					
Below	45.8% (11/24)	NA	46.2% (6/13)	45.5% (5/11)	0.647
Same or above	54.2% (13/24)	NA	53.8% (7/13)	54.5% (6/11)	
Plate height					
Below	91.4% (32/35)	100% (11/11)	84.6% (11/13)	90.9% (10/11)	0.406
Same or above	8.6% (3/35)	0% (0/11)	15.4% (2/13)	9.1% (1/11)	

Table 4. Multiple linear regression results.

Dependent Variable	Predictor	Regression Coefficient - Not standardised (B)	Regression Coefficient - Standardised (Beta)	p-Value	IC 95% (B)			Variance explained by the predictor (%)	R ²
					a	a	a		
Constant Scores (operated shoulder)	Constant value	78.6		< 0.001	72.7	a	84.4	30.7	0.307
	Neer Classification (IV/others)	-19.0	-0.55	0.001	-29.3	a	-8.7		
DASH Score (operated shoulder)	Constant value	7.0		0.024	1.0	a	12.9	17.9	0.179
	Neer Classification (IV/others)	13.6	0.42	0.013	3.1	a	24.09		

In one patient (2%), migration of a screw into the joint progressed to osteonecrosis, requiring removal. Joint penetration by a screw is one of the main complications in the treatment of proximal humeral fractures with a locking plate, with a reported incidence of 1–13%. Penetration may be related to inadequate intraoperative positioning or may be secondary to humeral head collapse due to osteonecrosis or varus consolidation.¹⁸

There were no postoperative neurological changes. Theoretically, the anterolateral approach poses a greater risk to the axillary nerve. However, studies using the MIPO technique did not observe damage to this structure.¹²

With the MIPO technique, there is no direct approach to or isolation of the axillary nerve. However, the use of the last two proximal rows in the plate should be avoided because of their proximity to the nerve.¹⁸ Gardner pioneered the use of an anterolateral approach with direct exposure of the axillary nerve and did not observe iatrogenic injury of this structure. This approach has the advantage of using all the screws, as the nerve is isolated. The use of the inferior screw in the calcar region adds mechanical stability to the fracture, preventing collapse of the humeral head.¹⁸ As reported by Gardner, we observed no axillary lesion. Additionally, although we examined the dermatome for the axillary nerve only postoperatively, pre- and postoperative electromyography is the gold standard for evaluating the axillary nerve.¹⁶ The functional evaluation was performed using the Constant and DASH scores. The average Constant score was 72.1 ± 16.2 , which reflected significantly reduced function compared with the contralateral shoulder. Numerous studies have shown a decrease

in shoulder function after osteosynthesis.¹⁹ The DASH score was 12.1 ± 15.7 , which is similar to reports in the literature and reflects a satisfactory postoperative functional result. The only factor that correlated with a worsening of the functional scores was the type of fracture: Neer IV fractures were associated with a significant worsening of the functional score. In general, four-part fractures are associated with rotator cuff involvement and consequent functional worsening.¹² Our results are in agreement with the literature, although the majority of these studies performed the osteosynthesis using the deltopectoral approach or MIPO technique.¹⁷

Therefore, despite not being a comparative study, our functional results and complication rates were similar to those found in studies of patients undergoing osteosynthesis of proximal humerus fractures with locking plate that used the deltopectoral approach or split the deltoid using the MIPO technique. To date, few studies have evaluated the extended anterolateral approach in the treatment of proximal humerus fractures.^{14,17} We hope to contribute to knowledge in this area by increasing the number of patients surgically treated with this approach. A randomised study comparing all approaches would be ideal for comparing the results.

CONCLUSION

The treatment of proximal humerus fractures with locking plate using the extended anterolateral approach gave good functional results, although function was decreased, especially in patients with Neer IV fractures. The main complication was malunion. There were no side effects due to exposure of the axillary nerve.

AUTHORS' CONTRIBUTIONS: Each author contributed individually and significantly to the development of the article. Main contributions: Study design: GGM (0000-0002-8258-5350)*, ME (0000-0002-5176-2369)*; Statistical analysis: LM (0000-0002-6584-5333)*, GGM (0000-0002-8258-5350)*; Selection of manuscripts and final revision: FKK (0000-0002-1409-2124)*, AZF (0000-0002-8704-8378)*, PPSJ (0000-0001-6078-0975)*, ME (0000-0002-5176-2369)*, LM (0000-0002-6584-5333)*, GGM (0000-0002-8258-5350)*. All authors have revised and approved the final version of the manuscript. *ORCID (Open Researcher and Contributor ID).

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ANTEROLATERAL APPROACHES FOR PROXIMAL HUMERAL OSTEOSYNTHESIS: A SYSTEMATIC REVIEW

VIAS DE ACESSO ANTEROLATERAIS PARA OSTEOSSÍNTESE DO ÚMERO PROXIMAL: UMA REVISÃO SISTEMÁTICA

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ABSTRACT

Objective: Anterolateral approaches for proximal humerus osteosynthesis have great advantages because they allow direct exposure of the lateral aspect of the humerus without the muscular retraction seen in the deltopectoral approach. However, much resistance is found among surgeons due to the potential risk of iatrogenic injury to the axillary nerve. To identify the incidence of axillary nerve iatrogenic lesions and evaluate the functional results of proximal humerus osteosynthesis with locking plates using anterolateral approaches. **Methods:** The literature review followed the PRISMA protocol. **Results:** A total of 23 articles were selected from 786 patients submitted to anterolateral approaches. Three cases (0.38%) of iatrogenic axillary nerve lesions were confirmed. The results of the functional tests were similar to those of the deltopectoral approach. **Conclusion:** Anterolateral approaches are a viable and safe alternative for proximal humerus osteosynthesis with locking plate. Subacromial impingement was the most frequent complication. **Level of Evidence II, Systematic Review.**

Keywords: Humeral Fractures, Surgery, Complications, Osteosynthesis.

RESUMO

Objetivo: As vias de acesso anterolaterais para a osteossíntese do úmero proximal permitem a exposição direta do aspecto lateral do úmero sem necessitar das retrações musculares da via deltopectoral. Contudo, há grande preocupação com a possibilidade de lesão iatrogênica do nervo axilar e consequente piora no resultado funcional pós-operatório. Identificar a incidência de lesões iatrogênicas do nervo axilar e avaliar os resultados funcionais da osteossíntese do úmero proximal com placas bloqueadas, utilizando as vias anterolaterais. **Métodos:** Revisão da literatura seguindo o protocolo PRISMA. **Resultados:** Foram selecionados 23 artigos do total de 786 indivíduos submetidos às vias de acesso anterolaterais. Foram confirmados 3 casos (0,38%) de lesões iatrogênicas do nervo axilar. Os resultados dos testes funcionais foram semelhantes aos da via deltopectoral. **Conclusão:** As vias de acesso anterolaterais são uma alternativa viável e segura para a osteossíntese do úmero proximal com placas bloqueadas. **Nível de Evidência II, Revisão Sistemática.**

Descritores: Fixação interna de fraturas, fraturas do úmero proximal, complicações, cirurgia.

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INTRODUCTION

The deltopectoral approach is commonly used for surgical treatment of proximal humerus fractures;^{1,2} however, it can be difficult to expose cases of greater tuberosity fractures posteriorly deviated or cases of fractures with retroversion of the humeral head with this method.³

The anterolateral approach to proximal humerus fractures is performed between the anterior and middle portions of the deltoid. Thus, it provides better exposure of the greater tuberosity when posteriorly deviated, and also to the lateral aspect of the humerus, facilitating placement of a locking plate as the implant has a fixed angle.³

Some surgeons avoid the anterolateral approach due to the potential risk of iatrogenic injury to the anterior branch of the axillary nerve.⁴ This nerve can be identified during surgery either by direct visualisation (extended exposure) or by palpation through a deltoid incision, as described by the minimally invasive plate osteosynthesis (MIPO) technique.

Burkhead described the distance of the nerve to the acromion.⁵ Mackenzie reported an extended approach capable of exposing the anterolateral aspect of the proximal humerus safely for total shoulder arthroplasty.⁶ Studies of the anterolateral approach and the anatomical description of the axillary nerve have gained new popularity with the advent of locking plates.^{3,7-9}

All authors declare no potential conflict of interest related to this article.

This study was conducted at the Orthopedics and Traumatology Department of Faculdade de Ciências Médicas da Universidade Estadual de Campinas (UNICAMP), Campinas, SP, Brazil. Correspondence: Caixa Postal 6111, Campinas, SP, Brazil. 13081-970. ggmouraria@hotmail.com



This review identifies the incidence of iatrogenic axillary nerve lesions and evaluates the clinical results of internal fixation of proximal humerus fractures treated with locking plates using anterolateral approaches.

MATERIALS AND METHODS

This review followed the PRISMA protocol.¹⁰ The search was carried out in the PUBMED, EMBASE, and Cochrane databases using the following terms (PICOS method): Patient: humerus fracture, proximal humerus fracture, shoulder fracture and related terms; Intervention: deltoid split approach, anterolateral approach, Mackenzie approach and related terms; Comparison: Deltopectoral approach (unfixed item); Outcomes: axillary nerve palsy, axillary nerve injury, functional outcomes and related terms; Study design: randomised controlled trial, observational studies.

The review was conducted in August 2016 and repeated in June 2017 to include the most recent literature. The criteria for including articles were English language, proximal humerus fracture due to trauma, description of the approach, use of a locking plate, minimum 6-month follow-up, and relevant functional results, such as functional score, range of motion, pain, or satisfaction. Studies that did not achieve all of these criteria were excluded. Studies that used an extended approach through which the skin was incised in an elliptical flap were also excluded.¹¹ Information regarding institutions, authors, and journals was not revealed to minimise bias. The selected articles were evaluated in full by two reviewers regarding the demographic characteristics of the patients, follow-up time, type of fracture, type of approach, functional results assessed by clinical and radiographic parameters, rehabilitation protocol, and quality of the publication. The disagreements were resolved by joint review of the same reviewers. Agreement between the reviewers was assessed by Kappa statistics.

RESULTS

A total of 2,781 articles were obtained. Of these, 103 contained titles and abstracts relevant to the study and were selected for a complete reading of the text. After this stage, 24 articles (Kappa = 0.60; $p < 0.001$) were included, of which 1,162 patients were selected, and 831 anterolateral approaches were performed. The general characteristics of the studies are described in Table 1. There was great heterogeneity between the studies. Only two randomised clinical trials compared anterolateral to deltopectoral approaches. Mean patient age was 63.4 years, and 67% were female. In the studies that compared the anterolateral approach with the deltopectoral approach, the distributions of age and sex were homogeneous between the groups. Seven studies (303 individuals) evaluated the correspondence between the fracture side and the dominant side, and 50.3% of cases were ipsilateral.

The fractures were classified according to Neer in 14 articles, according to the OTA/AO classification in five articles, and by both Neer and OTA/AO in three. Two studies did not define the fracture classification. According to the Neer classification, fractures in two parts corresponded to 30.5%, three parts to 51.0%, and four parts to 18.5% of the cases. Based on the AO classification, type A fractures corresponded to 20.8%, type B 45.8%, and type C 33.4%. No difference was observed in fracture type between the groups in studies that compared the type of approach.

The most commonly used anterolateral approach was deltoid split with MIPO, described in 18 articles (695 patients). The extended deltoid split (Mackenzie), was used in four articles (77 patients). Two studies (total, 59 patients) used both approaches depending on the type of fracture or plate size.

Table 1. General characteristics of the articles.

Author	Year	Type of study	N (**)	Age	Approaches
Sohn et al. ¹²	2017	Prospective	90/45	64	Deltoid-split (MIPO) x Deltopectoral
Buecking et al. ¹³	2014	Prospective	90/48	69*	Deltoid-split (MIPO) x Deltopectoral
Fischer et al. ¹⁴	2016	Retro	50/20	59.4	Deltoid-split (MIPO) x Deltopectoral
Liu et al. ¹⁵	2015	Retro	91/39	60.2*	Deltoid-split (MIPO) x Deltopectoral
Jung et al. ¹⁶	2013	Retro	32/32	72.4	Deltoid-split (MPO)
Martetschläger et al. ¹⁷	2012	Retro	70/37	59	Deltoid-split (MIPO) x Deltopectoral
Wu et al. ¹⁸	2011	Retro	60/28	58.6*	Deltoid-split(MIPO)/ Extended deltoid split) x Deltopectoral
Röderer et al. ¹⁹	2010	Retro	54/54	70	Deltoid-split (MIPO)
Hepp et al. ²⁰	2008	Retro	83/39	65	Deltoid-split (MIPO) x Deltopectoral
Lin et al. ²¹	2014	Retro	86/43	63*	Deltoid-split (MIPO) x Deltopectoral
Falez et al. ²²	2016	Retro	74/74	68.5	Deltoid-split (MIPO)
Chen et al. ²³	2015	Retro	27/27	67.3	Deltoid-split (MIPO)
Koljonen et al. ²⁴	2015	Retro	40/40	63	Deltoid-split (MIPO)
Bockmann et al. ²⁵	2015	Retro	52/52	67	Deltoid-split (MIPO)
Oh et al. ²⁶	2015	Retro	26/26	67	Deltoid-split (MPO)
Singh et al. ²⁷	2015	Retro	20/20	45.9	Deltoid split (MIPO)
Imarisio et al. ²⁸	2013	Retro	29/29	53	Deltoid-split (MIPO)
Barco et al. ²⁹	2012	Retro	23/23	62	Deltoid-split MIPO
Ruchholtz et al. ³⁰	2011	Retro	50/50	65.5	Deltoid-split (MIPO) x Extended deltoid split
Gavaskar et al. ³¹	2010	Retro	15/15	43	Deltoid split (MIPO)
Laflamme et al. ³²	2008	Retro	27/27	64	Deltoid split (MIPO)
Gardner et al. ³³	2008	Retro	23/23	65	Extended deltoid split
Somasundaram et al. ³⁴	2013	Retro	21/11	64.6	Extended deltoid split x Deltopectoral
Acklin et al. ³⁵	2012	Retro	29/29	64	Deltoid-split (MIPO)

*Related only to the anterolateral approach; **Total number of individuals completing follow-up in the study/individuals among whom were submitted to the anterolateral approach. Retro, retrospective.

Studies that did not expose the axillary nerve (MIPO) described a longitudinal incision starting from the lateral or anterolateral edge of the acromion, following distally by 5 cm or starting 1 cm below the acromion and following distally by up to 4 cm.¹² The anterior and middle fibres of the deltoid were dissected (no more than 5 cm in relation to the acromion). Next, a digital scan was performed to identify the axillary nerve without visualising it. After identifying the nerve, two alternatives were observed. The first was maintenance of a skin bridge over the nerve path associated with a second 2–3-cm distal incision, guided or not by fluoroscopy, to access the distal portion of the plate. The second was the performance of mini incisions, sufficient for the passage of a screw each, guided by fluoroscopy.

Studies that exposed the axillary nerve (extended approach) made an incision of 10 cm (range, 6–12 cm) that began at the lateral or anterolateral edge of the acromion and followed distally parallel to the axis of the diaphysis. The anterior and middle portions of the deltoid were separated, and the axillary nerve was identified under direct and protected visualisation.

The most commonly used locking plate was the PHILOS (Proximal Humerus Internal Locking System; DePuy Synthes) followed by NCB-PH (Non-Contact Bridging-Proximal Humerus; Zimmer). In

addition to osteosynthesis, one study used a bone graft, and another (autologous) used a bone substitute.^{23,34} Another study used the same anterolateral approach for osteosynthesis with both locking plates (14 cases) and intramedullary nails (9 cases).³³

The Constant–Murley score was the most frequently used functional evaluation, (21 articles) with an average of 75.2 points in patients treated with an anterolateral approach. (Table 2) The Disabilities of the Arm, Shoulder and Hand (DASH) test was the second most used (nine articles) with an average of 16.9 in the same group. Among studies that compared the approaches, no study showed a significant difference in the functional scores between the anterolateral and the deltopectoral approaches. The anterolateral approach group showed a significantly better performance during the first postoperative month.

Three cases (0.38%) of iatrogenic lesions of the anterior axillary nerve branch identified by clinical criteria (18 articles) or associated with electrophysiological studies (5 articles) were confirmed. (Table 2) The main clinical criteria observed were atrophy of the anterior deltoid and loss of shoulder elevating strength.

One study compared the operated side with the contralateral healthy shoulder and observed a decrease in anterior flexion and lateral elevation, but did not attribute these deficits to axillary nerve injury.¹⁹ Another study identified the same clinical presentation in three patients, but only one had the axillary nerve lesion confirmed by electromyography.¹⁶ Hypotrophy of the anterior deltoid was identified in one case of another study, but the electromyography did not present changes.²⁹ All confirmed cases of iatrogenic axillary nerve injury occurred during the minimally invasive approach.

Axillary nerve evaluation was the only complication described in all articles. The main complication was subacromial impingement. No other complications were uniformly evaluated and are described in Table 3.

DISCUSSION

Surgical treatment for fractures of the proximal humerus has undergone a great evolution with locking plates. The biomechanical characteristics of this implant provide better fracture stability, particularly in elderly patients and those with osteoporosis.³⁶ Locking plates have a fixed angle and should be attached to the lateral aspect of the humerus. Thus, exposing this area is fundamental to the surgical approach.³⁶ The deltopectoral approach does not require identifying the axillary nerve and this approach is the most performed by surgeons for proximal humerus osteosynthesis.

Mackenzie was the first to describe the extended anterolateral approach to arthroplasties; no iatrogenic lesions were detected on the axillary nerve. Gardner demonstrated the safety and efficacy of this approach in proximal humeral osteosynthesis. However, today few surgeons opt for this approach due to the potential risk to the axillary nerve.³⁷ We have seen an increase in the number of articles that evaluated the use of the anterolateral approach, especially by MIPO.

The most commonly used anterolateral approach was the MIPO technique. All articles respected the parameters established by Burkhead for the axillary nerve safety zone.⁵ Use of the most distal screws of the plate should be avoided due to the risk of injury to the axillary nerve in the MIPO technique.⁴ However, these screws are responsible for stabilising the proximal posteromedial region of the humerus, adding biomechanical stability.³⁸ Thus, the extended anterolateral approach with direct observation of the axillary nerve, allows use of these screws safely, leading to more stability for the osteosynthesis. Furthermore, no case of axillary nerve injury was observed in patients treated with the extended approach as observed by Mackenzie and Gardner.⁶ The studies were heterogeneous in the axillary nerve evaluation methods, as some performed only a clinical

Table 2. Clinical evaluation.

Author	Year	Score / Functional evaluation	Number axillary palsy (evaluation method)
Sohn et al. ¹²	2017	Constant, UCLA, VAS	None (Clinical)
Buecking et al. ¹³	2014	Constant, ADL, VAS	None (Clinical)
Fischer et al. ¹⁴	2016	Constant, DASH, ASES, ROM,	None (ENMG)
Liu et al. ¹⁵	2015	Constant, DASH, ROM	None (Clinical)
Jung et al. ¹⁶	2013	Constant, VAS, ROM, ADL	1 (ENMG)
Martetschläger et al. ¹⁷	2012	Constant, ADL, ROM, ASES, DASH, Strength	None (Clinical)
Wu et al. ¹⁸	2011	Constant, DASH	None (ENMG)
Röderer et al. ¹⁹	2010	Constant, ROM	None (Clinical)
Hepp et al. ²⁰	2008	Constant, DASH	None (Clinical)
Lin et al. ²¹	2014	Constant	1 (Clinical + ENMG)
Falez et al. ²²	2016	Constant	None (Clinical)
Chen et al. ²³	2015	Constant	None (Clinical)
Koljonen et al. ²⁴	2015	Constant, QuickDASH, ROM	None (Clinical)
Bockmann et al. ²⁵	2015	Constant, ADL, VAS	None (Clinical)
Oh et al. ²⁶	2015	DASH, UCLA, ROM, VAS	None (Clinical)
Singh et al. ²⁷	2015	Constant	None (Clinical)
Imariso et al. ²⁸	2013	Constant	None (Clinical)
Barco et al. ²⁹	2012	Constant, DASH	None (ENMG)
Ruchholtz et al. ³⁰	2011	Constant, VAS, DASH	None (Clinical)
Gavaskar et al. ³¹	2010	Constant, ROM	None (Clinical)
Laflamme et al. ³²	2008	Constant, DASH	None (Clinical)
Gardner et al. ³³	2008	Quick-DASH, ROM	None (Clinical)
Somasundaram et al. ³⁴	2013	Constant, DASH	None (Clinical)
Acklin et al. ³⁵	2012	Constant	1 (Clinical)

ADL score: activities of daily living; SST score: simple shoulder test; ASES score: American Shoulder and Elbow Surgeons; VAS: visual analogue scale of pain; ROM: range of motion; ENMG: electroneuromyography; DASH, the Disabilities of the Arm, Shoulder and Hand test.

Table 3. Incidence of complications.

Complication	Variation	Average	Number of articles that did not seek complications
Head implant loosening	0–8 %	3.32%	5
Infection	0–8%	1.4%	6
Screw perforation	0–12%	2.7%	5
Osteonecrosis	0–6%	0.8%	0
Impingement	0–25%	4.8%	6
Malreduction	0–10%	6.6%	1
Non-union	0–15%	1.36%	2

evaluation, whereas others used electromyography. However, the presence of anterior hypotrophy in the deltoid did not necessarily correlate with neurological damage, and it may be assumed that a functional evaluation is more effective and predictive of outcome than electromyography.

Four-part fractures were the least prevalent. Thus, there is no way of stating whether the choice through the anterolateral approach (mainly through the MIPO technique) was prioritised in cases of less complexity. Decreased shoulder function and complications are much more frequent in patients with four-part fractures.¹² The shoulders in this review were evaluated mainly by the Constant and DASH scores and showed a good postoperative function. On average, the scores were similar to those that used a deltopectoral

approach.^{37,38} Most of the articles did not describe the range of motion, perhaps because its importance in postoperative patient satisfaction has not yet well been defined in the literature.³² The main complication was subacromial impingement. In some articles, it was unclear whether the impact was due to an incorrectly positioned plate or a secondary varus collapse of the head. However, one of the consequences of humeral head varus consolidation is secondary impact. Thus, if we add the patients who evolved with symptoms of impact with those who consolidated in varus, an incidence of 11.4% of complications related to the final position of the implant or reduction of the fracture was observed. This finding presupposes difficulty with fracture reduction, positioning of the plate and, adding mechanical stability to the fracture using the MIPO technique. This can occur due to a mistake of using the last proximal screws on the plate due to risk to the axillary nerve.^{32,35} In this case, the main strategies to avoid collapse of the varus were to tie the cuff to the plate or to place long screws near the subchondral bone, which can lead to joint perforations. Screw perforations into the shoulder joint occurred acutely in 2.7% of cases and were related to the lack of an intraoperative observation of this complication. However, progressive migration of the screws in the articular region correlated with both varus consolidation and osteonecrosis evolution. The association between osteonecrosis with migration of the screws to the articular region causes a significant worsening of functional outcome.³⁹

The evolution for osteonecrosis occurred on average in <1% of patients, a smaller incidence compared with the literature;³⁹ this could be related to a selection bias of the articles, as 85% of fractures were Neer 2 or 3. In addition, medial comminution criteria as described by Hertel⁴⁰ were not evaluated in most studies. However, an anterolateral approach, whether by the MIPO technique or extended, is less aggressive to soft tissue and may lead to a lower chance of osteonecrosis by preserving irrigation of the humeral head.³⁹ The progression to osteonecrosis is not always associated with a worse prognosis, especially in cases of partial necrosis.³⁹ This review had several limitations. First, only two randomised articles were identified. In addition, the studies were heterogeneous and lacked standardisation regarding the fracture classification, follow-up time, and a detailed description of the clinical evaluation method of the axillary nerve. Finally, the quality of the identified articles did not allow elaboration of the meta-analysis.

CONCLUSION

This systematic review found a low incidence of iatrogenic axillary nerve lesions and good functional outcomes in patients undergoing proximal humeral osteosynthesis treated with locking plates using an anterolateral approach by the extended deltoid split or MIPO technique. Subacromial impingement was the most frequent complication. Anterolateral approaches are an alternative for treating proximal humerus fractures.

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