U.PORTO

FMUP FACULDADE DE MEDICINA UNIVERSIDADE DO PORTO

MESTRADO INTEGRADO EM MEDICINA

2016/2017

João Francisco Matos Mendes

Critical Shoulder Angle: correlação com a extensão e retração das roturas tendinosas do supraespinhoso

Critical Shoulder Angle: correlation with extension and retraction of supraspinatus tendon tears

março, 2017

João Francisco Matos Mendes

Critical Shoulder Angle: correlação com a extensão e retração das roturas tendinosas do supraespinhoso

Critical Shoulder Angle: correlation with extension and retraction of supraspinatus tendon tears

Mestrado Integrado em Medicina

Área: Ortopedia e Traumatologia

Tipologia: Dissertação

Trabalho efetuado sob a Orientação de:

Doutor Manuel António Pereira Gutierres

Trabalho organizado de acordo com as normas da revista:

Journal of Shoulder and Elbow Surgery

março, 2017

U.PORTO
FMUP FACULDADE DE MEDICINA UNIVERSIDADE DO PORTO
UNIDADE CURRICULAR PROJETO DE OPÇÃO DISSERTAÇÃO / MONOGRAFIA

Projeto de Opção do 6º ano - DECLARAÇÃO DE INTEGRIDADE

Eu, João Francisco Matos Duarte, abaixo assinado, nº mecanográfico 201103631, estudante do 6º ano do Ciclo de Estudos Integrado em Medicina, na Faculdade de Medicina da Universidade do Porto, declaro ter atuado com absoluta integridade na elaboração deste projeto de opção.

Neste sentido, confirmo que **NÃO** incorri em plágio (ato pelo qual um indivíduo, mesmo por omissão, assume a autoria de um determinado trabalho intelectual, ou partes dele). Mais declaro que todas as frases que retirei de trabalhos anteriores pertencentes a outros autores, foram referenciadas, ou redigidas com novas palavras, tendo colocado, neste caso, a citação da fonte bibliográfica.

Faculdade de Medicina da Universidade do Porto, 16/03/2017

Assinatura conforme cartão de identificação:

João Francisco Matos Duarte

U.PORTO
FMUP FACULDADE DE MEDICINA UNIVERSIDADE DO PORTO
UNIDADE CURRICULAR PROJETO DE OPÇÃO DISSERTAÇÃO / MONOGRAFIA

Projecto de Opção do 6º ano – DECLARAÇÃO DE REPRODUÇÃO

NOME

João Francisco Matos Mendes

NÚMERO DE ESTUDANTE	E-MAIL
201103631	joaofr_mendes@hotmail.com

DESIGNAÇÃO DA ÁREA DO PROJECTO

Ortopedia e Traumatologia

TÍTULO DISSERTAÇÃO

Critical Shoulder Angle: correlation with extension and retraction of supraspinatus tendon tears

ORIENTADOR

Doutor Manuel António Pereira Gutierres

COORIENTADOR (se aplicável)

(não aplicável)

ASSINALE APENAS UMA DAS OPÇÕES:

É AUTORIZADA A REPRODUÇÃO INTEGRAL DESTE TRABALHO APENAS PARA EFEITOS DE INVESTIGAÇÃO, MEDIANTE DECLARAÇÃO ESCRITA DO INTERESSADO, QUE A TAL SE COMPROMETE.	☐
É AUTORIZADA A REPRODUÇÃO PARCIAL DESTE TRABALHO (INDICAR, CASO TAL SEJA NECESSÁRIO, Nº MÁXIMO DE PÁGINAS, ILUSTRAÇÕES, GRÁFICOS, ETC.) APENAS PARA EFEITOS DE INVESTIGAÇÃO, MEDIANTE DECLARAÇÃO ESCRITA DO INTERESSADO, QUE A TAL SE COMPROMETE.	☒
DE ACORDO COM A LEGISLAÇÃO EM VIGOR, (INDICAR, CASO TAL SEJA NECESSÁRIO, Nº MÁXIMO DE PÁGINAS, ILUSTRAÇÕES, GRÁFICOS, ETC.) NÃO É PERMITIDA A REPRODUÇÃO DE QUALQUER PARTE DESTE TRABALHO.	☐

Faculdade de Medicina da Universidade do Porto, 16/03/2017

Assinatura conforme cartão de identificação: João Francisco Matos Mendes

Ao meu Pai e à minha Mãe,

pelo seu apoio incondicional desde sempre.

Critical Shoulder Angle: correlation with extension and retraction of supraspinatus tendon tears

CSA and correlation with SSP tears

João Mendes[1], Manuel Gutierres, MD, PhD[2]

[1]Faculdade de Medicina, Universidade do Porto, Porto, Portugal

[2]Faculdade de Medicina, Universidade do Porto; Departamento de Ortopedia e Traumatologia, Hospital S. João, Porto, Portugal

Corresponding Author:

João Francisco Matos Mendes

Faculdade de Medicina da Universidade do Porto

Alameda Prof. Hernâni Monteiro, 4200-319 PORTO, Porto, Portugal

Tel: +351919634520

E-mail: joaofr_mendes@hotmail.com

Disclaimer: The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

This study has the approval by the Ethical Committee from our Institution (Comissão de Ética para a Saúde do Centro Hospitalar de São João/ Faculdade de Medicina da Universidade do Porto).

Elsevier Editorial System(tm) for Journal of Shoulder and Elbow Surgery

Manuscript Draft

Manuscript Number: JSES-D-17-00169

Title: Critical Shoulder Angle: correlation with extension and retraction of supraspinatus tendon tears

Article Type: Original Article

Keywords: Critical shoulder angle; scapular morphology; rotator cuff tear; osteoarthritis; shoulder radiograph; supraspinatus muscle.

Corresponding Author: Mr. João Francisco Matos Mendes,

Corresponding Author's Institution: Faculdade de Medicina, Universidade do Porto

First Author: João Francisco Matos Mendes

Order of Authors: João Francisco Matos Mendes; Manuel Gutierres, MD, PhD

Abstract: Background
The critical shoulder angle (CSA) is associated with the risk for rotator cuff tears (RCT) and primary osteoarthritis (OA). Musculotendinous retraction is considered the most relevant pathophysiological consequence of chronic tendon tearing. This study analyzed the existence of this association and explored a possible relation between CSA, supraspinatus muscle (SSP) retraction and tear extension.
Methods
We included 50 patients submitted to shoulder surgery, in which 38 have RCT and 7 have OA. Data about number of RCT muscles affected, tear gravity and extension, SSP retraction, gender and age were collected. CSA value quality was ensured using Suter-Henninger classification and with two-observer measuring, followed by a Bland-Altman plot.
Results
The CSA mean value on RCT patients was 35,3° ± 4,9° and on OA patients 27,9° ± 5,1°. The complete SSP tear group had a mean CSA of 36,7° ± 5,2°, significantly higher (p=0.03) than the partial tear group (33,3° ± 3,88°). Spearman test showed significant positive correlation between extension and retraction (R=0,525; p<0,01) but no correlation between CSA and retraction (p = 0,1). The large tear group is significantly older than the isolated SSP tear group (63,9 ± 9,02 years vs. 58 ± 7,35 years; p<0,05).
Conclusions
Higher CSA values are associated with the risk of RCT and lower values with OA. Larger angles are associated with increasing SSP tear gravity. No significant association between CSA and SSP retraction was found, although bigger SSP tears have more tendon retraction. Older age increases the risk of larger tears.

From: João Francisco Matos Mendes
Faculdade de Medicina da Universidade do Porto
Alameda Prof. Hernâni Monteiro, 4200-319 PORTO
Porto, Portugal

Dear editor:

We would like to submit a manuscript by João Mendes and Manuel Gutierres entitled "Critical Shoulder Angle: correlation with extension and retraction of supraspinatus tendon tears". It is a case series study about the influence of critical shoulder angle on the pathogenesis of degenerative diseases of the shoulder where we have deepened the study regarding the supraspinatus muscle. We investigated a possible correlation with the extension of the tear and the retraction of the tendon. Regarding this last parameter, we have not found any studies.
We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.We believe that this manuscript represents honest work, and may be a subject of interest to the readers of your journal.
We confirm that it has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.
We assess that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.
We further confirm that any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.
We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author.

Correspondence and phone calls about the paper please be directed to João Mendes, at the following address, telephone number, and e-mail address :

João Francisco Matos Mendes
Faculdade de Medicina da Universidade do Porto
Alameda Prof. Hernâni Monteiro, 4200-319 PORTO, Porto, Portugal
Tel: +351919634520
E-mail: joaofr_mendes@hotmail.com

Thank you very much for your attention to our paper.

The authors,

(João Mendes and Manuel Gutierres)

Date: 16 FEB 2017

Conflicts of Interest Statement

João Mendes: This author, their immediate family, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article.

Manuel Gutierres: This author, their immediate family, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article.

The authors:

(João Mendes and Manuel Gutierres) Date: 16-02-2017

Critical Shoulder Angle: correlation with extension and retraction of supraspinatus tendon tears.

Abstract

Background

The critical shoulder angle (CSA) is associated with the risk for rotator cuff tears (RCT) and primary osteoarthritis (OA). Musculotendinous retraction is considered the most relevant pathophysiological consequence of chronic tendon tearing. This study analyzed the existence of this association and explored a possible relation between CSA, supraspinatus muscle (SSP) retraction and tear extension.

Methods

We included 50 patients submitted to shoulder surgery, in which 38 have RCT and 7 have OA. Data about number of RCT muscles affected, tear gravity and extension, SSP retraction, gender and age were collected. CSA value quality was ensured using Suter-Henninger classification and with two-observer measuring, followed by a Bland-Altman plot.

Results

The CSA mean value on RCT patients was 35,3° ± 4,9° and on OA patients 27,9° ± 5,1°. The complete SSP tear group had a mean CSA of 36,7° ± 5,2°, significantly higher (p=0.03) than the partial tear group (33,3° ± 3,88°). Spearman test showed significant positive correlation between extension and retraction (R=0,525; p<0,01) but no correlation between CSA and retraction (p = 0,1). The large tear group is significantly older than the isolated SSP tear group (63,9 ± 9,02 years vs. 58 ± 7,35 years; p<0,05).

Conclusions

Higher CSA values are associated with the risk of RCT and lower values with OA. Larger angles are associated with increasing SSP tear gravity. No significant association between CSA

and SSP retraction was found, although bigger SSP tears have more tendon retraction. Older age increases the risk of larger tears.

Level of evidence

Level IV; case series with no comparison groups; epidemiology study.

Keywords

Critical shoulder angle; scapular morphology; rotator cuff tear; osteoarthritis; shoulder radiograph; supraspinatus muscle.

Introduction

Shoulder pain is a very limiting problem of an individual's daily life activities. It is considered the 3rd largest cause of musculoskeletal consultations in primary healthcare[29]. Rotator cuff tendinopathies (RCT) are the most common cause of shoulder pain in clinical practice, followed by other disorders like osteoarthritis (OA) of the glenoumeral joint [11, 18].

The etiology of these two disorders is multifactorial and poorly understood, notwithstanding their socioeconomic impact. There are some factors related like age, trauma and degeneration [6, 17, 28, 32], but there are also changes in acromial, glenoid and humeral morphologies that are degenerative-related and therefore considered risk factors. These morphology changes can be detected by radiograph imaging, for example, and modify its parameters when comparing with non-pathological shoulders [1, 12, 23-25].

As such there has been a great effort in the search for new parameters of monitoring and understanding of these pathologies, with the goal of improvement the quality of life of these patients.

The critical shoulder angle (CSA) is newly identified radiological parameter, first described in 2013 by Moor et al. [19]. It consists in an angle obtained by a line that connects the superior and inferior margins of the glenoid fossa and a second line that connects the inferior glenoid margin to the most inferolateral point of the acromion (**Figure 1**). It can be measured by using common shoulder radiographs with true anteroposterior (AP) incidence (also called double-obliquity).

The CSA combines the measurement of the lateral extension of the acromion and the inclination of the glenoid fossa, that are known risk factors for RCT. [5, 19, 22] On the other hand, a small lateral extension may increase the glenoumeral load and lead to a degenerative OA.

There is evidence of a significant association between CSA values and the genesis of degenerative pathologies. While bigger values are associated with degenerative RCT and eccentric OA, smaller values are associated with concentric OA [3, 4, 19, 21, 26]. Furthermore, a

significant relation between the severity of these pathologies and CSA was documented, in which bigger CSAs lead to an increased risk of symptomatic, larger RCTs and symptomatic eccentric OA. Smaller CSAs lead to an increased risk and severity of symptomatic concentric OA. [3] A recent report found that higher CSA values significantly increased probability of retear after rotator cuff repair.[7] Another study found that mean CSA, in combination with age and trauma, can predict the presence of a posterosuperior RCT. [21]

The explanation in which this association subsists is that the increase in CSA results in a verticalization of the force vector of the deltoid, pulling the humeral head upwards toward the rotator cuff. There is an increase of the shear force between the glenoid and the humeral head, and mechanical overload leads to a compensatory activity of supraspinatus muscle (SSP), required to maintain shoulder stability during active abduction, causing non-traumatic RCTs. Oppositely, smaller CSAs increase the load on glenoumeral joint's surface, caused by a higher compressive force from the deltoid muscle, with more than normal joint reaction forces, causing degeneration and development of OA. This theory was proved in several biomechanical studies with shoulder simulators. [9, 19, 20, 30, 31]

From a quantitative point of view, in several studies, the mean CSA value observed in control groups was 33/34°, in individuals with RCT between 35 and 40° and with OA around 28°. CSAs above 35° are RCT and eccentric OA-related and below 30° are concentric OA-related. [3-5, 19, 21, 22, 26, 27]

The musculotendinous retraction of rotator cuff muscles is mainly accepted as the most relevant pathophysiological consequence of chronic tendon tearing. It is considered a major limitation for a successful operative tendon-to-bone repair. [8, 10, 13, 14, 16, 33] A report made by Meyer et al.[16] has demonstrated that the retraction of SSP muscle, in combination with Goutallier grading[10] could be a more powerful predictor for success of a rotator cuff repair surgery.

We hypothesized that CSA, as a predictor of SSP tearing and its directly proportional association with the gravity of the lesion could have a correlation with the size of SSP tendon retraction.

The aim of this study is to find if the existence of the previously found association between higher CSA and RCT and lower CSA and OA in our population. We wanted to assess the correlation with CSA magnitude and the gravity of RCT tears (including SSP tear isolated), and to study a possible association between CSA, SSP retraction and tear extension. The association with age will be considered also in this study.

Methods

Patient selection

The population included in this study were individuals submitted to shoulder surgery at Hospital S. João, Porto, between January 2011 and October 2016.

We included a total of 50 patients with true AP shoulder radiographs, recorded in the institutions' database, with previously diagnosed RCT, OA, shoulder dislocation and subacromial impingement. We collected data about gravity, number of RCT muscles affected and extension of tears, retraction of SSP gender and age. This study was approved by the Ethics Committee from our Institution.

Individuals with postoperative radiographs, with non-true AP radiographs and with low quality true AP radiographs were excluded from this study. Furthermore, patients with inflammatory arthritis, shoulder fractures and younger than 18 years were excluded. Finally, patients with a combination of both RCT and concentric OA pathologies were excluded.

The quality of radiographs was evaluated according to the Suter-Henninger scapular classification system[27]. Scapulas showing any glenoid double contour with >50% of glenoid height and with inverted teardrop patterns at the upper glenoid rim were excluded from this study. A 5° anteversion of the scapula results in a >2° CSA deviation from a true AP radiograph. Using this classification system, the authors refer that there is an 89% probability of having a CSA within the <2° range to have therefore a reliable true AP view.

A total of 50 patients meet these inclusion criteria. Among them, we have 38 RCT patients, 7 concentric OA patients, 4 shoulder dislocations and 1 subacromial impingement. 1 patient with RCT had eccentric OA simultaneously.

The history of these patients was obtained retrospectively using the data recorded from previous medical appointments. The diagnosis was confirmed by MRI (Magnetic Ressonance Imaging), CT (Computer Tomography) or ultrasound and then during surgery.

Regarding RCT patients, the details about the extension, retraction and muscles affected were obtained from MRI, CT and ultrasound reports made by radiology specialists. To assess the gravity of the supraspinatus muscle (SSP) lesion, based on its extension, a score was created to divide these patients in five categories. Score "1" (Score_SupraSp 1) included patients whose tear extension is found in the first quartile of all measurable tears, and Score_SupraSP 2,3 and 4 included tears in the second, third and fourth quartile, respectively. Finally, Score_SupraSP 5 refers to full-thickness/complete tears. As such an increase of this score is directly proportional to the gravity of the SSP tear.

It was also documented the presence of partial and complete tears of the infraspinatus (ISP) and subscapularis (SSC) muscles.

The CSA measure was made using the software integrated in the institution´s informatic system (by Sectra®), using the technique previously described. Two observers, blinded to the MRIs findings, made a total of 3 measurements on the same radiographs. The first observer made a first measurement and then a second 2 months after, to evaluate intraobserver reliability. The second observer made the 3rd measurement for the interobserver reliability.

Statistical Methods

Statistical analysis was conducted with IBM® SPSS Statistics 24. Intraobserver and interobserver reliabilty was evaluated according to the Bland-Altman method[2]. Descriptive analysis was performed to assess means, standard deviations (SD) and minimum and maximum values. Student t test was performed to compare means between groups. A confidence interval of 95% was used. A Spearman correlation was made to assess the correlation between age, CSA, SSP retraction and SSP extension. Statistical significance was set as $p<0,05$.

Results

The CSA measure had an excellent intraobserver reliability, with only 0,15° bias and limits of agreement of -1,5° and 1,8°. The interobserver reliability was great with a 0.3° bias and limits of agreement between -3.6° and 4,2° (**Figure 2**).

The mean age of all individuals in the study was 59,14 ± 12,622 years (20 to 81 range), and 35 were female (70%) and 15 were male (30%). The concentric OA patients were significantly older comparing to RCT patients age (70,3 ± 9,2, range 59 to 81, versus 60,5 ± 8,4 years, range 43 to 79; p<0,01). No significant difference was found between mean age of women and men and no correlation was found between age and CSA in each of the groups.

The CSA mean value on RCT patients was 35,3° ± 4,9° (range 22,1° to 48,2°), on concentric OA patients 27,9° ± 5,1° (range 19,8° to 32,7°) and on dislocation patients 35,1° ± 3,6° (range 30,8 to 38,1°) (**Table I)**. The eccentric OA patient had a CSA of 39° and the subacromial impingement patient had CSA of 33,5°.

Among RCT patients (76%; N=38), there were 37 cases of SSP tears (97,4%), 10 cases of SSC tears (26,3%) and 9 cases of ISP tears (23,7%). Of these, 22 were cases of isolated SSP tears (57,9%), 1 isolated SSC tear (2,6%) and there were no isolated ISP tears. Regarding large tears (RCT involving more than 1 muscle; N=14), there were 5 cases of SSP and ISP tears (13,2%), 5 cases of SSP and SSC tears (13,2%) and 4 cases of SSP, ISP and SSC tears (10,5%).

About SSP tears, 16 (43,2%) were partial and 20 (54,1%) were complete/full-thickness; 3 ISP tears were partial (33,3%) and 6 were complete (66,7%); 7 SSC tears were partial (70%) and 3 were complete (30%).

Score_SupraSP 2 patients were significantly younger than Score_SupraSP 1 (p=0.01) and 5 (p< 0,01) patients, but no significant difference between the other remaining groups was found.

Regarding CSA mean value, there was found only a statistical difference between Score_SupraSP 1 and 5 (p<0,05) (**Figure 3**). Consequently, we have reduced this 5-stage SSP

score into a simpler 2-stage, binary score (ScoreBin_SupraSP), in which ScoreBin_SupraSP 1 represents a partial tear and ScoreBin_SupraSP 2 a complete tear.

The mean CSA differed significantly (p=0.03) between ScoreBin_SupraSP 1 (33,2° ± 3,9°, range 27,7 to 39,8°) and ScoreBin_SupraSP 2 (36,8° ± 5,2°, range 22,1 to 48,2°) (**Figure 4**). No significant differences were found between the mean age of these two groups.

Regarding the retraction of the SSP tears, the Spearman correlation showed a significant correlation between retraction and extension of SSP tears (R=0,525; p<0,01)). However, no significant correlation was found between retraction and CSA (p = 0,1) (**Figure 5**). Data used to study Score_SupraSP is resumed in **Table II**.

SSP isolated tears had a mean CSA of 34,04° ± 5,5° (range 22,1 to 48,2°) and large tears a CSA of 36,99° ± 3,38° (range 29,40 to 40,50). The mean age on the first group was 58 ± 7,35 years (range 43 to 68), and the second group was significantly older with 63,9 ± 9,02 years (range 50 to 79; p<0,05). Data used to study Score_SupraSP is resumed in **Table III**.

Discussion

When Moor et al. created this radiological index [19], they had the goal of using a simple, economical and highly reproducible way to assess the risk of having RCT or OA. Afterwards, several studies appeared to prove that exists a cause and effect relationship [9, 19, 20, 30, 31] behind this relationship.

The most relevant finding in our present report is that our results regarding mean CSA in RCT (35,3°) and OA groups (27,9°) were consistent with the reports made by Blonna et al. (36° for RCT and 28° for OA) [3], Moor et al. (38° for RCT and 28,1° for OA) [19, 21, 22], Cherchi et al. (36,4°for RCT) [4] and Spiegl et al. (37,3º for RCT and 28,7° for OA)[26]. Moor et al. even predicted that patients with CSA > 35° are at risk for RCT with a sensitivity of 82% and a specificity of 92% and patents with CSA < 30° are at risk for concentric OA with a sensitivity of 78% and specificity of 97%.[19] This reinforces even more the strong association between CSA and RCT and OA, reaffirming this finding made by those previous studies.

Our case of eccentric OA also had a high CSA value (39°) consistent with a previous described study by Blonna et al.[3], where they have related an association between larger angles and increased risk of eccentric OA.

We have also found that patients with complete SSP tears have a significantly higher CSA than patients with partial SSP tears. These results are somewhat similar of those Moor et al. [21] found. They have also studied the influence of CSA on SSP tears and found that patients with complete SSP tears have a significant higher CSA and age comparing to patients with structurally intact tendons. Nevertheless, our results were expected and fit perfectly in the theory that higher CSAs lead to more severe RCTs. On the other side, our data regarding SSP extension and age were not consistent with this mentioned study and theory.

Our report also studied a possible association between retraction and CSA. Although it was found that there is a positive correlation between extension and retraction of the SSP muscle,

we did not found a correlation between CSA and retraction. This may be explained by the fact that the retraction is more related to the time since the occurrence of the injury, which leads to muscle atrophy and fat infiltration, than with the anatomical features implied in a high CSA shoulder (more lateral extension of the acromion and higher inclination of the glenoid fossa, leading to an overload of supraspinatus muscle activity).

The already mentioned study made by Blonna et al [3] also found that larger tears are associated with higher CSAs and age. In this report, we studied the same factors in our population and we only found a significant association between tear size and age.

The CSA could have an important clinical utility in the near-future. A pre-operative analysis of the CSA can help in clinical decision, predicting the surgical outcome after a total shoulder replacement. A shoulder replacement in an abnormal CSA shoulder may lead to a higher probability of recurrence. We can also use this parameter for a better selection criteria for a reverse shoulder replacement. Furthermore, the CSA can be used to achieve new surgical techniques based on it. An anatomic cadaveric study made by Katthagen et al. [15] has shown that the combination of a standard anterolateral acromioplasty and lateral acromion resection (5 mm) has reduced significantly CSA (from > 35° to between 30-35°) without damaging the deltoid origin. This new surgical approach is promising and further studies should be done to better assess the feasibility of this technique.

There are some limitations in this study. First, the number of patients included in our study is somewhat limited (n=50), and some of these patients were included in this study but weren't used for the main goals of this study, such as our patients with subacromial impingement and shoulder dislocation. Consequently, a power sample analysis could not be done. The retrospective characteristics of this study and the absence of a group control (there are no double-obliquity radiographs on non-pathological shoulders in our Institution) are another

223 important limitations, as well as a selection bias (only symptomatic and undergoing surgery
224 patients were selected).
225 However our inclusion criteria were very precise and restrict (excluding interobserver and
226 intraobserver bias and using a pre-established and scientifically proved radiological
227 classification that ensures that there are no significant deviations of CSA caused by malrotation
228 of the scapula on our radiographs, the Suter-Henninger scapular classification system [27]) giving
229 high quality CSA values. Beyond that, most of the results obtained had a clear statistical
230 significance and were consistent with several studies made previously. Nevertheless, more
231 studies in this area are necessary to explore the potentialities of this radiological parameter and
232 to find a practical clinical utility in the future.

Conclusion

This study confirms the previously related association between higher CSA values with RCT and lower CSA values with OA. Also, larger angles are associated with an increasing gravity of SSP tears. Although bigger SSP tears have more tendon retraction, there is no significant association between CSA and SSP retraction. Older age increases the risk of larger tears.

References

1. Banas MP, Miller RJ, Totterman S. Relationship between the lateral acromion angle and rotator cuff disease. J Shoulder Elbow Surg. 1995;4(6):454-61.
2. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986;1(8476):307-10.
3. Blonna D, Giani A, Bellato E, Mattei L, Calo M, Rossi R, et al. Predominance of the critical shoulder angle in the pathogenesis of degenerative diseases of the shoulder. J Shoulder Elbow Surg. 2016;25(8):1328-36.
4. Cherchi L, Ciornohac JF, Godet J, Clavert P, Kempf JF. Critical shoulder angle: Measurement reproducibility and correlation with rotator cuff tendon tears. Orthop Traumatol Surg Res. 2016;102(5):559-62.
5. Daggett M, Werner B, Collin P, Gauci MO, Chaoui J, Walch G. Correlation between glenoid inclination and critical shoulder angle: a radiographic and computed tomography study. J Shoulder Elbow Surg. 2015;24(12):1948-53.
6. Fehringer EV, Sun J, VanOeveren LS, Keller BK, Matsen FA, 3rd. Full-thickness rotator cuff tear prevalence and correlation with function and co-morbidities in patients sixty-five years and older. J Shoulder Elbow Surg. 2008;17(6):881-5.
7. Garcia GH, Liu JN, Degen RM, Johnson CC, Wong A, Dines DM, et al. Higher critical shoulder angle increases the risk of retear after rotator cuff repair. J Shoulder Elbow Surg. 2016.
8. Gerber C, Schneeberger AG, Hoppeler H, Meyer DC. Correlation of atrophy and fatty infiltration on strength and integrity of rotator cuff repairs: a study in thirteen patients. J Shoulder Elbow Surg. 2007;16(6):691-6.

9. Gerber C, Snedeker JG, Baumgartner D, Viehofer AF. Supraspinatus tendon load during abduction is dependent on the size of the critical shoulder angle: A biomechanical analysis. J Orthop Res. 2014;32(7):952-7.
10. Goutallier D, Postel JM, Bernageau J, Lavau L, Voisin MC. Fatty muscle degeneration in cuff ruptures. Pre- and postoperative evaluation by CT scan. Clin Orthop Relat Res. 1994(304):78-83.
11. Greenberg DL. Evaluation and treatment of shoulder pain. Med Clin North Am. 2014;98(3):487-504.
12. Hamada K, Fukuda H, Mikasa M, Kobayashi Y. Roentgenographic findings in massive rotator cuff tears. A long-term observation. Clin Orthop Relat Res. 1990(254):92-6.
13. Hersche O, Gerber C. Passive tension in the supraspinatus musculotendinous unit after long-standing rupture of its tendon: a preliminary report. J Shoulder Elbow Surg. 1998;7(4):393-6.
14. Jost B, Pfirrmann CW, Gerber C, Switzerland Z. Clinical outcome after structural failure of rotator cuff repairs. J Bone Joint Surg Am. 2000;82(3):304-14.
15. Katthagen JC, Marchetti DC, Tahal DS, Turnbull TL, Millett PJ. The Effects of Arthroscopic Lateral Acromioplasty on the Critical Shoulder Angle and the Anterolateral Deltoid Origin: An Anatomic Cadaveric Study. Arthroscopy. 2016;32(4):569-75.
16. Meyer DC, Wieser K, Farshad M, Gerber C. Retraction of supraspinatus muscle and tendon as predictors of success of rotator cuff repair. Am J Sports Med. 2012;40(10):2242-7.
17. Minagawa H, Yamamoto N, Abe H, Fukuda M, Seki N, Kikuchi K, et al. Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: From mass-screening in one village. J Orthop. 2013;10(1):8-12.
18. Mitchell C, Adebajo A, Hay E, Carr A. Shoulder pain: diagnosis and management in primary care. BMJ. 2005;331(7525):1124-8.

19. Moor BK, Bouaicha S, Rothenfluh DA, Sukthankar A, Gerber C. Is there an association between the individual anatomy of the scapula and the development of rotator cuff tears or osteoarthritis of the glenohumeral joint?: A radiological study of the critical shoulder angle. Bone Joint J. 2013;95-B(7):935-41.
20. Moor BK, Kuster R, Osterhoff G, Baumgartner D, Werner CM, Zumstein MA, et al. Inclination-dependent changes of the critical shoulder angle significantly influence superior glenohumeral joint stability. Clin Biomech (Bristol, Avon). 2016;32:268-73.
21. Moor BK, Rothlisberger M, Muller DA, Zumstein MA, Bouaicha S, Ehlinger M, et al. Age, trauma and the critical shoulder angle accurately predict supraspinatus tendon tears. Orthop Traumatol Surg Res. 2014;100(5):489-94.
22. Moor BK, Wieser K, Slankamenac K, Gerber C, Bouaicha S. Relationship of individual scapular anatomy and degenerative rotator cuff tears. J Shoulder Elbow Surg. 2014;23(4):536-41.
23. Neer CS, 2nd. Degenerative lesions of the proximal humeral articular surface. Clin Orthop. 1961;20:116-25.
24. Neer CS, 2nd. Replacement arthroplasty for glenohumeral osteoarthritis. J Bone Joint Surg Am. 1974;56(1):1-13.
25. Neer CS, 2nd, Watson KC, Stanton FJ. Recent experience in total shoulder replacement. J Bone Joint Surg Am. 1982;64(3):319-37.
26. Spiegl UJ, Horan MP, Smith SW, Ho CP, Millett PJ. The critical shoulder angle is associated with rotator cuff tears and shoulder osteoarthritis and is better assessed with radiographs over MRI. Knee Surg Sports Traumatol Arthrosc. 2016;24(7):2244-51.
27. Suter T, Gerber Popp A, Zhang Y, Zhang C, Tashjian RZ, Henninger HB. The influence of radiographic viewing perspective and demographics on the critical shoulder angle. J Shoulder Elbow Surg. 2015;24(6):e149-58.

28. Tempelhof S, Rupp S, Seil R. Age-related prevalence of rotator cuff tears in asymptomatic shoulders. J Shoulder Elbow Surg. 1999;8(4):296-9.
29. Urwin M, Symmons D, Allison T, Brammah T, Busby H, Roxby M, et al. Estimating the burden of musculoskeletal disorders in the community: the comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. Ann Rheum Dis. 1998;57(11):649-55.
30. Viehofer AF, Gerber C, Favre P, Bachmann E, Snedeker JG. A larger critical shoulder angle requires more rotator cuff activity to preserve joint stability. J Orthop Res. 2016;34(6):961-8.
31. Viehofer AF, Snedeker JG, Baumgartner D, Gerber C. Glenohumeral joint reaction forces increase with critical shoulder angles representative of osteoarthritis-A biomechanical analysis. J Orthop Res. 2016;34(6):1047-52.
32. Yamamoto A, Takagishi K, Osawa T, Yanagawa T, Nakajima D, Shitara H, et al. Prevalence and risk factors of a rotator cuff tear in the general population. J Shoulder Elbow Surg. 2010;19(1):116-20.
33. Zanetti M, Gerber C, Hodler J. Quantitative assessment of the muscles of the rotator cuff with magnetic resonance imaging. Invest Radiol. 1998;33(3):163-70.

Figure and Table Legends

Fig. 1 True AP radiograph of a 70-year-old female patient with RCT and a CSA of 40,6°. CSA is obtained between a line that connects the superior and inferior margins of the glenoid fossa and a second line that connects the inferior glenoid margin to the most inferolateral point of the acromion.

Fig. 2 Intraobserver (above) and interobserver (under) reliability demonstrated by the Bland-Altman method. CSA_1 and 2: 1st and 2nd measure by the same observer. CSA_3 3rd measured by the other observer.

Fig. 3 Box plot representing the gravity of the SSP tear (Score_SupraSp 1 to 5), in which score 5 represents a complete tear. Only between Score 1 and 5 was significant difference between CSA value.

Fig. 4 Box plot representing the gravity of the SSP tear with the binary score (ScoreBin_SupraSp), in which score 1 represents a partial tear and score 2 represents a complete tear.

Fig. 5 On the left, the Spearman correlation test between the extension of SSP tears (Score_SupraSP 1 to 5; 5 represents a complete tear) and the retraction of the tendon. On the right, a dispersion graph showing the relation between CSA and retraction of the SSP tendon. No significant correlation was found.

Table I Data synopsis of mean CSA and age on rotator cuff tears, concentric and eccentric osteoarthritis (OA).

Table II Data Synopsis of Score_SupraSp. It divides the size of the SSP tear in a crescent order of gravity (5 indicates a complete tear). Data is organized according to CSA, Age and retraction of the SSP tendon

Table III Data Synopsis of ScoreBin_SupraSp. It divides the SSP tear in partial (1) and complete (2). Data is organized according to CSA and Age.

Figure 1

Click here to download high resolution image

Figure 2

Click here to download high resolution image

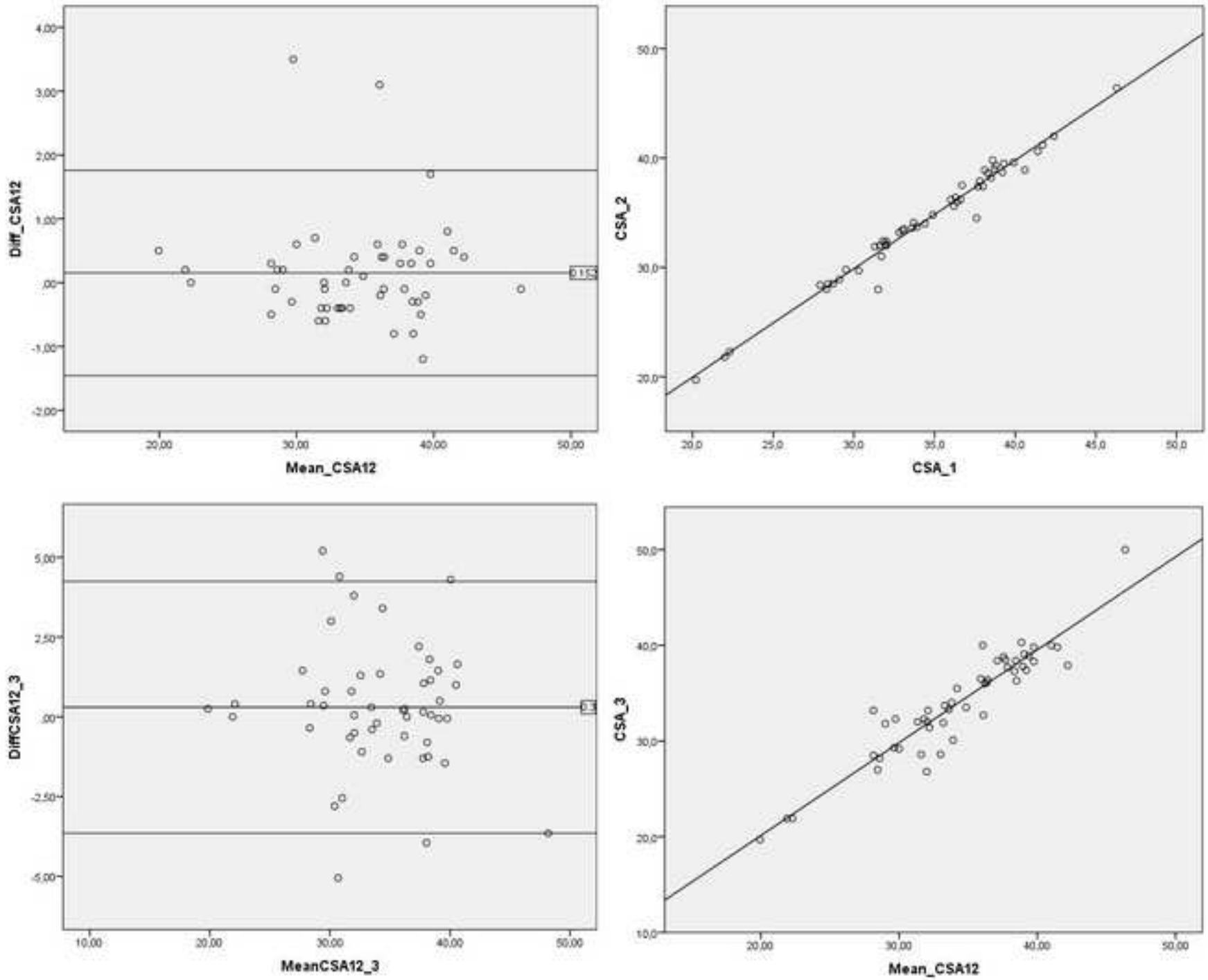

Figure 3

Click here to download high resolution image

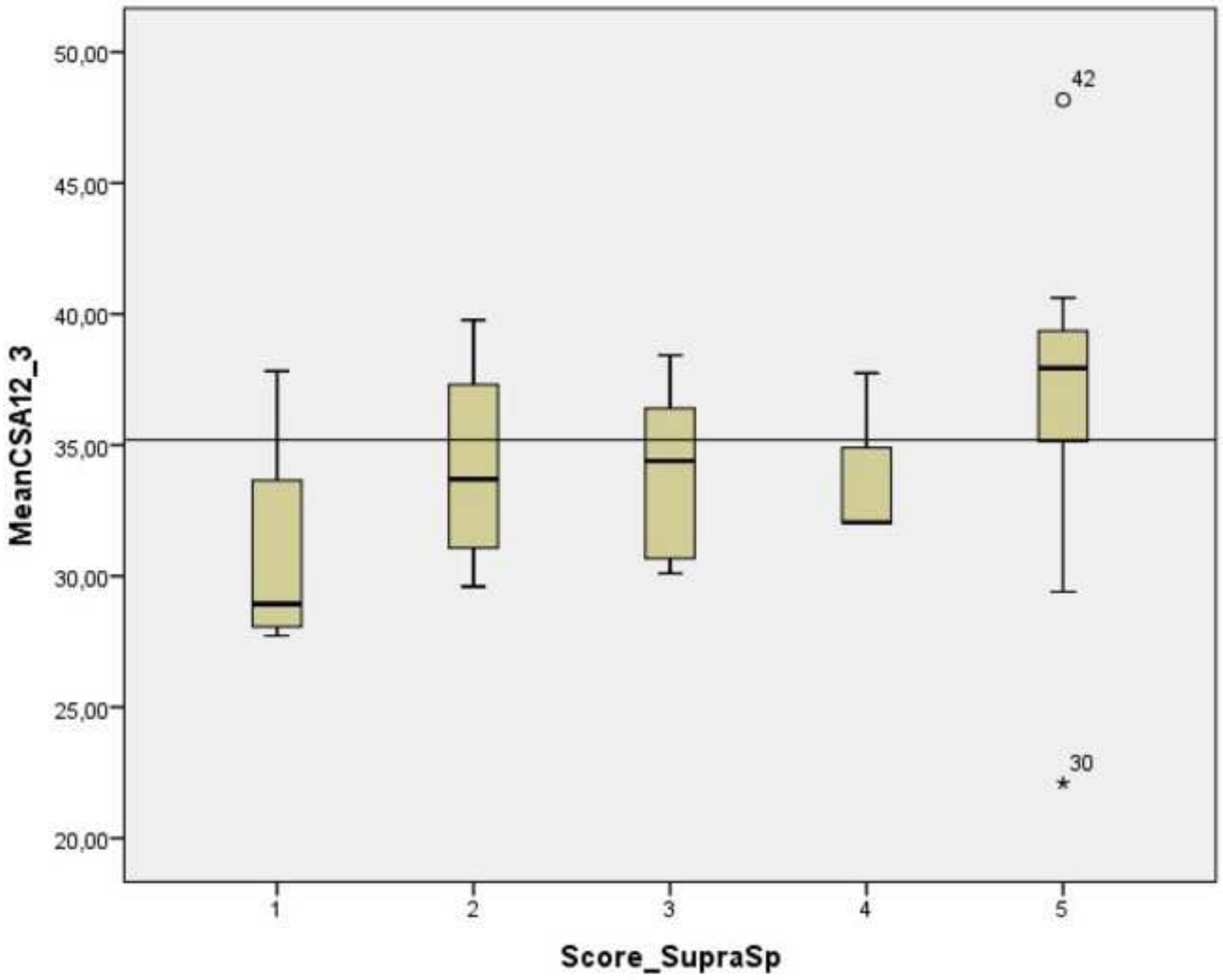

Figure 4

Click here to download high resolution image

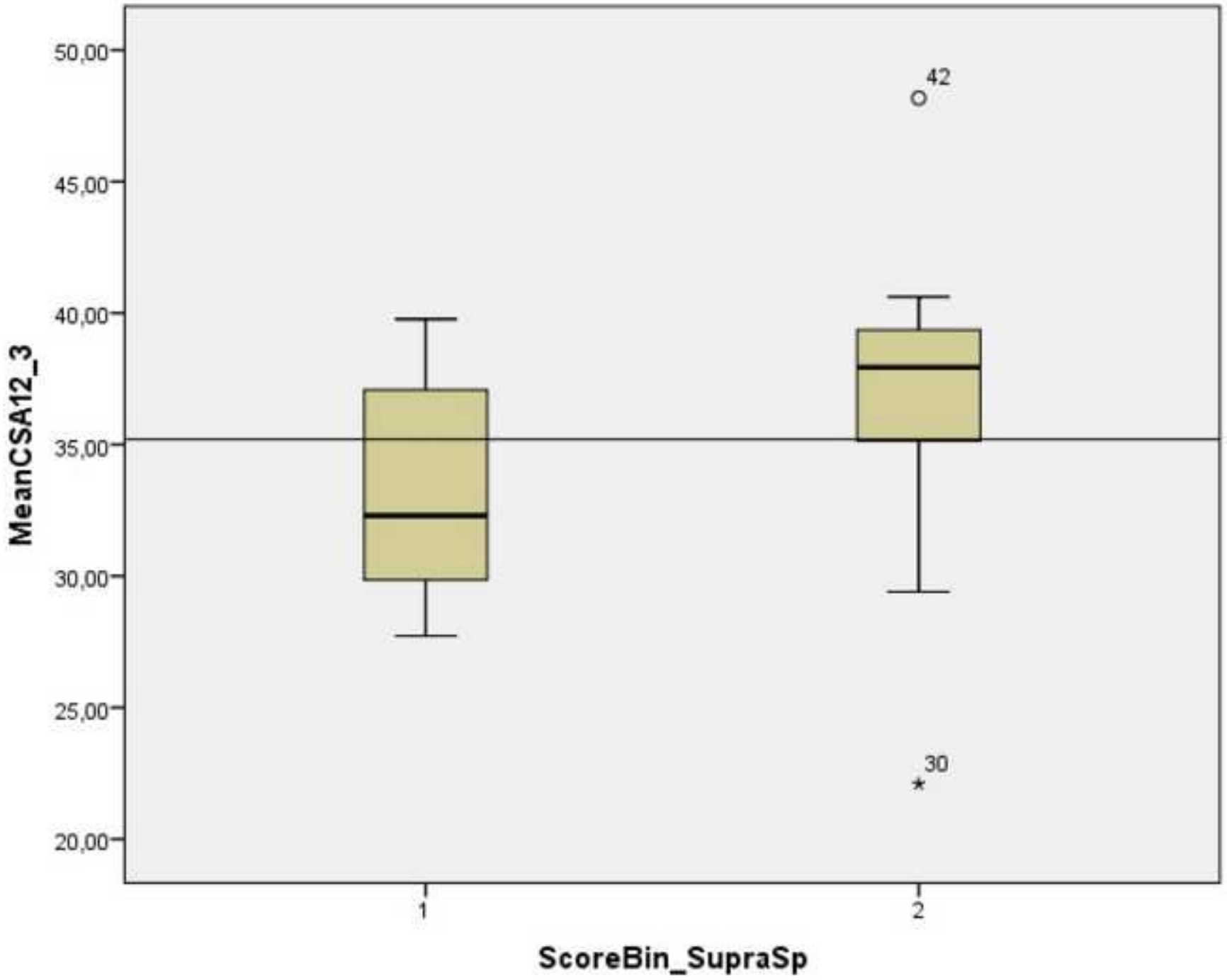

Figure 5

Click here to download high resolution image

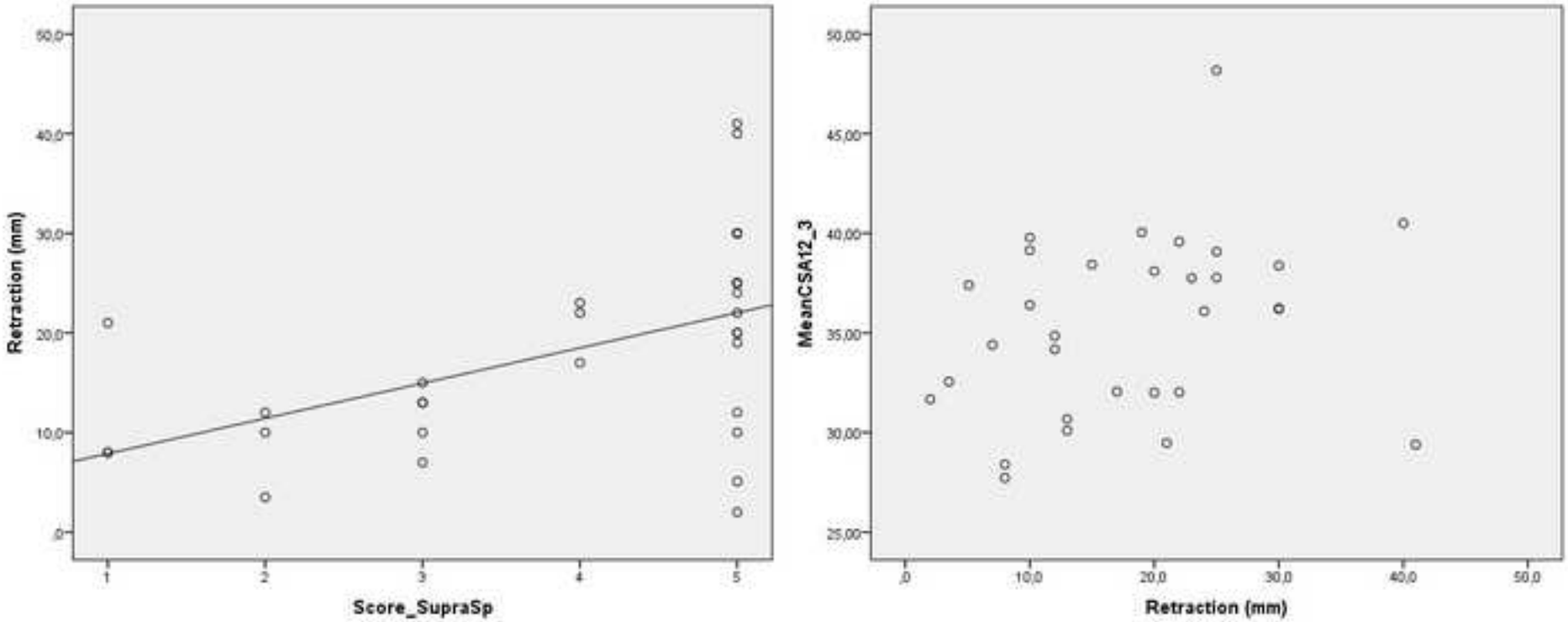

Table 1

MeanCSA12_3(°)	*Mean*	*SD*	*Min*	*Max*	*N*
Rotator Cuff Tears	35,3	4,9	22,1	48,2	38
Concentric OA	27,9	5,1	19,8	32,7	7
Eccentric OA	39,0		39,0	39,0	1
Total	34,1	5	13,6	35,7	46
Age					
Rotator Cuff Tears	60,5	8,4	43	79	38
Concentric OA	70,3	9,2	59	81	7
Eccentric OA	70,0		70	70	1
Total	66,9	8,8	57	77	46

OA, osteoarthritis; SD, standard deviation; Min, minimum; Max, maximum

Table 2

MeanCSA12_3(°)					
Score_SupraSp	Mean	SD	Min	Max	n
1	30,9	4,7	27,7	37,8	4
2	34,2	4,3	29,6	39,8	4
3	34,0	3,6	30,1	38,4	5
4	33,9	3,3	32,0	37,8	3
5	36,7	5,2	22,1	48,2	20
Total	35,2	4,9	22,1	48,2	36
Age					
Score_SupraSp	Mean	SD	Min	Max	n
1	63,8	4,5	57	66	4
2	49,3	6,9	43	59	4
3	62,2	9,0	50	73	5
4	54,7	4,9	49	58	3
5	62,2	7,9	51	79	20
Total	60,3	8,4	43	79	36
Retraction (mm)					
Score_SupraSp	Mean	SD	Min	Max	n
1	12,3	7,5	8	21	3
2	8,5	4,4	4	12	3
3	11,6	3,1	7	15	5
4	20,7	3,2	17	23	3
5	22,4	10,8	2	41	17
Total	18,1	10,0	2	41	31

SD, standard deviation; Min, minimum; Max, maximum.

Table 3

MeanCSA12_3(°)

ScoreBin_SupraSp	Mean	SD	Min	Max	n
1	33,2	3,9	27,7	39,8	16
2	36,8	5,2	22,1	48,2	20
Total	35,2	4,9	22,1	48,2	36
Age					
ScoreBin_SupraSp	Mean	SD	Min	Max	n
1	57,9	8,7	43	73	16
2	62,2	7,9	51	79	20
Total	60,3	8,4	43	79	36

SD, standard deviation; Min, minimum; Max, maximum.

Ao Prof. Doutor Manuel Gutierres, pela sua orientação. O seu total apoio e disponibilidade, as críticas e opiniões, o saber transmitido e a total e pronta colaboração no solucionar de dúvidas e problemas que foram surgindo foram, sem dúvida, fundamentais para a realização deste trabalho.

À minha família da FMUP, cujo percurso ao longo destes 6 anos foi feito sempre com companheirismo e união.

À Camila, minha fã número 1, cujo apoio e encorajamento nos momentos fáceis e difíceis foi fundamental não só agora, mas também ao longo destes anos em que caminhamos juntos.

E, por último, ao meu Pai e à minha Mãe, pelo seu apoio incondicional, incentivo, amor e paciência que mostram desde sempre na superação dos obstáculos, e por acreditarem sempre que podia conseguir tudo.

A todos, o meu profundo agradecimento.

Anexos

1. Parecer da Comissão de Ética do Centro Hospitalar de S. João
2. Normas de Publicação da Revista

Unidade de Investigação

Tomei conhecimento. Nada a opor.

04 de Janeiro de 2017

A Coordenadora da Unidade de Investigação

(Prof.ª Doutora Ana Azevedo)

DIRECÇÃO CLÍNICA

10 JAN 2017

Aprovado. Ao CA.

(Prof.ª Doutora Ana Azevedo)

AUTORIZADO

CONSELHO DE ADMINISTRAÇÃO REUNIÃO DE 12 JAN 2017

Presidente do Conselho de Administração

Diretor Clínico | Enfermeira Diretora | Vogal Executivo | Vogal Executivo

Exmo. Senhor

Presidente do Conselho de Administração do

Centro Hospitalar de S. João – EPE

Assunto: Pedido de autorização para realização de estudo/projecto de investigação

Nome do Investigador Principal: João Francisco Matos Mendes

Título do projecto de investigação: Influência do Crtitcal Shoulder Angle na génese da patologia degenerativa do ombro. Estudo numa população de doentes operados.

Pretendendo realizar no Serviço de Ortopedia e Traumatologia do Centro Hospitalar São João o estudo/projeto de investigação em epígrafe, solicito a V. Exa., na qualidade de Investigador/Promotor, autorização para a sua efectivação.

Para o efeito, anexa toda a documentação referida no dossier da Comissão de Ética do Centro Hospitalar de S. João respeitante a estudos/projectos de investigação, à qual endereçou pedido de apreciação e parecer.

Com os melhores cumprimentos.

Porto, 17 de outubro de 2016

O INVESTIGADOR/PROMOTOR

Parecer da Comissão de Ética para a Saúde do

Centro Hospitalar de São João / Faculdade de Medicina da Universidade do Porto

Título do Projecto: Influência da 'Critical Shoulder Angle' na génese da patologia degenerativa do ombro. Estudo numa população de doentes operados

Nome do Investigador Principal: João Francisco Matos Mendes

Serviço onde decorre o Estudo: No Serviço de Ortopedia. Apresentou declaração do Director de Serviço, Dr. Rui Pinto. O Prof. Doutor Manuel Gutierres, orientador do projecto, será o elo de ligação.

Objectivos do Estudo:
Esta investigação tem como objectivo principal a medição do 'Critical Shoulder Angle' em radiografias de doentes submetidos a cirurgia do ombro no HSJ e averiguar a existência duma correlação entre o valor absoluto deste ângulo e o tipo de patologia degenerativa subjacente, assim como a sua gravidade, nesta população.
Insere-se no âmbito do Mestrado Integrado em Medicina da FMUP, sob orientação do Prof. Doutor Manuel Gutierres.

Benefício/risco: Não aplicável

Confidencialidade dos dados: A identificação dos doentes não será revelada. Todos os dados serão codificados.

Respeito pela liberdade e autonomia do sujeito de ensaio: Não aplicável

***Curriculum* do investigador**: Adequado à investigação.

Data previsível da conclusão do estudo: Janeiro de 2017

Conclusão: Proponho um parecer favorável à realização deste projecto de investigação.

Porto, 18 de Novembro de 2016

O Relator (John Preto)

7. SEGURO

a. *Este estudo/projecto de investigação prevê intervenção clínica que implique a existência de um seguro para os participantes?*

SIM ☐ (Se sim, junte, por favor, cópia da Apólice de Seguro respectiva)

NÃO ☐

NÃO APLICÁVEL ☒

8. TERMO DE RESPONSABILIDADE

Eu, João Francisco Reis Rendas,

abaixo-assinado, na qualidade de Investigador Principal, declaro por minha honra que as informações prestadas neste questionário são verdadeiras. Mais declaro que, durante o estudo, serão respeitadas as recomendações constantes da Declaração de Helsínquia (com as emendas de Tóquio 1975, Veneza 1983, Hong-Kong 1989, Somerset West 1996 e Edimburgo 2000) e da Organização Mundial da Saúde, no que se refere à experimentação que envolve seres humanos. Aceito, também, a recomendação da CES de que o recrutamento para este estudo se fará junto de doentes que não tenham participado em outro estudo no decurso do actual internamento ou da mesma consulta.

Porto, 23 / Outubro / 2016

O Investigador Principal

PARECER DA COMISSÃO DE ÉTICA PARA A SAÚDE DO CENTRO HOSPITALAR DE S. JOÃO

emitido na reunião plenária da CES de 18 / Novembro / 2016

A Comissão de Ética para a Saúde APROVA por unanimidade o parecer do Relator, pelo que nada tem a opor à realização deste projecto de investigação.

(http://www.jshoulderelbow.org)

> Submit your paper (http://ees.elsevier.com/jses/)

> Track your paper (http://www.elsevier.com/authors/journal-authors/submit-your-paper#track)

> Order journal (order-journal)

> View articles (http://www.jshoulderelbow.org)

> Free sample (http://www.sciencedirect.com/science/journal/sample/10582746)

> Abstracting (abstracting-indexing)

> Editorial board (http://www.journals.elsevier.com/journal-of-shoulder-and-elbow-surgery/editorial-board)

Guide for Authors

INFORMATION FOR AUTHORS

PURPOSE AND POLICIES

The *Journal of Shoulder and Elbow Surgery* is a scientific medical journal containing information relative to the investigation of the development, preservation, and restoration of the form and function of the shoulder girdle, arm, elbow, and associated structures by medical, surgical, and physical means.

The objectives of the *Journal* are to enhance the professional study and practice of shoulder and elbow surgery, to act as a stimulant to research by providing a forum for discussion of new scientific advances, and to further international cooperation among shoulder and elbow societies by serving as an official publication for recognized societies.

To accomplish these goals, the *Journal* accepts for publication original articles, descriptions of surgical and other patient care techniques, case reports, historical and current reviews, editorials, comments on published material, and announcements or proceedings of participating societies.

The *Journal* requires at least a two-year follow-up for all patients enrolled in clinical treatment studies. Exceptions at the editor's discretion will be allowed when studies are stopped due to adverse events, or other significant or important differences are detected before the two-year minimum follow-up is reached (e.g. studies of fracture where union is the outcome measure of interest), or for certain case reports.

All manuscripts which deal with the study of human subjects must be accompanied by Institutional Review Board (IRB) or Ethical Committee Approval, or the national or regional equivalent in your geographic area. The name of the Board or Committee giving approval and the study number assigned must accompany the submission, preferably by a scanned copy of the IRB or Ethical Committee Approval uploaded to the submission.

All manuscripts which deal with animal subjects must be approved by an Institutional Review Board (IRB), Ethical Committee, or an Animal Utilization Study Committee, and this statement, and approval number, must accompany the submission, preferably by a scanned copy of the IRB or Ethical Committee Approval uploaded to the submission. The manuscript should contain information about any post-operative care and pain management for the animals.

Materials are accepted for exclusive publication in the *Journal of Shoulder and Elbow Surgery*, and published manuscripts along with their illustrations become the property of the *Journal*. Permission to reproduce material published in the *Journal* must be obtained from the publisher. Authors will also be consulted, when possible, in regard to republication of their material.

Statements and opinions expressed in the articles and communications herein are those of the author(s) and not necessarily those of the Editor(s) and publisher, and the Editor(s) and publisher disclaim any responsibility or liability for such material. Neither the

For authors of Case Reports and Database-Mining Articles in particular, you are encouraged to submit to the *JSES Open Access* (*JSESOA*) at https://ees.elsevier.com/jsesoa/default.asp (https://ees.elsevier.com/jsesoa/default.asp) . *JSESOA* will be a quarterly publication, online only. Other types of articles that should be submitted to the *JSESOA* include: National Arthroplasty Registry reports; Original articles; Review articles; Technique articles; and Validation studies of Outcome Instruments.

Author's guidelines, as well as the review process, are similar to those for the *JSES*.

To provide open access, the *JSESOA* has an open access fee (also known as: open access publication fee) which needs to be met by the authors or their research funders. Submission to the *JSESOA* is free of charge; however, if the paper is accepted for publication in the *JSESOA*, the open access publication fee will be charged. Fees at this time will be $1,250 (US) for original or review articles, and $750 (US) for case reports or technical notes.

The open access fee is all inclusive; Elsevier will not add any additional charges. Depending on local regulations, VAT can be charged by local authorities.

SUBMISSION OF MANUSCRIPTS

Manuscripts and all other communications for the Editor(s) must be written in English. Submission of the materials in the correct format will expedite the review process and prevent unnecessary delay in publication.

For authors whose primary language is not English, we urge you to consider a language review of your manuscript by a primary English speaker **prior** to submission to the journal. There are also now several such services available via the Internet which will review your paper, and improve the English grammar and syntax.

Authors must submit new manuscripts **and all related documentation** electronically via the Elsevier Editorial System (EES) at http://ees.elsevier.com/jses (http://ees.elsevier.com/jses) .

On receipt of the manuscript or other materials, peer review will be performed by an Editor and usually two additional reviewers. Should the material require revision, authors are requested to complete and submit revisions within three months.

Levels of Evidence: Although this will be reviewed by our Editorial Staff, and their opinion will be final, the *Journal* asks authors to assign a Level of Evidence to all clinically oriented manuscripts. The following table is offered to assist authors:

Type of Study	Treatment Study	Prognosis Study	Study of Diagnostic Test	Cost Effectiveness Study
LEVEL I	Randomized controlled trials with adequate statistical power to detect differences (narrow confidence intervals) and follow up >80%.	High-quality prospective cohort study with >80% follow-up, and all patients enrolled at same time point in disease	Testing previously developed diagnostic criteria in a consecutive series of patients and a universally applied "gold" standard	Reasonable costs and alternatives used in study with values obtained from many studies, study used multi-way sensitivity analysis
LEVEL II	Lower quality randomized trials (follow up <80%, improper randomization techniques, no masking Prospective comparative study	Lower quality prospective cohort study (<80% follow-up, patients enrolled at different time points in disease) Retrospective study Untreated controls from a randomized controlled trial	Development of diagnostic criteria in a consecutive series of patients and a universally applied "gold" standard	Reasonable costs and alternatives used in study with values obtained from limited studies, study uses multi-way sensitivity analysis
LEVEL III	Case-control study Retrospective comparative study	Case-control study	Study of nonconsecutive patients and/or without a universally applied "gold" standard	Analyses based on a limited section of alternatives and costs, or poor estimates of costs
LEVEL IV	Case series with no comparison group	Case series with no comparison groups	Use of a poor reference standard Case control study	No sensitivity analysis
LEVEL V	Expert opinion	Expert opinion	Expert opinion	Expert opinion

Treatment Studies investigate the results of treatment on patient outcomes and complications.

Prognosis Studies investigate the natural history of a disease or disorder, and evaluate the effect of a patient characteristic on the outcome of the disease.

Diagnostic Studies evaluate the effectiveness of a diagnostic test or outcome assessment.

Economic/Decision Analysis or Modeling Studies explore costs and alternatives or may either develop or assess the effectiveness of decision models.

Systematic Reviews and Meta-Analyses are assigned a Level of Evidence equivalent to the lowest level of evidence used from the manuscripts analyzed.

Prospective Study-Defined is a study in which the research question was developed, (and the statistical analysis for determining power) were developed before data was collected).

Retrospective Study-Defined is a study in which the research question was determined after the data was collected (even for studies where the authors collected general data prospectively).

Cover Letter

It is essential that the material be accompanied by two cover letters. The first letter must include information on prior or duplicate submission or publication elsewhere of any part of the work including details of any presentation of the study as an abstract at a professional meeting, a statement that the manuscript has been read and approved by all authors, and a statement that each author believes that the manuscript represents honest work. All manuscripts will be checked by an internet-based algorithmic searching method to check for possible duplication of previously published work.

This first letter also should identify the name, mailing address, and e-mail address of the author responsible for all future correspondence regarding the manuscript.

The second cover letter, **the conflict of interest (CoI) statement**, must deal with disclosures and must be signed and dated by all authors. This second cover letter must also be submitted online during the article submission process. Individual CoI statements may also be uploaded. All CoI statements should be in a pdf format.

This second letter must first list any conflicts of interest for the authors, their immediate families, and any research foundation with which they are affiliated, including receiving royalties, stock or stock options, consultant agreements, or ownership from or with any commercial entity related to the subject of this work. This information must be described for all authors listed on the paper, and should be provided in the form of a list of the authors. If no such conflict of interest exists for an author, please state the following after the authors' name: "This author, their immediate family, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article."

This second letter must then list any outside funding or grants received that assisted in this study, the name of the source providing the funding, and the grant number. If any outside funding or grant was received, it should be described if the outside source of funds was involved in data collection, data analysis, or the preparation of or editing of the manuscript.

Finally, where applicable, please upload a copy of your Institutional Review Board (IRB) or Ethical Committee Approval, or your national or regional equivalent, including the name of the Board or Committee giving approval, and the study number assigned -

please note IRB requirements for human and animal studies as set out in Purposes and Policies above.(
/
)

The name of the Approval giving authority and the Study Number must also be included within your manuscript's Title Page file.

PATIENT CONSENT

Appropriate consents, permissions and releases must be obtained where authors wish to include case details or other personal information or images of patients and any other individuals in their JSES submission. It is generally *not sufficient* to anonymise a photograph simply by using eye bars or blurring the face of the individual concerned. Consent documents should be uploaded in the document category Figure Permissions, thus NOT seen by reviewers and NOT unblinding your submission.

PREPARATION OF MANUSCRIPTS

The *Journal* adheres to the "Uniform Requirements for Manuscripts Submitted to Biomedical Journals" (the Vancouver style) developed by the International Committee of Medical Journal Editors as described in the Journal of the American Medical Association (1993;269:2282-6) (also may be retrieved at http://www.icmje.org/ (http://www.icmje.org/)), with the exception that the references must be placed in alphabetic order by author(s) name, numbered sequentially, and appear as superscript numbers in the text but without brackets (see section on "References").

Formatting Manuscripts: The *Journal* suggests that authors follow these guidelines when writing and formatting their work:

Randomized controlled trials should follow the CONSORT (Consolidated Standards of Reporting Trials) guidelines (http://www.consort-statement.org (http://www.consort-statement.org)).

Case reports, case series, cross-sectional and other observational studies should follow the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines (http://www.strobe-statement.org (http://www.strobe-statement.org)). If the detailed methods are explicitly stated in the manuscript for single case studies, STROBE is not needed.

Authors producing systematic reviews and meta-analyses should follow the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (http://www.prisma-statement.org (http://www.prisma-statement.org)).

Type the manuscript with margins of at least 25 mm (1 inch). Use double-line spacing throughout the entire manuscript, typing in Times New Roman font size 12, **and include continuous line numbering**. Please use Insert Page Break and begin each of the following

sections on a new page: Abstract; Introduction; Materials and Methods; Results; Discussion; Conclusion; References; and Figure and Table Legends. **Figures and Tables should be uploaded separately and individually** (see below). Number the pages consecutively in the lower right-hand corner of each page beginning with the Title Page as number 1. Place a six-word short-form/running title in the header space of the manuscript document. The manuscript file must be in a Word format. Manuscripts without continuous line numbering will be returned to the author.

Word Count Submissions of review and original articles (including abstract, introduction, materials and methods, results, discussion and conclusion) should have a maximum word count of 4,750; submissions which exceed this limit **will be returned to the author** for further revision without being reviewed. Case reports should not exceed 2,250 words.

Review and Technique Articles
The *Journal* has limited space to publish numerous review and technique articles and these are usually solicited by the Review Article and Special Projects Editors. Authors must remember the *Journal* only publishes one review paper per issue, or about 12 per year. In a typical year, the *Journal* receives in excess of 200 review articles submitted in consideration for publication. Hence, the acceptance rate of review articles for the *Journal* is usually around 3%-4%. Authors considering submission of a review article are encouraged to read "What is the value of a systematic review? (*J Shoulder Elbow Surg* 23:1-2, 2014; http://dx.doi.org/10.1016/j.jse.2013.09.001 (http://dx.doi.org/10.1016/j.jse.2013.09.001))" to critically evaluate whether their submission may be suitable for publication in the journal. Please contact the Review and Special Projects Editor (T. Bradley Edwards, M.D.) via ✉ jsesedit@gmail.com (mailto:jsesedit@gmail.com) outlining your proposed article. Video Technique Articles are acceptable but will be published only on the website.

Title Page
The title page should include a concise but informative title of the article, plus a six-word short-form/running-title, and the first name, middle initial, and last name along with the highest earned academic degree of each author. The title page should also include the name of the department and the institution to which each author's work should be attributed. The name, mailing address, and e-mail address of the author responsible for correspondence should be identified, as should any source of support in the form of grants, equipment, or other items. The title page file must be in a Word format.

If illustrations must be published in color, note this explicitly on the title page of the article.

Disclaimer: List here (on the title page) any financial remuneration the authors, or any member of their family, may have received related to the subject of the article. If no such financial biases exist for any author, state "none". Please also include information about

Institutional Review Board (IRB) or Ethical Committee approval related to the study, including the name of the IRB providing approval and the study number.

Please also include on your title page Acknowledgments of those who have contributed to the paper but whose contributions do not justify authorship. They may be named and their contribution described. Such persons must have given their permission to be so named, because readers may infer their endorsement of the data and the conclusions reached. Technical help may also be acknowledged.

Upload the title page on the EES system as Title Page. **Do not include** the above information in your manuscript text which for review purposes should be blinded.

Abstract
The first text page of observational and experimental articles and review articles should be an abstract of no more than 250 words. This abstract should state the purpose of the study, basic procedures, essential findings, and principal conclusions, and should be formatted into: Hypothesis and/or Background; Methods; Results; and Discussion and/or Conclusion. The abstract should emphasize new and important aspects of the observation or study, but may not contain data that are not presented in the main text.

Case reports do not require an abstract and are published without abstracts.

For full research articles, include the Level of Evidence of the study performed (see above) and Keywords at the end of the abstract. The authors should assign their own Level of Evidence although this will be reviewed by the *Journal*'s Editorial Staff and should also list 6-8 Keywords that highlight the topic of the article, allowing for easier electronic retrieval.

Manuscript Text
The text of observational and experimental articles is divided into 5 sections with the headings: Introduction; Materials and Methods; Results; Discussion; and, Conclusions. Each section should start on a new page. Longer articles may need subheadings within headings to clarify their content. Other articles, such as reviews, case reports and editorials need not take the form of manuscripts describing observational or experimental studies. A case report should include Keywords at the end of the Introduction.

All manuscript texts should be blinded for review purposes. Blind institute location, author initials and references by same authors. To blind an item, use Black Text Highlight Color to black-out the text.

Introduction. The purpose of the article should be stated and the rationale for the study or observation summarized. Pertinent references should be given, but the subject should not be reviewed extensively.

Materials and Methods. Clearly describe the selection of the observational or experimental subject(s). Identify the methods, apparatus, and procedures in sufficient detail to allow others to reproduce the results. Give references to established methods, including statistical methods. Identify precisely all devices or drugs used, including generic names, manufacturers, and manufacturer locations.

Give numbers of observations. Report any losses to observation. Provide details about randomization. Describe statistical methods in enough detail to enable a knowledgeable reader who has access to the original data to verify reported results. Avoid sole reliance on statistical hypothesis testing, such as the use of *P* values, which might fail to convey important quantitative information. Avoid nontechnical uses of technical terms in statistics, such as random or significant. All recent clinical studies should be performed with Institutional Review Board (IRB) approval, and confirmation of IRB approval should be given in this section.

In general, exact P-values or statistical measures should be given, rather than, e.g., $p < 0.05$. Please also remember the proper use of significant figures and do not overuse extra decimal places, taken as an average, which may imply a degree of precision which does not exist in the work.

Results. Results should be presented in a logical sequence in the text, illustrations and/or tables. Do not repeat in the text the data presented in tables and illustrations, but emphasize or summarize the important observations. For reports on reconstructive procedures, a minimum 2-year evaluation period is recommended.

Discussion. New and important aspects of the study should be emphasized, and conclusions that follow from them should be made. It is not desirable to repeat the data or material given in other sections of the manuscript. The discussion should describe the implications of the findings and their limitations, including suggested future research needs. The observations can be related to relevant studies. Unqualified statements and conclusions incompletely supported by the data should be avoided. Recommendations may be included.

Conclusions. A short concluding paragraph summarizing the hypothesis and reason for the study and its results should be included.

References

The Reference List should be in alphabetical order by authors' last name, in double-line spacing, and numbered sequentially. At the end of each reference, please include the Digital Object Identifier (DOI) (http://www.doi.org/ (http://www.doi.org/)) or ISBN number for all references dating from 2002 to today. References with identical author(s) should be listed by youngest first. If there is more than one reference with the same first author, use 2nd, 3rd author etc to decide the alphabetical order. When a reference citation has 6 or fewer authors, list all the authors; when there are 7 or more authors, list the first

6 then "et al." Identify references in the text, tables, and illustration legends by superscript Arabic numerals without brackets. References must conform to Vancouver style. Abbreviate titles of journals according to the style used in *PubMed*.

Examples of the correct forms of references are provided below:
Journal article: 1. Richards RS, Curl LA, Moorman CT, Mallon WJ. Sterile synovio-cutaneous fistula: A potential complication of repair of large and massive rotator cuff tears. J Shoulder Elbow Surg 2006;15:436-439. doi:10.1016/j.jse.2005.03.008
Book chapter: 2. Zarins B, Prodromos CC. Shoulder injuries in sports. In: Rowe CR, editor. The shoulder. New York: Churchill Livingstone; 1988. p. 411-33. (ISBN No. 978-0443084577)

Illustrations and Legends
Each figure should be uploaded as a separate file (and name/numbered in the Description box on the Attach Files page of the submission process). For photographic images upload your images in a standard acceptable digital format (e.g., *.tif or *.jpg) to the journal's online submission website (http://ees.elsevier.com/jses (http://ees.elsevier.com/jses)). For line illustrations, use thick, solid lines and bold, solid type; avoid the use of shading or dotted patterns. If illustrations must be published in color, note this explicitly on the title page of article. For more detailed information on preparing your figures for submission, please visit: http://www.elsevier.com/artworkinstructions (http://www.elsevier.com/artworkinstructions).

Letters, numbers, and symbols should be clear and of sufficient size that when reduced for publication each will be legible. Figures should be numbered in the order of their mention in the text and the number included in the Description box. Title and explanations of figures (and tables) belong on a dedicated legends page following the reference list in the manuscript, and not on the illustrations themselves. If a figure has been taken from previously copyrighted material, the legend must give full credit to the original source (see below).

Figure/Photograph Permissions: Photographs in which a person's face is recognizable *must* be accompanied by a letter of release from that person explicitly granting permission for publication in the *Journal*. X-rays should NOT show patient's name. For any previously published material, authors must obtain written permission for both print and electronic reprint rights from the copyright holder / publisher. This is necessary even if you are an author of the borrowed material. These permission letters must then be uploaded as part of the submission process or the author must state in an uploaded document that the permission has been requested and provide an approximate date when the permission is expected to be received. Authors are also responsible for paying any fees required by copyright holders to reprint material.

Tables
Each table should be uploaded as an individual Table document separate from the manuscript (and name/numbered in the Description Box). Tables should be uploaded in

a format that can be edited, preferably .doc or .docx. Tables should be self-explanatory and numbered in Roman numerals. They should be mentioned in numerical order through the text. Table Legends (and figure legends) should be listed on a dedicated page of the manuscript text that follows the reference list. Abbreviations should be defined in a footnote at the end of the table. If any material in a table or a table itself has been taken from previously copyrighted material, a footnote must give full credit to the original source and permission of the author and publisher must be obtained. Table permission letters should be uploaded in the document category Figure/Photograph Permissions.

Big Data

Authors are requested to upload their full databases of studies, both clinical and basic science, as Supplemental Files. This information should be both blinded and anonymized. At present this is not mandatory, but recommended. Please use standard files types. Supplemental Files are published online as a link; the JSES print edition includes details of links.

Instructions for Submitting Videos

The *Journal* encourages authors to submit a video to be published on the *Journal*'s web site at http://www.jshoulderelbow.org/ (http://www.jshoulderelbow.org/) as an illustration incorporated in an article that the author is submitting for publication or as video paired with a journal cover illustration. All videos are subject to peer review. We expect professional quality and narration, regardless of method of production. A sound track is highly desirable and is requested.

These formats for video will be accepted
• MPEG-1 or MPEG-2 (.mpg)
• QuickTime (.mov)
The *Journal* will not edit any video, but a reviewer may suggest that the author make changes.

Requirements

- Include in your CoI statement (second cover letter) a statement confirming that the video is part of your submission and has been viewed by all authors.
- Submit a single video per manuscript, not multi-part videos.
- Maximum length of videos is 4.5 minutes.
- Video file cannot exceed 50 MB. The submission program will time out if the file size is larger than 50 MB.
- Please ZIP the file and upload the zipped file to hasten the upload time.
- A complete legend for the video must be included in the manuscript.
- The video must be cited in the text of your manuscript just like a figure.

- Sound narration is highly desirable and is requested.

Units of Measurement
Measurements of height, length, weight, or volume should be reported in metric units. Temperatures should be given in degrees Celsius; blood pressures should be given in millimeters of mercury. All laboratory measurements should be reported in the metric system.

Abbreviations
Only standard abbreviations should be used, and abbreviations should be avoided in the title or abstract. The full term for an abbreviation should precede its first use in the text unless it is a standard unit of measurement.

LETTERS TO THE EDITOR

Letters to the Editor should be sent to the Editor-in-Chief of the *Journal* via the EES system following the guidelines for all other submissions. Letters should be no longer than 2 pages in length. Letters should be signed by all authors and concern only articles that have been published recently in the *Journal of Shoulder and Elbow Surgery*. A response to the letter will be requested from the author of the article in question, and both the letter and response will be published together if there is a response.

ANNOUNCEMENTS

Announcements of participating society activities must be received at least 10 weeks before the desired issue of publication. Send announcements to the office of the Editor-in-Chief.

REPRINTS

Single reprints of articles must be obtained from the author. Reprint order forms will be sent to authors after articles are slated for publication in a specific issue.

June 2016