

Subtalar arthrodesis: does a second screw increase the fusion rate?

Artrodese subtalar: um segundo parafuso aumenta a taxa de consolidação?

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ABSTRACT

Objective: To evaluate whether there is a difference in the fusion rates of subtalar arthrodesis using one or two compression screws.

Methods: A retrospective study evaluated the fusion rate of patients subjected to subtalar arthrodesis between January 2012 and December 2016. Fusion was determined clinically using radiographs and, in the case of doubt, computed tomography.

Results: The final sample consisted of 80 patients, 78.8% of whom were male, and the mean final evaluation time was 23.27 months. Subtalar arthrosis due to a calcaneal fracture was the etiologic factor in 95% of the patients. The group subjected to arthrodesis with one screw represented 68.75% of the patients, and the group with two screws represented 31.25% of the patients. The incidence of nonfusion was 10.9% in the group where one screw was used against 4.0% in the group where two screws were used, without statistical significance (p-value = 0.425).

Conclusion: The use of a second screw did not improve the fusion rates of subtalar arthrodesis.

Level of Evidence III; Therapeutic Studies; Retrospective Comparative Studies.

Keywords: Arthrodesis; Subtalar joint; Bone screws; Fracture healing; Pseudarthrosis.

RESUMO

Objetivo: Avaliar se há diferença nas taxas de fusão da artrodese subtalar com a utilização de um ou dois parafusos de compressão.

Métodos: Estudo retrospectivo avaliando a taxa de consolidação dos pacientes submetidos à artrodese subtalar, entre janeiro de 2012 e dezembro de 2016. A consolidação foi determinada clinicamente e por meio de radiografias e, nos casos duvidosos, com tomografia computadorizada.

Resultados: A amostra final foi de 80 pacientes, com tempo final médio de avaliação de 23,27 meses, sendo 78,8% do sexo masculino. 95% tiveram como fator etiológico a artrose subtalar por seqüela de fratura de calcâneo. O grupo submetido à artrodese com um parafuso representou 68,75% dos pacientes e 31,25% com dois parafusos. A incidência de não-consolidação foi de 10,9% no grupo em que se utilizou um parafuso contra 4,0% no que se utilizaram dois parafusos, sem significância estatística (p-valor= 0,425).

Conclusão: A utilização de um segundo parafuso não melhorou as taxas de união da artrodese subtalar.

Nível de Evidência III; Estudos Terapêuticos; Estudo Retrospectivo Comparativo.

Descritores: Artrodese; Articulação subtalar; Parafusos ósseos; Consolidação da fratura; Pseudoartrose.

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INTRODUCTION

Subtalar arthrodesis is a very common surgery in the practice of the foot and ankle surgeon. Its indications are diverse and include inflammatory arthritis, instability, tarsal coalition and posttraumatic arthrosis; the latter is the main indication, usually after fracture of the calcaneus and/or talus⁽¹⁻³⁾.

The goal of surgery is joint fusion, promoting pain relief and improving function. For this, various devices are used such as screws, Kirschner wires and staples. The most commonly used method is internal fixation with screws⁽⁴⁻⁸⁾. To obtain joint fusion, among several factors, fixation stability and compression are essential⁽⁹⁻¹²⁾.

All precautions to perform an effective arthrodesis must be taken because nonfusion is a complication that can reach rates of 15 to 30%^(2,6,13). Several factors influence joint fusion, including the presence of comorbidities, obesity, smoking, the etiology of subtalar arthrodesis indication, chronic use of certain medications and bone quality. Factors related to the technique are also related to subtalar pseudarthrosis, such as the use of bone grafts, adequate debridement of the joint cartilage and the method used for joint fixation, including its stability and compression capacity^(2,3,6,8,14-16).

There is no consensus on the most effective technique for subtalar arthrodesis in the literature, especially the ideal number of screws to obtain adequate fixation^(4-7,17). The use of two screws is supported by several biomechanical studies, proving greater stability (mainly rotational and torsional) and compression than using one screw^(1,14,18-20). In turn, studies have advocated the use of one screw, achieving excellent fusion rates or no significant difference in the fusion rate when comparing the use of two screws^(4-7,17,21,22). Another important advantage would be the lower chance of complications related to the synthesis material, such as prominence and postoperative pain.

Additionally, much has been discussed regarding the direction and positioning of the screws when two or more implants are used. In a study with frozen fresh cadaver joints, the use of two parallel screws showed more compression than divergent screws, and a third screw increased compression further⁽²³⁾. When tested in artificial bones, the delta configuration (divergent screws, one of them being a retrograde in the posterior facet and another being an antegrade in the anterior facet) promoted greater rigidity and less degree of deflection between the talus and calcaneus⁽²⁴⁾.

The lack of agreement between the study results, both in terms of patients and biomechanical studies with artifi-

cial bones and cadavers, does not allow one to determine the ideal technique for subtalar arthrodesis^(20,23,24). Another important factor is that some studies simultaneously compare different forms of fixation and the use of distinct bone grafts, making it difficult to interpret their findings⁽²⁵⁾.

The aim of this study was to compare the fusion rates of primary subtalar arthrodesis using one or two compression screws and evaluate whether an additional screw increases the joint fusion rate.

METHODS

This study was approved by the Research Ethics Committee with registration in the Brazil Platform under CAAE number: 87146518.8.0000.5273.

This retrospective study evaluated patients subjected to subtalar arthrodesis performed by the foot and ankle group of the institution between January 2012 and December 2016 after the patients signed the informed consent form.

All patients undergoing surgery were included. Surgical indications other than posttraumatic subtalar arthrosis were excluded from the study. Patients with chronic comorbidities and regular use of medications associated with interference in the bone fusion mechanism (e.g., corticosteroids), smokers, patients with a history of previous local infection and vascular disease were excluded. Exclusion criteria included those subjected to revision surgeries or the use of bone grafts, association with other surgical procedures in the approached foot, arthrodesis using material other than screws, insufficient data in the medical records or the absence of adequate imaging. Patients who did not maintain follow up until complete joint fusion or those who did not follow the postoperative protocol employed in the service were excluded.

The choice for strict exclusion criteria, such as the withdrawal of patients with comorbidities or undergoing surgeries using any type of bone graft was due to analysis of the influence of the number of screws on the fusion rate of subtalar arthrodesis.

Joint fusion was evaluated in all patients through radiographic examinations [anteroposterior (AP) and lateral views of the ankle and Broden's oblique view] after 12 weeks from the surgery. In questionable cases, computed tomography was requested (Figures 1 and 2). The radiographic criterion for fusion evaluation was the obliteration of the joint space, with the presence of bone trabeculae crossing the subtalar joint. The tomographic criterion was the presence of trabeculation or calcium density crossing more

than 50% of the anterior space of the subtalar joint. Only the posterior facet was considered because this is the joint portion that effectively presents fusion^(25,26).

Surgical technique

The procedures were performed by different surgeons of the institution, all specialists and members of the foot and ankle surgery group.

The patient was placed in the lateral decubitus position with a tourniquet applied at the thigh level. Access to the tarsal sinus was performed, with dissection by planes until exposure of the subtalar joint and removal of the joint

surfaces and visualization of the subchondral bone. Next, micro perforations of the joint facets of the talus and calcaneus were performed using a Kirschner wire and temporary fixation with the guidewire. After confirming the correct position of the guidewire and joint reduction with scopy, subtalar fixation was performed with one or two cannulated screws with 7.0 mm of partial thread, retrogradely. The number of screws was chosen based only on the surgeon's preference. After wound suture and local dressing, patients were immobilized with a medical walking boot. On the first postoperative day, the dressing was changed, a plastered boot with the ankle flexed at 90° and the patients were instructed not to support the operated limb. After two weeks, the stitches were removed, and a plaster boot with heels was made. Patients were advised to perform progressive weight bearing by the 12th week. At that time, radiographs were performed and clinical and radiographic fusion were observed. In cases with doubt about the radiographic fusion, computed tomography (CT) was performed to evaluate the joint fusion. If fusion was not observed, the use of the cast boot with heel was maintained, and the patient was instructed to return for a monthly follow up and perform new examinations.

Statistical analysis

The data collected by the research instrument were arranged in a spreadsheet of the *Microsoft Excel 2013* program, also used for the construction of the graphs of the work. Statistical analyses were performed by the IBM SPSS (Statistical Package for the Social Sciences), version 22.0. The descriptive analysis was based on the construction of graphs, frequency distributions and calculation of descriptive statistics.

Two complementary proportions were compared using the binomial test. Chi-squared test was used to verify whether a significant association existed between two qualitative variables. When chi-squared test proved to be inconclusive, Fisher's exact test or the Yates correction was used for chi-squared test. In the inferential analysis of the quantitative variables, the normal distribution hypothesis was verified by the Kolmogorov-Smirnov (KS) and Shapiro-Wilk (SW) tests. When the normal distribution hypothesis was not rejected, the comparison of the quantitative variable of patients from two independent groups was performed by Student's t-test and the equality of the variances was evaluated by Levene's test. When the normality hypothesis of the distribution was rejected for any of the subgroups, or if one of the subgroups had a sample size smaller than 12, the comparison of the quantitative variable of two in-



Figure 1. Simple radiograph of the lateral view of the ankle of a patient with failure in the fusion of subtalar arthrodesis using one screw (left) and computed tomography with sagittal reconstruction of the same patient (right).

Source: Author's personal archive.

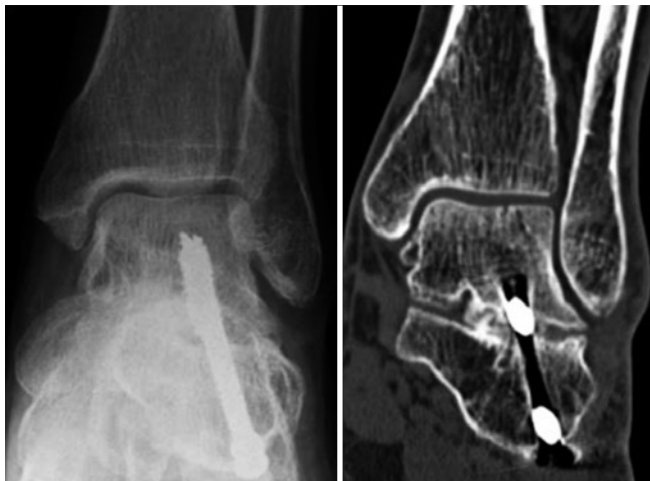


Figure 2. Simple anteroposterior radiograph of the ankle with fusion failure in a patient subjected to subtalar arthrodesis with two screws (left) and computed tomography with coronal reconstruction of the same patient (right).

Source: Author's personal archive.

dependent groups was performed by the nonparametric Mann-Whitney test. All discussions were carried out at a maximum significance level of 5% (0.05) and a 95% confidence level.

RESULTS

Two hundred thirty patients subjected to subtalar arthrodesis in the selected period were eligible to participate in the study. After the exclusion criteria were applied, the final sample consisted of 80 patients, among whom 17 were females (21.2%) and 63 were males (78.8%). The difference between these proportions was statistically significant (p -value < 0.001 of the Binomial test).

The frequency distributions of variables that characterize cases of subtalar arthrodesis, overall and by gender, are shown in Table 1. The patients' ages ranged from 25 to 67 years, with a mean age of 47.6 years. In relation to the number of screws, one screw was used in most cases (68.8%), while two screws were used in 31.2% of the cases.

The highest surgical indication in the sample was due to sequelae of calcaneal fractures, corresponding to 95% of the total, while sequelae of talus fractures and osteochondral lesions corresponded to 3.8% and 1.2%, respectively.

The overall fusion rate of subtalar arthrodesis was 91.3%. The incidence of nonfusion in cases of subtalar arthrode-

sis was estimated to be 8.7% (CI: 3.7-13.7%). Patients who progressed to pseudarthrosis had a mean postoperative follow-up duration of 23.27 months (ranging from 14.8 to 54.1 months).

The comparison of the age of patients who evolved with joint fusion (ranging from 25 to 67 years; mean age = 48 years) and those with subtalar pseudarthrosis (32 to 56 years old; mean age = 43 years old) showed no statistically significant difference between the ages of the groups (p -value = 0.155; Mann-Whitney test).

Table 2 presents the prevalence of nonfusion and fusion for each surgical indication and number of screws used. All cases of nonfusion occurred in the group where the surgical indication was the sequelae of calcaneal fractures, but this difference was not statistically significant (p -value = 0.686). Nonfusion cannot be considered to be significantly associated with the surgical indication, given the small sample sizes of the other subgroups. Among surgical cases with one screw, the incidence of nonfusion was 10.9%; among cases using two screws, the incidence of nonfusion was 4.0% (p -value = 0.425; Fisher's exact test).

DISCUSSION

Subtalar arthrodesis usually presents with high fusion rates; in the literature, the rates can reach between 98 and

Table 1. Frequency distributions of the variables that characterize the cases of subtalar arthrodesis, by gender and overall.

Variable	Female n=17		Male n=63		Overall n=80		p-value of the test comparing the distributions of the variable in the male and female groups
	F	%	F	%	F	%	
Age (years)							
25 — 32	1	5.9%	3	4.8%	4	5.1%	0.387 ^(a)
32 — 39	0	0.0%	7	11.2%	7	9.0%	
39 — 46	5	29.5%	15	24.0%	20	25.2%	
46 — 53	5	29.4%	22	35.0%	27	33.8%	
53 — 60	3	17.7%	13	20.7%	16	20.2%	
60 — 67	3	17.7%	3	4.8%	6	7.7%	
Number of screws							
1 screw	10	58.8%	45	71.4%	55	68.8%	0.320 ^(b)
2 screws	7	41.2%	18	28.6%	25	31.2%	
Surgical indication							
Sequelae of calcaneal fractures	16	94.2	60	95.2%	76	95.0%	0.766 ^(c)
Sequelae of talus fractures	1	5.9%	2	3.2%	3	3.8%	
Osteochondral L. talus and calcaneus	0	0.0%	1	1.6%	1	1.2%	
Consolidated Fracture							
No	0	0.0%	7	11.1%	7	8.7%	0.335 ^(d)
Yes	17	100.0%	56	88.9%	73	91.3%	

(a) Mann-Whitney's test; (b) Chi-squared test; (c) Chi-squared test with Yates correction; (d) Fisher's exact test.

Source: Prepared by the author based on the results of the research.

Tabela 2. Fusion frequencies by type of surgical indication and number of screws used.

Variable	Non consolidated		Consolidated		p-value
	F	%	F	%	
Surgical indication					
Sequelae of calcaneal fractures	7	9.2%	69	90.8%	0.686 ^(a)
Sequelae of talus fractures	0	0.0%	3	100.0%	
Osteochondral L. talus and calcaneus	0	0.0%	1	100.0%	
Number of screws					
1 screw	6	10.9%	49	89.1%	0.425 ^(b)
2 screws	1	4.0%	24	96.0%	

(a) Chi-squared test with Yates correction; (B) Fisher's exact test.

Source: Prepared by the author based on the results of the research.

100%^(4,7,14). The occurrence of nonfusion is influenced by several factors that are related to the characteristics and comorbidities of the patient or even the surgical technique and material used^(2,14,15). To minimize the confounding bias of possible fusion failures, we chose to include only the surgical indications due to posttraumatic subtalar arthrosis because it is the most prevalent cause. In our sample, the prevalence of subtalar arthrodesis in cases of posttraumatic arthrosis occurred mainly in middle-aged males (78.75%) aged between 39 and 53 years (60%), with statistical significance (p-value < 0.001). These data confirm findings in other previous studies^(15,16,22) and identify the profile of a patient who is known to be more prone to trauma; particularly, in this study, calcaneal fracture was mainly responsible for the etiology of posttraumatic arthrosis (95%).

Nonfusion is described as one of the most frequent surgical complications and can reach rates of up to 30%^(2,6,13). Our overall nonfusion rate reached 8.7%, which is consistent with other studies such as those by Davies et al.⁽⁵⁾ (6%) and Vilá-Rico et al.⁽²²⁾ (4.6%). The mean follow-up period of these patients was 23.27 months (14.8-54.1 months), which is sufficient time to confirm the failure of fusion^(4,8,14).

Although some studies correlate the increase in age with the increase in nonfusion rates⁽²⁾, we did not observe a statistically significant difference (p-value = 0.155) in the comparison of age between the patients who evolved to subtalar arthrodesis fusion and those who did not (mean age = 48 and 43 years, respectively). Relevance was probably not obtained because of the small number of patients in the nonfusion group.

In the present study, we observed a nonfusion rate of subtalar arthrodesis of 10.9% in the group in which one

screw was used and a rate of 4% in the group in which two screws were used. However, this difference was not significant (p-value = 0.425), corroborating the findings of other articles in the literature. DeCarbo et al.⁽²¹⁾ found fusion rates of 85.4% and 75% using one and two screws, respectively, with no statistically significant difference (p-value = 0.368). Vilá-Rico et al.⁽²²⁾ found 100% fusion rates in both groups, also comparing the AOFAS score, with no statistically significant difference (p-value = 0.79) and with screws placed in the posterior subtalar.

We believe that the probable biomechanical (mainly torsion and rotation) superiority of the use of two screws, already demonstrated in several studies⁽¹⁰⁻¹²⁾, is counterbalanced by the reduction of the bone contact surface (due to the presence of an additional screw, which is equally important for the fusion of arthrodesis).

Additionally, it should be considered that the patients selected in our study do not have identified risk factors for pseudarthrosis, which may not require maximum stability for fusion to occur⁽¹⁶⁾. The idea of choosing a biomechanically more stable construction in a population with higher risk factors may be interesting and eventually achieve some significant difference in the fusion rate regarding the use of one or two screws.

To our knowledge, this is the first study whose methodology presents a way to evaluate the effect of the number of screws alone on the fusion rate of arthrodesis. Several studies, when not tested on inanimate objects or cadavers, compare patients with several known risks for fusion failure and it is not possible to measure how much this interferes in the comparison of the results^(1,6,19-22). The criteria used in our study were aimed to exclude these risk factors by isolating the *number of screws* in the final result of the fusion.

We are aware that the work has several limitations. The small sample size, resulting from the application of several exclusion criteria, had a significant influence on the number of patients in the nonfusion subgroup, which may have contributed to the lack of statistical significance in the comparison between the groups.

One of our exclusion criteria was the use of bone grafts of any type, which is a factor frequently discussed in the literature but still without consensus⁽²⁷⁾. Shah⁽²⁵⁾ retrospectively evaluated 135 subtalar fusions with different bone grafts, including distinct fixation forms (one or two parallel and divergent screws) and concluded that the bone graft did not improve the arthrodesis rates. Additionally, the author included diabetic and smoker patients. Because the participants had several predisposing factors, it is difficult

to understand the influence of each of these variables on the pseudarthrosis rate of the study. To avoid confounding bias, we chose to make the groups of the present study the most homogeneous possible, thus eliminating any factors that could interfere with the fusion rate of arthrodesis other than the number of screws used.

However, we did not evaluate the positioning and arrangement of the screws in the subgroup in which two implants were used. Several authors have performed biomechanical studies on synthetic bones and fresh cadaver bones to determine the best distribution of the screws^(20,23,24). Matsumoto et al.⁽²³⁾ biomechanically assessed the stability of three forms of subtalar joint fixation (two diverging screws, two parallel screws and three screws) in artificial bones and noted a significant increase in compression with three screws. In another study with artificial bones and cadaver bones, eight different synthesis configurations were tested, and delta fixation presented a significant mechanical advantage for subtalar arthrodesis⁽²⁴⁾.

An adequate radiographic study is fundamental for the correct diagnosis of pseudarthrosis. However, computed tomography showed superiority in the evaluation of joint fusion^(26,28,29). All patients had simple radiographs of the foot and subtalar joint; however, only in doubtful cases did we use CT to diagnose the subtalar joint, and we did not use a graduation system to determine the percentage of fusion obtained^(26,29).

Finally, the retrospective character of the study and non-application of functional scores in the operated patients did not allow us to perform randomization of the technique to be used or to compare the functional result obtained with each of the performed techniques.

CONCLUSION

The use of a second screw for subtalar arthrodesis in patients with posttraumatic arthrosis did not significantly increase the joint fusion rates.

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