

Evaluation of the result and consolidation of arthrodesis in the hindfoot using simple radiography versus computed tomography

Avaliação do resultado e da consolidação das artrodeses do retropé utilizando radiografia simples versus tomografia computadorizada

José Carlos Cohen¹, Fernando Sasaki Reis², Victor Macedo Enne²,
Vanessa de Albuquerque Dinoa³, Luis Eduardo Amorim⁴

ABSTRACT

Objective: Arthrodesis of the hindfoot presents good results in the literature, but non-union significantly compromises the functional result. Simple radiographs are the traditional method for evaluating consolidation of arthrodesis, but studies have demonstrated low sensitivity in identifying non-union, when compared with computed tomography. **Methods:** During the period 2010 to 2014, 16 patients (17 feet) were evaluated retrospectively using the AOFAS score, the consolidation of arthrodesis in each joint of the hindfoot was analyzed by means of simple radiography and computed tomography. The percentage of consolidated joint surface was then calculated, comparing the two diagnostic methods. We used Pearson's coefficient for the correlation between the percentage of consolidation observed in the computed tomography and the functional result. **Results:** The average AOFAS score was 69 points. We observed average scores of 90.3% of the area of radiographic consolidation in isolated subtalar arthrodesis; 76.4% for combined subtalar arthrodesis; and 83.8% for total analysis of subtalar arthrodesis. Talonavicular arthrodesis had 92.4% consolidation and 100% in calcaneocuboid. When we analyzed the consolidation with computed tomography, we observed 53.7% of consolidation for isolated subtalar arthrodesis, 35.7% for combined arthrodesis, 45.3% for total subtalar arthrodesis, 75.5% for talonavicular arthrodesis and 86.5% for calcaneocuboid arthrodesis. Pearson's coefficient demonstrated a weak correlation between percentage of fusion and AOFAS score (r0.02). **Conclusion:**

RESUMO

Objetivo: As artrodeses do retropé apresentam bons resultados na literatura, porém a não união compromete significativamente o resultado funcional. Radiografias simples são o método tradicional usado para avaliar a consolidação das artrodeses, porém estudos demonstram a baixa sensibilidade na identificação de não união quando comparada à tomografia computadorizada. **Métodos:** Durante o período de 2010 a 2014, 16 pacientes (17 pés) foram avaliados retrospectivamente utilizando a pontuação da escala AOFAS, foi analisada a consolidação da artrodeses em cada articulação do retropé por meio de radiografia simples e tomografia computadorizada. O percentual da superfície articular consolidada foi então calculado comparando-se os dois métodos diagnósticos. Utilizamos o coeficiente de Pearson para a correlação entre percentual de consolidação observada na tomografia computadorizada e o resultado funcional. **Resultados:** A média da escala AOFAS foi de 69 pontos. Nas artrodeses subtalares isoladas, observamos uma média de 90.3% de área de consolidação radiográfica; 76,4% nas artrodeses subtalares combinadas; e 83,8% na análise total das artrodeses subtalares. Nas artrodeses talonaviculares houve 92,4% de área de consolidação e de 100% na calcaneocuboide. Ao analisarmos a consolidação com tomografia computadorizada observamos 53,7% para artrodeses subtalar isolada, 35,7% para artrodeses combinada, 45,3% para o total de artrodeses subtalares, 75,5% para as artrodeses talonaviculares e 86.5% na calcaneocuboide. O coeficiente de Pearson demonstrou

¹ Coordinating Physician of the Foot and Ankle Surgery Group of Hospital Federal de Ipanema and Hospital Universitário Clementino Fraga Filho da UFRJ. Master's degree in Medicine from UFRJ.

² Foot and Ankle Surgery Intern at Hospital Universitário Clementino Fraga Filho da UFRJ year 2015/2016.

³ Radiologist at Hospital Universitário Clementino Fraga Filho da UFRJ.

⁴ Assistant Professor of the Department of Orthopedics and Traumatology of Faculdade de Medicina da UFRJ.

Correspondence to:

José Carlos Cohen
Rua: Visconde de Pirajá, 547 – sala 701 – Ipanema
Zip Code: 22410-003 – Rio de Janeiro, RJ, Brazil
E-mail: cohenorto@yahoo.com

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Arthrodesis of the hindfoot presents favorable results. However, simple radiography proved inferior to computed tomography in that an overestimation of the extent of consolidated area was observed.

Keywords:

Arthrodesis; Fracture healing; Tomography, x-ray computed

INTRODUCTION

Hindfoot arthrodeses are procedures that have been used successfully since the beginning of the last century, when sequelae caused by neuromuscular diseases such as Charcot-Marie-Tooth and poliomyelitis caused deformity and instability in the foot and ankle. Arthrodeses are currently reserved for cases where it is not possible to preserve the hindfoot joints using osteotomies, since the subtalar, talonavicular and calcaneocuboid joints perform important biomechanical functions, simultaneously providing rigidity, mobility, and flexibility to the hindfoot for shock absorption during gait. However, hindfoot arthrodeses are still widely used, mainly for the treatment of degenerative arthrosis caused by trauma, diabetes, rheumatoid arthritis, ligament instability, malalignment, and congenital deformities.

There has been considerable progress involving the internal fixation of arthrodeses, making the immobilization time less prolonged and theoretically with better functional recovery. Nevertheless, non-consolidation of hindfoot arthrodeses is still an important problem, with rates ranging from 2% to 36% for triple arthrodesis⁽¹⁻³⁾ and from 0 to 20% for isolated subtalar arthrodesis⁽⁴⁾. Smoking, diabetes and obesity are considered risk factors, increasing the chance of nonunion^(5,6).

Nonunion is defined as incomplete bone healing six months or more after arthrodesis⁽⁷⁾. Radiographs have habitually been used to assess post-arthrodesis consolidation in the hindfoot. However, several studies have demonstrated the limited capacity of plain radiographs to visualize the presence of nonunion or consolidation with safety, probably due to the combination of a complex post-surgical anatomy of the articular surfaces and to bone overlap, hindering the visualization of areas of radiolucency in the joint space on the radiographs. In addition, lack of adequate imaging may partly contribute to the variability in the frequency of nonunion described in the literature. These rea-

uma fraca correlação entre o percentual de fusão e o escore AOFAS (r0,02). **Conclusão:** As artrodeses do retropé apresentaram resultados favoráveis. Entretanto, a radiografia simples provou-se inferior à tomografia computadorizada na medida em que se observou uma superestimação da extensão da área consolidada.

Descritores:

Artrodeses; Consolidação da fratura; Tomografia computadorizada por raios X

sons have led to an increase in the use of computed tomography for the evaluation of arthrodeses in orthopedics, and it is currently considered the best imaging method for evaluation of bone healing^(8,9).

In order to correlate the findings of the images obtained with computed tomography and with plain radiography, a retrospective study was conducted in patients undergoing hindfoot arthrodesis to evaluate the consolidation of the arthrodeses and to compare the degree of this consolidation with the functional result, using the American Orthopedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale (Figure 1), already validated for the Portuguese language⁽¹⁰⁾.

METHODS

After the approval of the study by the Institutional Review Board of Hospital Federal de Ipanema and following the ethical principles for medical research involving human beings (World Medical Association Declaration of Helsinki), 16 patients (17 feet) undergoing hindfoot arthrodesis between 2010 and 2014 were retrospectively evaluated using the AOFAS evaluation questionnaire, validated for Portuguese, and examined through plain radiographs and computed tomography. Inclusion criteria were patients older than 18 years, minimum follow-up of 6 months, diagnosis of hindfoot arthrosis, painful tarsal coalition, and deformity associated with both neurological abnormality and with posterior tibial tendon insufficiency. Exclusion criteria were: patients presenting with active or systemic infection, incapacitating conditions of the hip, knee or ankle; neuropathic arthropathy, morbid obesity (BMI greater than 40), inadequate bone stock (metabolic bone disease or severe osteopenia), previous ankle or hindfoot arthrodesis, immunological abnormalities, insulin-dependent diabetes mellitus or if the patient was on any medication that could interfere with bone healing (NSAIDs or high doses of corticosteroids).

Pain (40 points)	
• None	40
• Mild, occasional	30
• Moderate, daily	20
• Severe, almost always present	0
Function (50 points)	
Activity limitation, support requirement	
• No limitation, no support	10
• No limitation of daily activities, limitation of recreational activities, no support	7
• Limited daily and recreational activities, cane	4
• Severe limitation of daily and recreational activities, walker, crutches, wheelchair, orthosis (ankle brace, ankle immobilizer)	0
Maximum walking distance, blocks	
• Greater than 6	5
• 4-6	4
• 1-3	2
• Less than 1	0
Walking surfaces	
• No difficulty on any surface	5
• Some difficulty on uneven terrain, stairs, and slopes	3
• Severe difficulty on uneven terrain, stairs, and slopes	0
Gait abnormality	
• None, slight	8
• Obvious	4
• Marked	0
Sagittal motion (flexion + extension)	
• Normal or mild restriction (30° or more)	8
• Moderate restriction (15° – 29°)	4
• Severe restriction (less than 15°)	0
Hindfoot motion (inversion + eversion)	
• Normal or mild restriction (75 – 100% normal)	6
• Moderate restriction (25 – 74% normal)	3
• Marked restriction (less than 25% normal)	0
Ankle-hindfoot stability (anteroposterior, varus-valgus)	
• Stable	8
• Unstable	0
Alignment (10 points)	
• Good, plantigrade foot, forefoot and hindfoot well aligned	10
• Fair, plantigrade foot, some degree of ankle and hindfoot malalignment observed, no symptoms	5
• Poor, nonplantigrade foot, severe and symptomatic malalignment	0
TOTAL POINTS: _____	

Figure 1 | American Orthopedic Foot and Ankle Society Ankle-Hindfoot Score, in translation adapted and validated for Portuguese⁽¹⁰⁾.

The preoperative diagnoses were: post-traumatic arthrosis after intra-articular calcaneal fracture in 4 patients and one patient after navicular fracture, 3 patients with pes planus caused by insufficiency in the posterior tibial tendon, 3 patients with primary arthrosis, 2 patients with cavovarus foot (1 of neurological origin and the other idiopathic), 1 patient with post-Muller-Weiss syndrome sequelae, a post-polio sequelae patient (pes planus), and a talocalcaneal tarsal coalition (Table 1).

Our sample consisted of 12 female patients and 4 male patients, 9 right and 8 left feet (one bilateral case). The mean age was 54 years with a minimum age of 34 and a maximum of 75 years.

All patients were clinically examined by the foot and ankle department interns under the supervision of the group's chief surgeon. The AOFAS ankle-hindfoot scale was used (minimum 0 and maximum 100 points), giving consideration to the fact that the 6 points referring to subtalar mobility were abolished or reduced in all cases. The mean postoperative follow-up was 43.5 months, with a minimum of 12 months and a maximum of 76 months. The use of bone grafts and the type of implants used were described (Table 2).

A subjective evaluation was performed asking the patients whether after the surgical procedure they considered themselves completely satisfied, satisfied but with some restrictions, satisfied but with moderate restrictions or unsatisfied.

Imaging Methods

The radiographs were obtained with weight bearing in the anteroposterior and lateral projections of the foot and CT images were obtained in the coronal, axial and sagittal planes. The radiographs were analyzed by the surgeon responsible for the research and the CT images evaluated by an independent radiologist with experience in musculoskeletal imaging, specifically of the foot and ankle, who was unaware of the clinical and functional evaluation of the patients. The surgeon was not aware of the evaluation by the radiologist and vice versa.

All the CT scans and radiographs were performed at the same institution, providing greater precision in the standard and techniques used during image acquisition. The extent of the fusion area on the radiographs and CT images were expressed as a percentage of arthrodesis for each studied hindfoot joint (subtalar, talonavicular, and calcaneocuboid) for all 16 patients (17 feet).

To quantify the extent of fusion in computed tomography, we used the method described in 2006 by Jones et al.⁽¹¹⁾ When screws or clamps crossed the joint, their diameters were included in the total length of the joint, but excluded from the length of the bone fusion surface. Joint fusion was defined as the presence of trabeculation or calcic density crossing the anterior joint space. For patients with subtalar arthrodesis, just the posterior subtalar joint was evaluated, as this was the only portion of the joint consistently fused during arthrodesis.

The subtalar joint was evaluated with 2 mm thick sections perpendicular to the plane of the joint and the midtarsal joints were evaluated with 2 mm axial sections perpendicular to the plane of the joints, measuring the lengths of the fused segments and the lengths of the articular surfaces in all sections. The percentage of fusion was

Table 1 | Data from the patients evaluated, etiology and type of arthrodesis performed

Patient	Sex	Side	Age	Diagnosis	Type of arthrodesis
1	F	R	44	Calcaneal fracture	Subtalar
2	F	L	71	Poliomyelitis	Talonavicular
3	F	L	56	Cavovarus foot	Subtalar
4	F	L	34	Talocalcaneal tarsal coalition	Subtalar and talonavicular
5	M	R	44	Calcaneal fracture	Subtalar
6	F	R	59	Pes planus	Talonavicular and calcaneocuboid
7	F	L	67	Primary arthrosis	Subtalar
8	F	L	60	Post-navicular fracture arthrosis	Subtalar and talonavicular
9	M	L	49	Calcaneal fracture	Subtalar
10	F	R	63	Pes planus	Subtalar and talonavicular
11	M	R	45	Primary arthrosis	Subtalar
12	M	R	59	Cavovarus foot	Triple arthrodesis
13	F	L	47	Primary arthrosis	Subtalar
14	F	R	38	Calcaneal fracture	Subtalar
15	F	R	75	Bilateral pes planus	Triple arthrodesis
16	F	R	57	Muller-Weiss	Subtalar and talonavicular

Table 2 | Use or nonuse of bone grafting, implant used, follow-up time and AOFAS score

Patient	Graft	Implant used	Postop. time	AOFAS
1	No	Two 7.0 mm screws	68 months	85
2	No	One 7.0 mm screw and one 3.5 mm screw	76 months	62
3	No	Two 7.0 mm screws	32 months	68
4	No	Two 7.0 mm screws	50 months	87
5	Yes	Two 7.0 mm screws	32 months	84
6	Yes	One 7.0 mm screw and three 3.5 mm screws	20 months	61
7	No	Two 7.0 mm screws	44 months	81
8	Yes	Two 7.0 mm screws	29 months	57
9	Yes (synthetic)	One 7.0 mm screw	70 months	93
10	No	Two 7.0 mm screws	44 months	60
11	Yes	Two 7.0 mm screws	58 months	74
12	No	One 7.0 mm screw and K wires	38 months	56
13	No	Two 7.0 mm screws	12 months	60
14	No	Two 7.0 mm screws	17 months	55
15D	No	Two 7.0 mm screws and 1 clamp	62 months	78
15E	No	One 7.0 mm screws and 3 clamps	71 months	73
16	No	Three 3.5 mm screws one 7.0 mm screw	17 months	39

calculated using the following formula: $100 \times (\text{sum of the lengths of the fused segments in all sections} / \text{sum of the articular surface lengths})$. When more than one joint was evaluated in the same patient, the images of each joint were separated and evaluated individually. The Radiant Dicom Viewer® program was used to measure these lengths.

For the radiographs, a goniometer marked in millimeters was used to measure the fused area in relation to the total length of the joint. For the subtalar joint, only the lateral radiograph was evaluated, while for the talonavicular and

calcaneocuboid joints, both views (AP and LATERAL) were analyzed.

Statistical analysis was performed using the Excel® program (Microsoft, Bellevue, Washington). Pearson's coefficient (r) was calculated to correlate the AOFAS score with the percentages of consolidation calculated on the CT scan.

Surgical Technique

All the patients were operated on in dorsal decubitus under spinal anesthesia. The pneumatic cuff was used for

transient ischemia after exsanguination of the affected lower limb. The subtalar and calcaneocuboid joints were accessed through a longitudinal lateral approach. After detaching part of the muscle belly of the extensor digitorum brevis, both joints became visible. We then prepared the articular surfaces of the posterior facet of the subtalar and calcaneocuboid, removing all remaining cartilage with the use of osteotomes and curettes. A medial longitudinal approach was used to access the talonavicular joint, in the intermuscular plane between the tibialis anterior and tibialis posterior. After drilling the articular surfaces with a 2.0 mm drill bit, the joints were fixed using screws, compression clamps and/or Kirschner wires, used alone or in combination (see Table 2). The bone graft, when used, was removed from the proximal tibia of the ipsilateral leg or from the iliac crest, according to the surgeon's preference.

The postoperative period consisted of plaster cast immobilization in the boot model for 6 weeks without support and for a further 6 weeks with partial weight bearing on crutches.

RESULTS

The mean AOFAS hindfoot score was 69 points in the 17 feet operated (minimum of 39, maximum of 93) (Table 2). None of the joints had apparent nonunion in the radiographic evaluation. When we analyzed the isolated subtalar arthrodeses separately, we observed a mean of 90.3% of radiographic consolidation area, in the subtalar arthrodeses associated with another hindfoot fusion we obtained a mean of 76.4% and in the total analysis of subtalar arthrodeses (isolated and associated) a mean of 83.8% of union area verified through plain x-ray in the lateral view. With regard to the talonavicular arthrodeses, we observed a mean of 92.4% in the simple radiographs in the AP and lateral views, and a mean of 100% in the calcaneocuboid joint. However, when analyzing the extension of the articular surface fused with bone trabeculae crossing the joint studied with the use of computed tomography, we observed the following mean values, respectively 53.7% for isolated subtalar arthrodesis, 35.7% for associated arthrodesis, 45.3% for the total subtalar arthrodeses, 75.5% for the talonavicular arthrodeses and 86.5% for the calcaneocuboid arthrodeses (Figure 2).

Comparing the observed percentage of fusion of the joints, using the radiographs with computed tomography, we clearly noticed an overestimation of bone healing in all joints evaluated by plain x-ray. Of the 15 subtalar arthrodeses performed (8 isolated cases), we observed tomographic consolidation of 50% or more in only 6 cases. However,

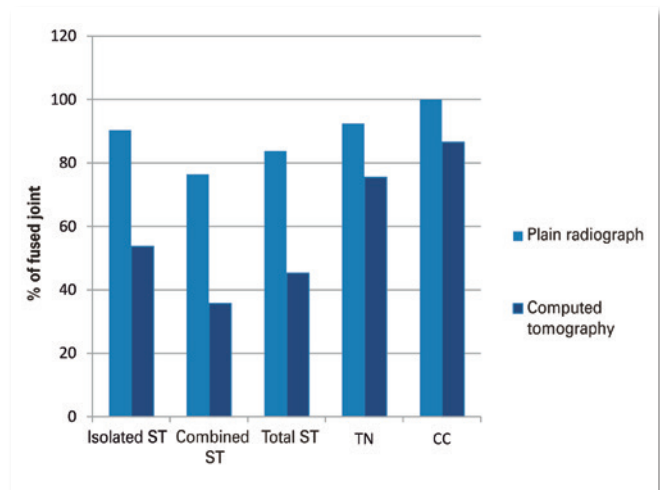


Figure 2 | Mean percentage of consolidation of the joints seen in the plain X-ray and CT scan.

when we analyzed the AOFAS score of these patients we obtained a mean of 70, which is a relatively high score considering the number of cases with incomplete fusion. Arthrodesis of the talonavicular joint was performed in 9 cases, of which only one case was performed separately (Figure 3). In 6 cases, the fusion area was considered 50% or more on the CT. Despite a relatively higher proportion of consolidated cases, we observed an AOFAS score with a mean of 63.6. The calcaneocuboid joint underwent arthrodesis in only 4 cases, and in all of these we obtained consolidation greater than or equal to 50% of the articular extension in the computed tomography (Table 3).

The bone graft was used in 5 cases (Figure 4), while synthetic graft was only used in one case. We observed a mean area of consolidation of 42% seen in the computed tomography in these cases, and due to the small number of patients it was not possible to determine whether there was a significant difference in the area of fusion in comparison to the rest of the cases in which no bone graft was used (Figures 5 and 6).

Pearson's coefficient showed a weak correlation between the percentage of fusion and the AOFAS score (r 0.02), which may reflect the limited number of patients in our sample or simply the fact that some nonunions are asymptomatic (Figures 7 and 8).

In the subjective evaluation, 8 patients were satisfied without reservations, 4 patients satisfied with slight reservations, 3 patients satisfied with moderate reservations and 1 patient dissatisfied with the result of the surgery (Figures 9 and 10).

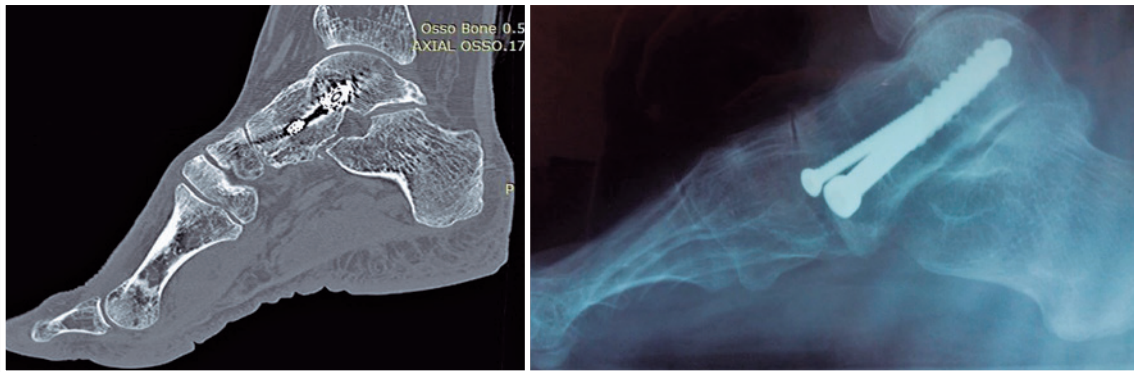


Figure 3 | Example of complete consolidation of the talonavicular joint in both plain X-ray and CT scan.

Table 3 | Percentage of consolidation seen in the CT scan for each joint studied in the sample

	Degree of consolidation in the CT scan			
	0-25%	25-50%	50-75%	75-100%
ST	6	3	1	5
TN	1	2	0	6
CC	0	0	1	3
TOTAL	7	5	2	14

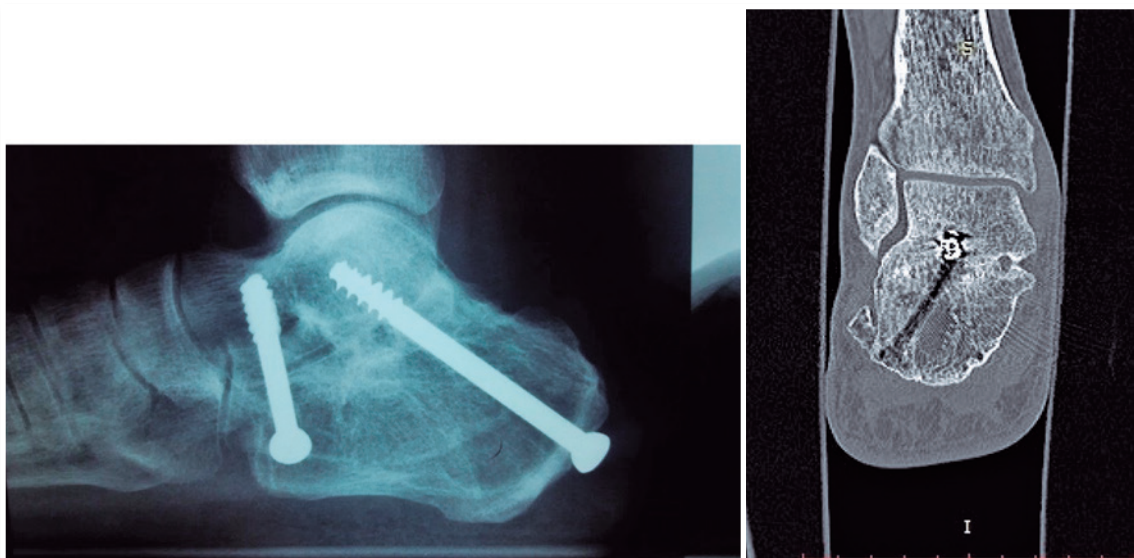


Figure 4 | Example of complete consolidation of the subtalar joint in the plain X-ray and CT scan with use of bone graft.

DISCUSSION

The use of more limited arthrodeses in the hindfoot was facilitated by the use of computed tomography and nuclear magnetic resonance spectroscopy, which can demonstra-

te more accurately which joints are involved, and also by the improvement of internal fixation methods⁽¹²⁾. Santin et al.⁽¹³⁾ demonstrated that the use of selected hindfoot arthrodeses was beneficial in patients with unresectable tar-

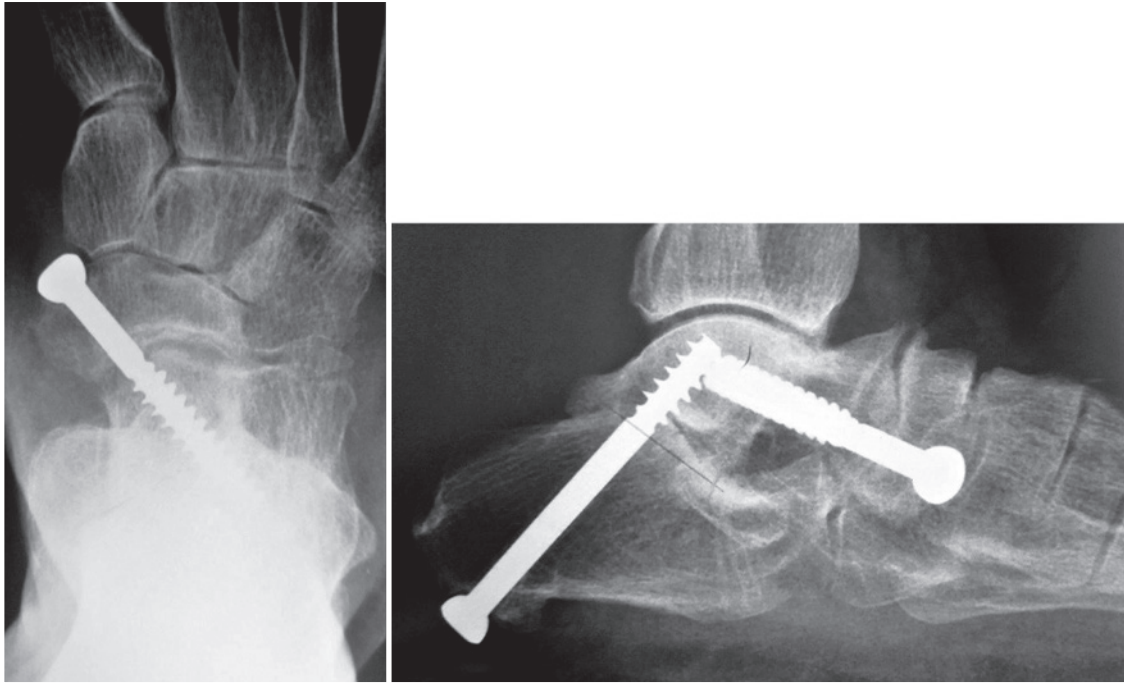


Figure 5 | Partial consolidation of the talonavicular and subtalar joints that is hard to visualize in the plain X-ray.

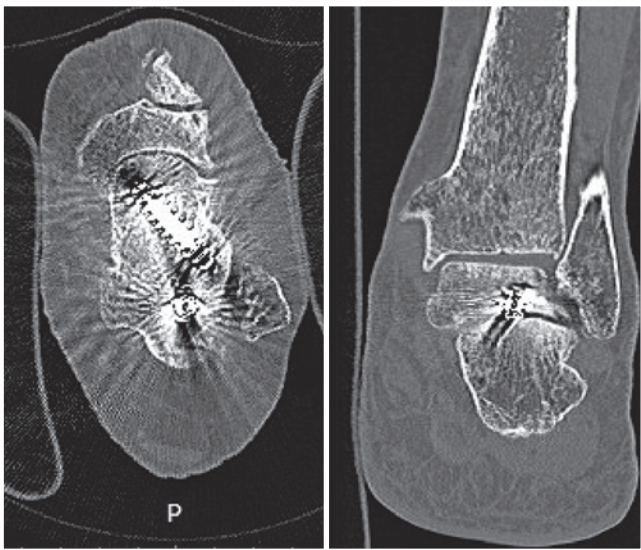


Figure 6 | Same patient from figure 5 confirming non-consolidation of the talonavicular joint and partial consolidation of the subtalar joint.

sal coalitions, recommending small fusions involving the fewest number of joints. Furthermore, in case of residual pain, triple arthrodesis can be performed at any time.

The precise evaluation of bone healing of hindfoot arthrodesis is difficult in some situations. The most common

method used in daily practice is joint evaluation of simple radiography whose union is considered present when there is disappearance of joint space and clinical improvement of pain. However, such a method is not considered ideal, since plain radiographs may overestimate the degree of consolidation. Moreover, clinical examination to detect the presence of nonunion through inversion and eversion of the hindfoot, either evidencing or not evidencing the presence of pain, is not a reliable method.

Therefore, computed tomography has become a more reliable method due to its ability to detect the presence of bone bridges through the consolidation site with three-dimensional images. Cerrato et al.⁽¹⁴⁾ conducted a study to evaluate the level of concordance between 4 foot and ankle surgeons in the assessment of arthrodesis consolidation by CT imaging. Eleven isolated subtalar arthrodeses were included in this study, demonstrating high inter-observer concordance. Therefore, tomographic evaluation of consolidation for hindfoot arthrodeses is an important diagnostic tool and is currently considered the best imaging method in the analysis of bone fusion.

While nonunion is defined as incomplete bone healing at 6 months after arthrodesis, there is no consensus regarding the extent of bone healing that constitutes a “complete” or “incomplete” arthrodesis. A prospective multicenter study⁽¹⁵⁾ recently identified 216 hindfoot and ankle arthrode-



Figure 7 | Plain X-ray and one of the sagittal sections of the CT scan (more lateral) with apparent consolidation of subtalar arthrodesis.

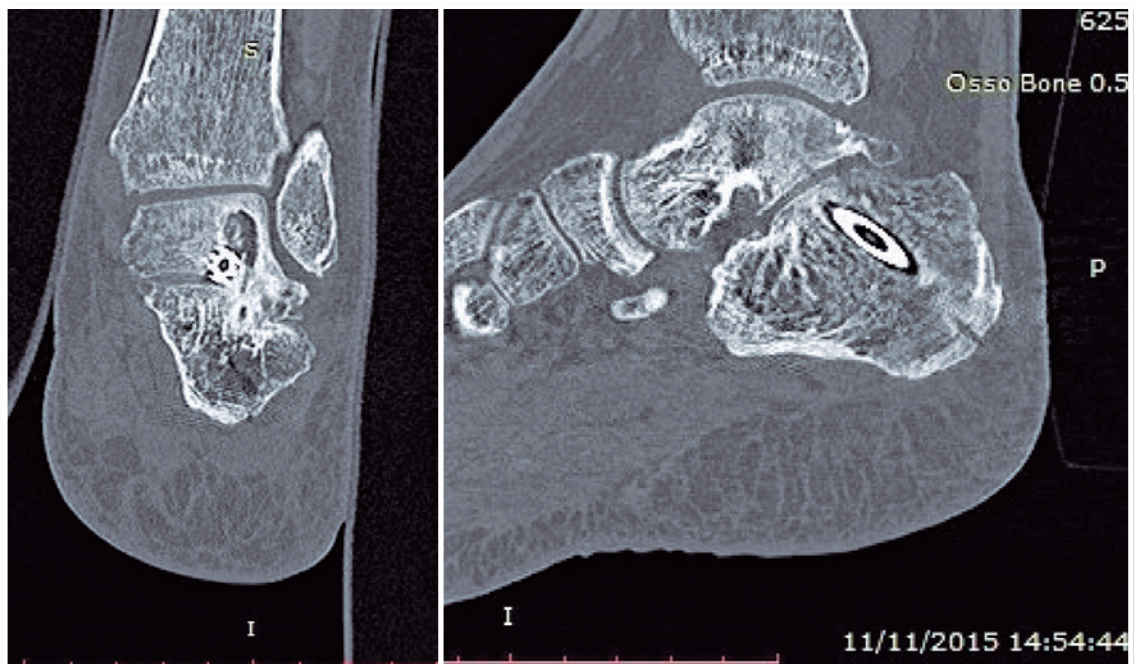


Figure 8 | Same patient from figure 7 with CT imaging coronal and sagittal sections demonstrating only partial consolidation (note the formation of a subchondral cyst in the talus).

ses. In this study, the authors used CT imaging to assess the extent of bone fusion mass in relation to the total length of the joint, and analyzed the correlation between the extent of consolidation and the clinical outcome. It was noted

that the greatest degree of clinical improvement occurred when there was 25 to 49% of consolidated arthrodesis area and that clinical improvement did not increase significantly when more than 50% of trabecular bone surface crossed

the fused joint, whereas in the patients with absent consolidation (0%-24%) there was no improvement in the evaluated scores.

Silvestre et al.⁽¹⁶⁾ retrospectively assessed 33 patients with hindfoot arthrodeses and found only 2 cases of nonunion involving the talonavicular joint. However, this study used only plain radiographs to evaluate consolidation, reserving computed tomography only for some cases that remained symptomatic.

A study carried out by Coughlin⁽⁸⁾, evaluating 15 patients undergoing hindfoot arthrodesis, demonstrated that CT imaging was a better diagnostic method than plain radiography for evaluation of the fusion area in the hindfoot; however, unlike Glazebrook et al.,⁽¹⁷⁾ they maintain that



Figure 9 | Plain X-ray with nonunion of the subtalar joint and consolidation of the talonavicular and calcaneocuboid joints.

50% of fusion observed on the CT scan of the individual joints would be necessary as the limit to consider the joint arthrodesed. Jones et al.⁽¹¹⁾, in a prospective study evaluating 13 patients with unconsolidated hindfoot arthrodeses treated through revision surgery and the use of low-intensity ultrasound, recommended that arthrodesis be considered clinically consolidated in the case of an area of 33% or more with bone trabeculae crossing the site of the pre-existing joint. Dorsey et al.⁽⁹⁾ also observed a 33% threshold in the consolidation rate as a stable fusion. Our sample had 6 subtalar arthrodeses and one talonavicular arthrodesis that demonstrated an arthrodesis area of 0 to 25%. It is interesting to note, however, that not all of these cases had a low AOFAS score, a fact already observed by Wilson et al.⁽³⁾ when they reported that of the 12 cases post-triple arthrodesis nonunion in 301 feet with radiographic evaluation, only 6 cases were asymptomatic and the other 6 had minimal to moderate symptoms. In addition, the presence of nonunion of an arthrodesed joint alone will have a greater clinical repercussion than a nonunion of a fused joint in conjunction with one or more hindfoot joints.

The weak correlation of Pearson's coefficient of the AOFAS score with the presence or absence of nonunion of the arthrodesis in our sample probably does not reflect reality as demonstrated by Krause et al.⁽¹⁵⁾ These authors demonstrated that patients with nonunion had a worse AOFAS score, indicating a negative impact on quality of life. This illustrates the importance of obtaining union after arthrodesis procedures involving the foot and ankle in order to achieve good results and an improvement in the quality of life of

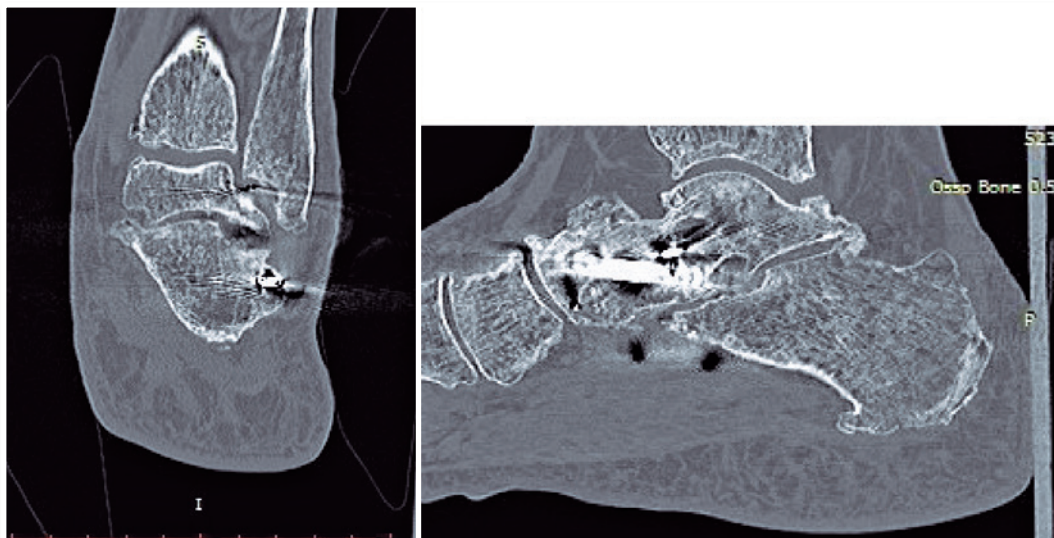


Figure 10 | Same patient from Figure 9, CT scan confirming the complete absence of union in the subtalar joint.

these patients. In addition, this study points out that the concept of asymptomatic nonunion is not true insofar as the cases of nonunion observed in CT scans result in worse scores.

The results of the present study are consistent with the findings of Easley et al.⁽⁴⁾ who demonstrated that subtalar arthrodesis is associated with a less favorable result and a higher rate of nonunion than previously reported. Isolated subtalar arthrodesis has traditionally been associated with high rates of patient satisfaction, low rates of complications, and a low rate of nonunion. With the expected loss of movement of the hindfoot following subtalar, talonavicular and calcaneocuboid arthrodesis, the maximum score is 94 points out of 100 possible points. The mean score of 69 points on the AOFAS scale in this study was consistent with previous reports published in the literature⁽¹⁸⁻²⁰⁾.

We unexpectedly noted a lower percentage of consolidation in combined subtalar arthrodeses than in subtalar arthrodeses performed separately. However, the high rate of patient-reported subjective satisfaction, in which 14 patients were satisfied with the surgical procedure, may indicate that the presence of effective consolidation in one of the hindfoot joints would result in blockage of other joints fused simultaneously, meaning that these are clinically minimally symptomatic or asymptomatic even in the absence of complete fusion.

The use of autologous bone grafts or adjuvants in bone healing, including both osteoinductive and osteoconductive substances in an attempt to increase the success rate of hindfoot arthrodesis, is still controversial. According to Michelson⁽²¹⁾ and Thodarson,⁽²²⁾ the use of demineralized bone matrix proved to be inconsistent. Due to the limited number of cases using autologous bone graft in our sample, it was not possible to demonstrate whether or not its use had a positive influence on the bone healing surface area. Fuchs et al.⁽²³⁾ used iliac grafts in 11 cases of subtalar arthrodesis following calcaneal fracture sequelae, obtaining consolidation in all cases at 12 weeks. In a multicenter study involving ankle and hindfoot arthrodeses in 379 patients (573 joints), using either autogenous bone graft or recombinant human platelet-derived growth factor in combination with beta-tricalcium phosphate (rhPDGF-BB/ β -TCP), it was noted that when more than 50% of the cross-sectional area of the joint visualized in the CT scan in the 9th postoperative week had been filled with one of the abovementioned types of materials, a higher consolidation rate was observed in the CT scan at 24 weeks after the surgical procedure⁽²⁴⁾.

The limitations of the present study are its retrospective nature, a limited number of patients and the lack of clinical evaluation and preoperative imaging. We can challenge the efficacy of CT image interpretation in determining the degree of union present, particularly when we take into account image degradation or artifact due to the implant, presence of bone loss or the varied bone grafting techniques. The interpretation of our results may have been influenced by the fact that the radiographs were evaluated only by a foot and ankle surgeon who also treated patients, while the CT images were evaluated by a single radiologist.

CONCLUSION

Patients undergoing hindfoot arthrodesis have favorable results and a high rate of subjective satisfaction; hence this method is a good salvage option in cases of degenerative, post-traumatic arthrosis, deformity and instability. However, the use of plain radiography in the evaluation of the consolidation of fused joints proved to be inferior to the use of computed tomography, inasmuch as an overestimation of the extension of the consolidated area was observed with the use of conventional x-ray. The relatively high number of joints with a percentage of less than 25% of bone consolidation (7 joints), shows that it is imperative to take precautions when preparing the joints for arthrodesis during the surgical procedure and to consider using bone grafts routinely in an attempt to minimize this potential complication.

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