

# Radiographic evaluation of the tibiotalar joint in patients with ipsilateral triple arthrodesis

## Avaliação radiográfica da articulação tibiotalar em pacientes com tríplice artrodese ipsilateral

Bruno de Carvalho Marques<sup>1</sup>, Isnar Moreira de Castro Junior<sup>1</sup>

1. Instituto Nacional de Traumatologia e Ortopedia, Rio de Janeiro, RJ, Brazil.

### ABSTRACT

**Objective:** This study radiographically evaluated the tibiotalar joints of patients receiving ipsilateral triple arthrodesis and analyzed the effects of this procedure over the short and medium terms.

**Methods:** A total of 150 triple arthrodesis procedures were performed between 2010 and 2015, and 56 patients (62 operated feet) participated in this study. The ankles were radiographically evaluated at the following time points: the initial or preoperative period, 1 year after the operation, and 3 to 5 years after the operation. The presence of arthrosis according to the Kellgren and Lawrence (K&L) scale and the onset time of secondary arthrosis worsening were observed.

**Results:** During the initial period, 31 ankles (50%) presented with no clear signs of arthrosis. Tibiotalar arthrosis presented with a worsening of 1 degree in 13 ankles 1 year after surgery (28.3%). Three to 5 years after surgery, a 1-degree worsening of 21 ankles (55.2%) was observed; 15.8% (n=6) of the ankles had a worsening of arthrosis greater than or equal to 2 degrees; and 11 ankles (29%) had no worsening or onset of tibiotalar arthrosis. The worsening or onset of tibiotalar arthrosis occurred an average of 22 months after the procedure. The mean postoperative evolution time was 32.4 months for those who presented with an arthrosis worsening of only 1 degree. Those who presented with a worsening of tibiotalar arthrosis of 2 or more degrees had an average postoperative evolution time of 43.7 months.

**Conclusion:** Radiographic findings strengthen the concept of arthrosis formation following triple arthrodesis in the tibiotalar joint, even over the short and medium terms.

**Level of Evidence IV; Therapeutic Studies; Case Series.**

**Keywords:** Arthrodesis; Osteoarthritis; Ankle joint; Foot diseases.

### RESUMO

**Objetivo:** Avaliar radiograficamente a articulação tibiotalar dos pacientes submetidos à tríplice artrodese ipsilateral, analisando a influência no curto e médio prazos deste procedimento.

**Métodos:** foram realizados 150 procedimentos de tríplice artrodese no período de 2010 a 2015. Participaram da pesquisa 56 pacientes (62 pés operados). Os tornozelos foram avaliados radiograficamente nos momentos: inicial ou pré-operatório, com 1 ano de pós-operatório e com 3 a 5 anos de pós-operatório. Foi observado a presença de artrose, de acordo com a escala de Kellgreen e Lawrence, e o tempo para o agravamento da artrose secundária.

**Resultados:** No momento inicial havia 31 tornozelos (50%) sem sinais claros de artrose. A artrose tibiotalar apresentou piora em 1 grau no 1º ano do pós-cirúrgico em 13 tornozelos (28,3%). No período de 3 a 5 anos de pós-operatório houve o agravamento de 21 tornozelos (55,2%) em 1 grau; 15,8% (n=6) tiveram piora da artrose maior ou igual a 2 graus; e onze tornozelos (29%) não tiveram qualquer piora ou surgimento de artrose tibiotalar. Houve uma média de 22 meses sem piora ou surgimento de artrose tibiotalar após o procedimento. O tempo médio de evolução pós-cirúrgica foi de 32,4 meses para os que tiveram piora de apenas 1 grau de artrose. Já aqueles que apresentaram piora em 2 ou mais graus de artrose tibiotalar, tiveram tempo médio de evolução pós-cirúrgica de 43,7 meses.

Work performed at the Instituto Nacional de Traumatologia e Ortopedia, Rio de Janeiro, RJ, Brazil.

**Correspondence:** Bruno de Carvalho Marques. Avenida Brasil, nº 500, 2º andar (CAEpé), São Cristóvão, CEP: 20940-070, Rio de Janeiro, RJ, Brazil  
E-mail: [cmarques.bruno@gmail.com](mailto:cmarques.bruno@gmail.com)

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**Conclusão:** As alterações radiográficas encontradas permitiram fortalecer o conceito da formação de artrose secundária à tríplice artrodese na articulação tibiotársica, mesmo no curto e médio prazos.

**Nível de Evidência IV; Estudos Terapêuticos; Série de Casos.**

**Descritores:** Artrodese; Osteoartrose; Articulação do tornozelo; Doenças do pé.

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## INTRODUCTION

Triple arthrodesis of the foot is a well-known procedure that fuses the subtalar, talonavicular, and calcaneocuboid joints. This procedure was initially described by Hoke (1921) and has been perfected over the years<sup>(1,2)</sup>. It is commonly indicated for patients with neuromuscular disorders, rigid foot deformities, arthrosis, and posttrauma sequelae as well as for those in the final stages of posterior tibial tendon dysfunction<sup>(3)</sup>. The technical demands of this procedure involve a prolonged recovery and result in reduced foot mobility. In addition, other complications associated with the procedure include deformity and/or residual pain, an absence of fusion, misalignment of the hindfoot, and avascular necrosis<sup>(4-6)</sup>.

Triple arthrodesis is also known to increase the risk of developing secondary arthrosis of the adjacent joints, such as those of the ankle (tibiotarsal) and tarsometatarsal joints<sup>(5)</sup>. A high prevalence (44%-58) of degenerative changes in these joints after the procedure is reported in the literature<sup>(1,4,7)</sup>, and severe cases occur in 9-27% of the attempts<sup>(8)</sup>. This rate is due to the increase in load pressure that occurs in these joints, especially in the ankle<sup>(9)</sup>. However, although this concept is already well validated, the postprocedure evolution of the appearance of these degenerative changes is unclear<sup>(10)</sup>.

This work radiographically evaluates the tibiotarsal joint of patients receiving triple arthrodesis, analyzes the presence and appearance of degenerative changes over the short and medium terms, and observes the evolution time for the worsening of these changes after the procedure.

## METHODS

This study was approved by the Research Ethics Committee with registration in the Brazil Platform under CAAE number: 70097317.4.0000.5273.

This retrospective observational study evaluated the occurrence or nonoccurrence of tibiotarsal arthrosis in patients receiving the triple arthrodesis procedure by the foot surgery specialists of an institute between 2010 and 2015.

Participants were initially selected through a medical records analysis, and the following descriptive data were collected from the sample: sex, age, preoperative diagnosis, date of surgical procedure, and date of pre- and postoperative radiographs.

Men and women aged between 18 and 69 years who received triple arthrodesis were included in this study. Patients were excluded if they were older than 70 years; had histories of rheumatologic pathology, previous joint infection, or arthropathy; had congenital joint pathology; had sequela from trauma in the tibiotarsal joint; had osteonecrosis of the talar dome; or had a neuromuscular pathology (e.g., polio, Charcot-Marie-Tooth, peripheral motor neuropathies, or others).

Ankle radiographs (anteroposterior and lateral views with loading and mortise view) were performed during the preoperative period (time point 0) as well as 1 year (time point 1) and 3 to 5 years (time point 3-5) after the surgery. The presence of signs of degeneration of the tibiotarsal joint was analyzed based on the Kellgren and Lawrence (K&L) scale<sup>(11)</sup> and its modification that Holzer et al. proposed in 2015<sup>(12)</sup> (Table 1). The presence and location of osteophytosis in all 3 ankle compartments (medial, central/superior, and lateral) and the presence or absence of signs of sclerosis of the talus dome or distal tibia were evaluated. Student's t-test for dependent samples was applied to analyze the evolution time of the onset or worsening of tibiotarsal arthrosis.

The same orthopedist viewed all of the radiographs at 2 time points, with an interval of 2 months. The authors of this study had no conflicts of interest.

A total of 150 triple arthrodesis procedures were performed at this institution between 2010 and 2015. Patients had a mean age of 55 years, and the female-to-male ratio of the patients was 115:35. A total of 88 procedures were excluded from this study based on an analysis of the inclusion and exclusion criteria.

## RESULTS

A total of 56 patients (62 operated feet) participated in the study. The most frequent diagnosis was acquired val-

gus flat foot (46 feet), followed by 8 feet with Muller-Weiss osteonecrosis, 5 feet per sequel due to trauma, 2 feet due to cavovarus foot of nonneurological origin, and 1 foot due to osteonecrosis of the talus head. The mean age of this group was 55.4 years, the female-to-male ratio was 50:12, and 10 patients received bilateral triple arthrodesis (Table 2).

The radiographic analysis of the tibiotarsal joint at baseline showed 31 ankles (50%) without clear signs of tibiotarsal arthrosis (10 grade 0: 21 grade I). Of these ankles, 28.5% (n=6) presented with signs of sclerosis of the distal tibia or talar dome, and the possible osteophytosis formed in these cases occurred primarily in the medial compartment in isolation (71.4%). A total of 19 ankles (30.6%) had grade II arthrosis, and 11 (17.7%) had grade III. One patient was missing their initial radiographic data, and no patients presented with grade IV tibiotarsal arthrosis. Of the patients with present arthrosis (grades II to IV), 30 ankles (70%) showed signs of talar or tibial sclerosis, and 60% (18 ankles) had multiple osteophytes. The medial compartment (93.3%), whether isolated or in combination, was the most affected area within our sample.

During the first postoperative year, 14 ankles (22.6%) did not show degenerative changes (grades 0 and 1 of the

K&L scale). A total of 32 (51.6%) had grades II and III, 16 (25.8%) had no radiographic data, and no grade IV cases were observed 1 year after surgery.

The radiographic analysis performed 3 to 5 years after surgery revealed only 3 ankles (4.8%) without clear signs of arthrosis (all with grade I), indicating the possible presence of isolated medial osteophytes in all 3 cases. A total of 36 ankles (58.1%) presented with signs of arthrosis (15 grade II: 20 grade III: 1 grade IV; Figure 1). Of these ankles, 66.7% (26 ankles) had multiple osteophytes, with 9 involving the medial, superior/central, and lateral compartments, 12 in the medial and central compartments, and 5 in the medial and lateral compartments (Figure 2). Only 6 ankles (15.4%) showed no clear signs of tibiotalar sclerosis (Figure 3). A total of 23 (37.1%) of the 62 ankles analyzed did not have radiographic images for evaluation during this period.

Of the 20 ankles (51.3%) of K&L grade III found in the analysis occurring between 3 and 5 years after the surgery, 16 (80%) were classified as grade 3A using the modified K&L classification<sup>(12)</sup>, and 4 were classified as grade 3B

**Table 1.** The Kellgren and Lawrence (K&L) scale<sup>(11)</sup> and its modification by Holzer et al.<sup>(12)</sup>

K&L		Modified K&L	
Grade 0	Normal	Grade 0	Normal
Grade I	Narrowing of suspected joint space and possible osteophytes at the border (suspected change)	Grade 1	Suspected presence of osteophyte in the medial or lateral malleoli, rare presence of sclerosis; joint space not compromised
Grade II	Possible narrowing of joint space and defined osteophytes (narrowing absent)	Grade 2	Presence of osteophyte defined in the medial malleolus, unimpaired joint space
Grade III	Moderate narrowing of joint space, multiple osteophytes, some subchondral sclerosis, possible joint deformity	Grade 3	Presence of osteophyte defined in the medial and/or lateral malleolus, moderate narrowing (<50%) of the joint space Grade 3A Talar Tilt $\leq 2^\circ$ ; Grade 3B Talar Tilt $>2^\circ$
Grade IV	Severe narrowing of joint space, severe subchondral sclerosis, presence of large osteophytes, joint deformity	Grade 4	Osteophyte defined in the medial and lateral malleoli as well as in the tibiotalar margins with severe (>50%) reduction of joint space; constant tibiotalar sclerosis

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

**Table 2.** Sample characteristics of the 56 patients (62 feet).

	N	%
Age (years) (n=56)		
Maximum	69	
Minimum	12	
Mean	55.4	
Sex		
Male	12	19.4%
Female	50	80.6%
Diagnosis		
Valgus flat foot	46	74.2%
ON Muller-Weiss	08	12.9%
Trauma	05	8.1%
Cavovarus foot	02	3.2%
ON of the head of the talus	01	1.6%
Year of surgery		
2010	09	14.5%
2013	18	29.1%
2014	16	25.8%
2015	19	30.6%
Operated side		
Right	31	50.0%
Left	31	50.0%
Triple arthrodesis (n=56)		
Bilateral	10	17.8%
Unilateral	46	82.2%

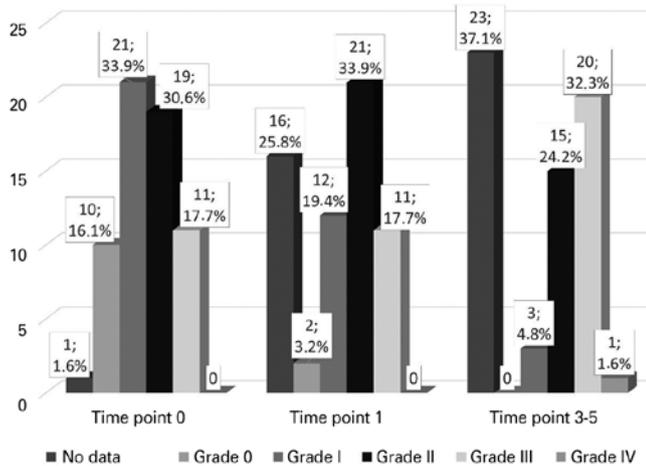
Source: Prepared by the author based on the results of the research.

(Figure 4). The talar tilt found in these ankles varied from 2.2° to 3.5° (average of 2.7°).

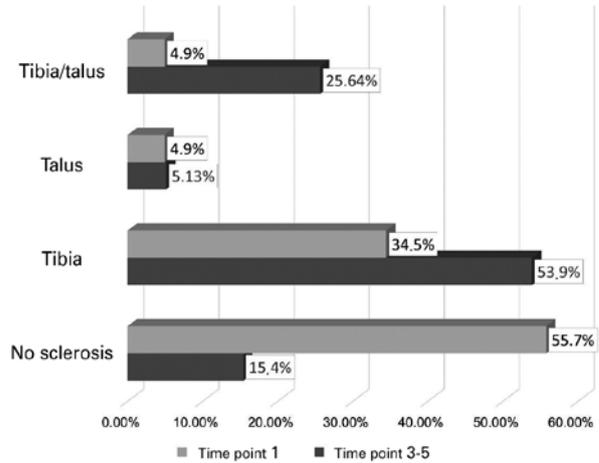
In the first year after the procedure, the rate of tibiotarsal arthrosis worsening (worsening by 1 degree of arthrosis) was 28.3% (13 ankles), which typically progressed from grade I to grade II. A total of 31 ankles (67.4%) showed no worsening or onset of tibiotarsal arthrosis during this period. Three to 5 years postoperatively, 1 degree of worsening was observed in 21 ankles (55.2%); 15.8% (n=6) presented with a worsening greater than or equal to 2 de-

grees; and 11 ankles (29%) had no worsening or new sign of tibiotarsal arthrosis compared with baseline (Figure 5).

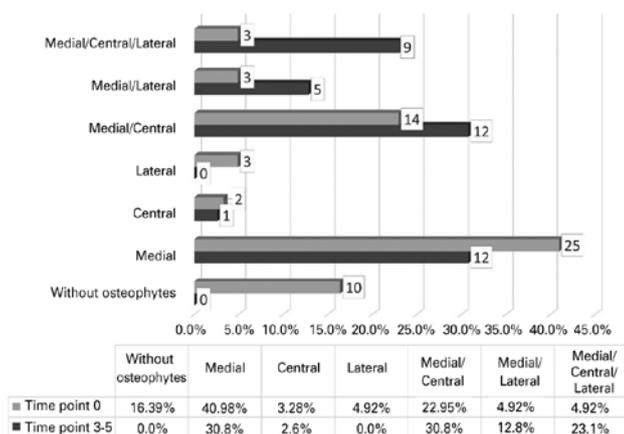
The ankles presented without worsening or the onset of tibiotarsal arthrosis for an average of 22 months after the procedure. The mean postoperative evolution time of those who had arthrosis worsening of only 1 degree was 32.4 months. Those who presented with tibiotarsal arthro-



**Figure 1.** Distribution of the degrees of tibiotarsal arthrosis according to the Kellgren and Lawrence (K&L) classification at baseline (0), 1 year after surgery (1), and 3 to 5 years surgery (3-5).  
**Source:** Prepared by the author based on the results of the research.



**Figure 3.** Prevalence of the presence or suspicion of subchondral sclerosis in the distal tibia or talar dome at baseline (0) and 3 to 5 years after surgery (3-5).  
**Source:** Prepared by the author based on the results of the research.



**Figure 2.** Prevalence of the location of osteophytosis in the medial, lateral, and central/upper compartments at the initial time point (0) and 3 to 5 years after surgery (3-5).  
**Source:** Prepared by the author based on the results of the research.



**Figure 4.** Examples of the ankle osteoarthritis present in our sample based on the Kellgren and Lawrence (K&L) scale and its modification by Holzer (2015), who added subtypes 3A and 3B.  
**Source:** Authors' personal archive.

sis worsening of 2 or more degrees (7 ankles) had a mean postoperative evolution time of 43.7 months (Figure 6).

The p-value associated with the comparison between the time of evolution of those who did not present with worsening or arthrosis onset (mean of 22 months) and those who had only 1 degree of ankle arthrosis worsening (mean of 32.4 months) was 0.014 ( $p \leq 0.05$ ).

## DISCUSSION

Patients with rheumatologic diseases, neuromuscular diseases, chronic deformities, or previous arthropathies

were excluded from our sample to reduce the interference of their direct or indirect degenerative actions.

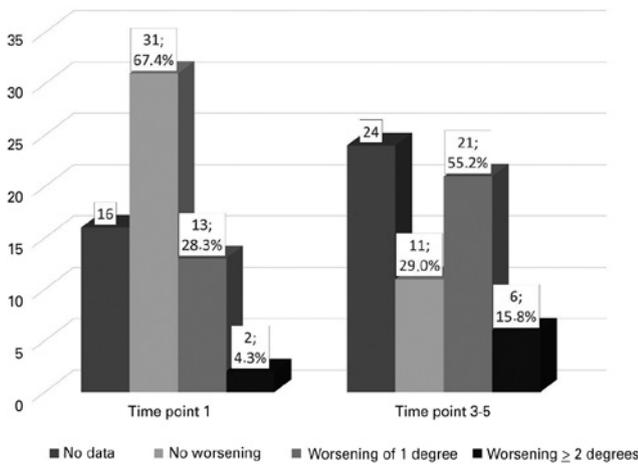
In our study, the rate of preoperative osteoarthritis was 49.2% (30 feet); at the 1-year follow up, it was 70% (32 of 46 operated feet), and at the 3- to 5-year follow up, it was 92.3% (36 of 39 operated feet). The mean time to progress to 1 degree of tibiotarsal arthrosis worsening was 32.4 months (range 12 - 56 months). Greater worsening was associated with a longer postoperative time in this study, with a mean of 43.7 months (range 11 - 60 months).

Four patients progressed to grade III of the K&L scale, with a talar tilt of  $>2^\circ$ , which is subtype 3B according to Holzer et al.<sup>(12)</sup>, and this inclination deteriorated over time. One patient presented with a tilt increase from  $1.5^\circ$  to  $3.5^\circ$  within 38 months.

This research adopted the K&L scale<sup>(11)</sup> to classify ankle osteoarthritis. Holzer et al. (2015) modified this scale specific to the ankle joint, adding subtypes 3A and 3B, which are characterized as K&L grade III arthrosis associated with the presence or absence of a talar tilt greater than  $2^\circ$ . Thus far, however, the modified system that Holzer proposed in 2015 has not been rigorously tested or validated.

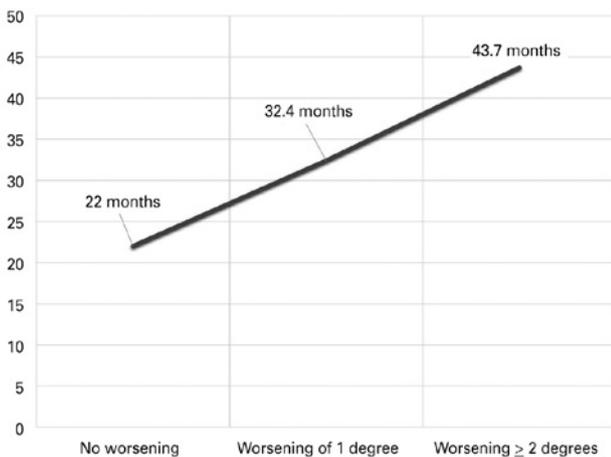
Ebalard et al.<sup>(10)</sup> published a multicenter retrospective study in 2014 that examined 65 patients and found a rate of tibiotarsal arthrosis that was 73% higher than that during the preoperative period. In that study, the Graves scale was used to classify arthrosis, and the analysis occurred 10 years after the procedure (range 10 - 31 years). In our study, the rates of ankle osteoarthritis were higher at different times, and the period for evaluation was briefer (3 to 5 years postoperative). We believe that this difference is due to the long time that the patients had access to a specialized service, which delayed diagnosis and treatment and consequently worsened the pathology.

Aarts et al.<sup>(13)</sup> performed a medium-term study of 55 feet receiving triple arthrodesis and reported that 58% of these feet did not present with tibiotarsal osteoarthritis worsening, and 31% presented with only 1 degree of worsening 7.5 years after the procedure. The worse aggravations were related to the presence of previous osteoarthritis and the persistence of the misalignment of the hindfoot, even after surgery. Pell et al.<sup>(14)</sup> studied 132 operated feet. No association was found between the presence of arthrosis and patient satisfaction. Nine ankles (7%) already showed some degree of tibiotarsal arthrosis during the preoperative period, progressing to 79 ankles (60%) during follow up. Despite these findings, the authors only describe the grades found and did not determine the mo-



**Figure 5.** Worsening rate of tibiotarsal arthrosis at time point 1 (1 year after surgery) and at time point 3-5 (3 to 5 years after surgery).

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



**Figure 6.** Mean evolution time of the onset or worsening of tibiotarsal arthrosis after triple arthrodesis.

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

ment of the worsening; thus, it is impossible to consider or analyze the evolution time of these degenerative changes in the adjacent joints.

Saltzman et al.<sup>(15)</sup> studied 57 patients (67 feet) aged 7 to 57 years by evaluating their radiographic changes over the long term. At the first evaluation, 21 ankles (31%) showed no radiographic evidence of degenerative change. The second evaluation was performed 19 years later, with a mean of 44 years after the procedure, and all patients showed some degenerative change. That study had numerous young and pediatric patients. We believe that these differences in the sample might interfere with the results found regarding the time to tibiotarsal osteoarthritis onset and the rate of arthrosis worsening compared with our study.

In a review article, Ahmad<sup>(16)</sup> stated that the arthrosis of adjacent joints is an expected consequence and should not be viewed as a procedural failure. In 2008, Groot et al.<sup>(4)</sup> studied 36 patients receiving triple arthrodesis due to idiopathic or posttraumatic causes and observed the appearance of tibiotarsal arthrosis in 15 patients (47% of cases) 6 years after the procedure. After a mean of 10 years (range 6 - 15 years), De Heus et al.<sup>(7)</sup> re-evaluated 54 patients who received triple arthrodesis or isolated subtalar arthrodesis using the Van Dijk scale<sup>(17)</sup>. They found 36 ankles with no signs of osteoarthritis and observed a 1-degree worsening in 14 feet and a  $\geq 2$  degrees worsening in 4 feet. They reported that the most severe cases had previous tibiotarsal arthrosis.

In a more recent study of 40 feet undergoing triple arthrodesis, Klerken et al.<sup>(18)</sup> reported an increase in the degrees of tibiotarsal osteoarthritis in 19 feet during the 15-year postoperative period. Unlike our study, their sample included patients with congenital club foot sequelae, neuromuscular diseases, neuropathies, and rheumatoid arthritis. However, they excluded the most severe cases because they evolved to tibiotarsal arthrodesis or ankle arthroplasty.

The limitations of our study are primarily related to the loss to follow up of numerous patients for the following reasons: 1 ankle (1.6%) without radiograph at baseline, 16 ankles (25.8%) operated on after 1 year, and 23 ankles (37.1%) with no satisfactory radiographic data for analysis 3 to 5 years after surgery. The literature has no data regarding the mean time of evolution for the worsening of tibiotarsal arthrosis comparable with that of our work at different evaluation time points. The t-test for dependent samples was applied to the sample at time points 0 and 1, and a significant difference was found between the mean times for the evolution of arthrosis of 1 degree. The same analysis could not be performed by comparing time point 0 with time point 3-5 because the study attrition prevented statistical comparison.

## CONCLUSIONS

The radiographic changes found in this study allow researchers to strengthen the concept of arthrosis formation secondary to triple arthrodesis in the tibiotarsal joint, even over the short and medium terms.

The radiographic analysis showed the worsening of this joint, with initial osteoarthritis rates of 49.2% (30 feet), with few signs of sclerosis or the presence of isolated medial osteophytes, increasing to 70% at 1 year and to 92.3% at 3 to 5 years. A total of 26 ankles (66.7%) presented with multiple osteophytes, and 84.6% presented with signs of tibiotarsal sclerosis. The mean time to progression to 1-degree worsening was 32.4 months after surgery.

Research on the evolution time of tibiotarsal arthrosis comparable with our work is lacking. Therefore, additional studies are necessary to improve our understanding of the time of worsening and the onset of tibiotarsal arthrosis following triple arthrodesis.

**Authors' contributions:** Each author contributed individually and significantly to the development of this article: BCM <sup>\*</sup>(<https://orcid.org/0000-0002-0479-0244>) conceived and planned the activities that led to the study; wrote the article and interpreted the results of the study; IMCJ <sup>\*</sup>(<https://orcid.org/0000-0002-7815-6086>) participated in the review process, interpreted the results of the study and approved the final version. <sup>\*</sup>ORCID (Open Researcher and Contributor ID).

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