



## Original Article

# Clinical and functional evaluation of forefoot reconstruction in patients with rheumatoid arthritis<sup>☆,☆☆</sup>

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### ABSTRACT

**Objective:** to evaluate the long-term results from reconstruction of the forefoot in patients with rheumatoid arthritis who underwent arthrodesis of the metatarsophalangeal joint of the hallux, resection arthroplasty of the heads of the lateral metatarsals and correction of the deformities of the smaller toes through arthrodesis of the proximal interphalangeal joint or closed manipulation.

**Methods:** seventeen patients (27 feet) who underwent forefoot reconstruction surgery by means of arthrodesis of the first metatarsophalangeal joint, resection of the heads of the lateral metatarsals and correction of the deformities of the smaller toes, were studied retrospectively. The mean follow-up was 68 months (12–148 months); the mean age was 52 years (range: 20–75 months); and four patients were male and 13 were female.

**Results:** the results were classified as excellent in 17 feet, good in two, fair in four and poor in two. The mean score on the AOFAS scale was 70 points; 21 feet (78%) were found to be asymptomatic; and six feet (22%) presented some type of symptom. Three feet presented pseudarthrosis, and one of these successfully underwent revision of the arthrodesis. There was no significant difference in scoring on the AOFAS scale or in the consolidation rate, between using a plate and screws and using Kirschner wires for fixation of the arthrodesis. **Conclusion:** arthrodesis of the first metatarsophalangeal joint with resection arthroplasty on the heads of the lateral metatarsals and correction of the deformities of the smaller toes, which was used in forefoot reconstruction in rheumatoid patients, showed good long-term results with a high satisfaction rate among the patients and clinical-functional improvement.

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## Avaliação clínico-funcional da reconstrução do antepé nos pacientes portadores de artrite reumatoide

### R E S U M O

*Palavras-chave:*  
Antepé humano  
Artrite reumatoide  
Artrodese

**Objetivo:** avaliar os resultados em longo prazo da reconstrução do antepé nos pacientes com artrite reumatoide submetidos à artrodese da articulação metatarsofalângica (MTF) do hálux, artroplastia de ressecção das cabeças dos metatarsos laterais e correção das deformidades nos dedos menores por meio de artrodese da articulação interfalângica proximal (IFP) ou manipulação fechada.

**Métodos:** foram estudados retrospectivamente 17 pacientes (27 pés) submetidos à cirurgia de reconstrução do antepé com artrodese da primeira articulação MTF, ressecção das cabeças dos metatarsos laterais e correção das deformidades nos dedos menores. O seguimento médio foi de 68 meses (12 a 148), a média de idade foi de 52 anos (20 a 75 meses) e quatro pacientes eram do sexo masculino e 13 do feminino.

**Resultados:** os resultados foram classificados como excelente em 17 pés, bom em dois, regular em quatro e ruim em dois. A pontuação média da escala Aofas (American Orthopaedic Foot and Ankle Society) foi de 70 pontos, 21 pés (78%) encontravam-se assintomáticos e seis (22%) apresentavam algum tipo de sintoma. Três pés apresentaram pseudoartrose. Um deles foi submetido à revisão da artrodese com sucesso. Não houve diferença significativa na pontuação da escala Aofas e nos índices de consolidação com o uso de placa e parafusos ou fios de Kirschner na fixação da artrodese.

**Conclusão:** a artrodese da primeira articulação MTF com artroplastia de ressecção das cabeças dos metatarsos laterais e correção das deformidades nos dedos menores, usada na reconstrução do antepé dos pacientes reumatoides, demonstrou bons resultados em longo prazo, com elevado índice de satisfação dos pacientes e melhoria clínico-funcional.

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## Introduction

Rheumatoid arthritis is a chronic and progressive systemic disease that presents incapacitating manifestations in the musculoskeletal system and may affect the foot and ankle in up to 90% of the cases. Half of them are located in the forefoot.<sup>1,2</sup> The involvement of the forefoot is characterized by chronic synovitis in the metatarsophalangeal (MTP) joints, capsular distension and loss of integrity of the collateral ligaments.<sup>3</sup> Presence of chronic capsule-ligament instability, destruction of the joint cartilage and reabsorption of the subchondral bone lead to typical deformities in the forefoot. Hallux valgus is the commonest condition in the first ray. The smaller toes typically present in rigid claw form, and with subluxation or dislocation of the lateral MTP joints. Progression of the deformities also leads to distal migration of the plantar pad and favors appearance of metatarsal pain, ulcerations and painful plantar calluses,<sup>1-3</sup> which cause difficulty in walking and in using conventional footwear.

Surgical treatment is indicated when the conservative measures fail to relieve the symptoms, and it has the main objectives of relieving the pain caused by synovitis and joint destruction, correcting the deformities, improving the gait pattern and adapting the feet to shoes.<sup>1-3</sup>

Historically, a variety of procedures have been described for treating rheumatoid forefeet and they have typically involved

correction of deformities of the MTP joint of the smaller toes by means of resection arthroplasty of the metatarsal heads or the base of the proximal phalanx, or both. Deformities in the smaller toes can be corrected by means of resection of the distal portion of the proximal phalanx, arthrodesis of the proximal interphalangeal joint or closed manipulation and intramedullary fixation. The options for correction of hallux valgus include resection arthroplasty of the metatarsal head or the proximal phalanx of the hallux; joint replacement using metallic or silicone implants; and arthrodesis of the MTP of the hallux.<sup>1-3</sup>

With evolution of the surgical techniques and better understanding of the deformities, arthrodesis of the MTP joint of the hallux has become the treatment method most used for correcting deformities of the first ray.<sup>4-6</sup> This procedure stabilizes the MTP of the hallux and allows this to receive greater pressure during gait. Through this, action by deforming forces on the MTP joints of the smaller toes is prevented, thereby helping toward diminishing metatarsal pain and promoting long-term results that are more satisfactory (pain relief, maintenance of alignment and patient satisfaction).<sup>5-9</sup>

This study had the aim of presenting the long-term results from reconstruction of the forefoot in patients with rheumatoid arthritis who underwent arthrodesis of the MTP joint of the hallux along with resection arthroplasty of the heads of the smaller metatarsals and correction of rigid deformities in the smaller toes by means of arthrodesis of the proximal interphalangeal joint or closed manipulation and osteoclasis.

## Sample and methods

Seventeen patients (27 feet) with a diagnosis of rheumatoid arthritis and severe forefoot deformity were included in this study. These patients underwent reconstructive surgery by means of the technique of arthrodesis of the first MTP joint of the hallux and resection arthroplasty of the heads of the lateral metatarsals, performed by the Foot and Ankle Group of Santa Casa de Misericórdia de São Paulo, between January 1998 and March 2010. All of these patients had severe hallux valgus deformities associated with pain, rigid deformities of the smaller toes and metatarsal transfer pain on the heads of the lateral metatarsals. Patients who underwent surgical correction by means of the technique under examination but whose postoperative follow-up was less than 12 months were excluded. The means length of follow-up was 68 months (range: 12–148). Four patients were male and 13 were female. The mean age at the time of the surgery was 52 years (range: 20–75 years).

Severe hallux valgus associated with incapacitating pain, rigid deformities of the smaller toes and metatarsal transfer of pain on the heads of lateral metatarsals led to the surgical indication, while patients whose postoperative follow-up was less than 12 months were excluded.

The patients were evaluated by means of personal interviews and clinical examinations. They were asked about whether they had any pain in their forefeet; whether they were able to use conventional closed footwear; and what their degree of satisfaction was, regarding the final results from the surgical procedure. In the clinical examination, we noted the alignment, the position of the foot when bearing weight and the presence or absence of hallux deformities. Following this, with the patient sitting on the examination table, we investigated the presence of metatarsal pain and pain at the medial eminence of the hallux. The medical files were reviewed to establish the preoperative complaints, location of the pain, severity of the deformities and presence of early or late postoperative complications.

Radiographic examinations were performed in dorsoplantar and lateral views on the forefoot with load-bearing. The preoperative radiographs were recovered from the radiographic archives of the Medical and Statistical Filing Service (SAME) of Santa Casa de Misericórdia de São Paulo. The images were evaluated with regard to presence or absence of consolidation and the type of fixation used for arthrodesis of the MTP of the hallux. The hallux valgus angle (HVA),<sup>10</sup> i.e. the angle formed between the lines that bisect the diaphysis of the proximal phalanx and the diaphysis of the first metatarsal, and the angle between the first and second metatarsals (intermetatarsal angle I-II (IMA I-II)),<sup>10</sup> i.e. the angle formed between the lines that bisect the diaphyses of the first and second metatarsals) were measured.

We compared the fixation method used for arthrodesis of the MTP of the hallux with the radiographic parameters obtained from the final radiographs and observed the consolidation rates and angular corrections obtained. We correlated the fixation method with the functional clinical results according to the AOFAS scale<sup>11</sup> for the MTP joint of the hallux.

The AOFAS functional scale<sup>11</sup> was used to quantitatively measure the postoperative results in order to evaluate the MTP joint of the hallux. This scale ranges from 0 to 100 points and takes into consideration items relating to pain, activity level, deformity and mobility. We divided the results into two groups: scores less than 70 points and scores greater than or equal to 70 points. We compared these groups in relation to age at the time of the surgery; initial degree of deformity (evaluated by measuring the HVA and IMA I-II); and the presence or absence of consolidation on the current radiographs.

The results were also classified in accordance with the criteria drawn up by Mann and Thompson,<sup>4</sup> who evaluated the presence of pain in the forefoot and the capacity to use closed footwear. The surgical result was considered to be excellent when the patients did not complain of pain when they were standing upright and were capable of using conventional closed footwear; good when they did not present painful complaints, but were only able to make use of open shoes; moderate when there was some residual pain but less than before the operation; and poor when there was no improvement or even worsening of the pain.

Patients' satisfaction with the surgical procedure was assessed using the scale of Johnson et al.<sup>12</sup> It was investigated whether they were completely satisfied, satisfied with slight reservations, satisfied with major reservations or dissatisfied.

## Surgical technique

The first MTP joint was treated by means of a dorsal longitudinal incision of around 5 cm, centered on the joint and deepened over the medial edge of the long extensor tendon of the hallux. The capsule and the collateral ligaments were released; the joint cartilage of the proximal phalanx and metatarsal head were removed; and medial exostectomy was performed. The arthrodesis was fixed using a plate and screws, single screws between fragments or two 2.0 mm Kirschner wires. Kirschner wires were used if, according to the surgeon's assessment during the operation, the bone quality did not allow fixation of greater rigidity. Arthrodesis was performed in the position recommended in the literature, with valgus of around 10°, dorsiflexion of 20° and neutral rotation.<sup>1-6</sup>

The MTP joint of the smaller fingers was exposed by means of two dorsal incisions of around 5 cm in the second and fourth intermetatarsal spaces. The collateral ligament, the dorsal portion of the capsule and intermetatarsal ligament were released circumferentially around the base of the proximal phalanx and the metatarsal head and neck. The metatarsal heads were resected in the distal of the metaphysis with the aid of a saw, starting with the second metatarsal and progressively repeating this for the other lateral metatarsals, taking care to maintain the metatarsal formula.

After resection of the metatarsal heads, the fixed deformities of the smaller toes were corrected. It was possible that manual osteoclasis or arthrodesis of the proximal interphalangeal joint alone would be performed, depending on the rigidity and severity of the deformity. At the end of this procedure, each toe was fixed with a 1.5 mm Kirschner wire, and the fixation was extended as far as the intramedullary region of the metatarsals.

After the operation, all the patients used sandals with weight-bearing on the forefoot, and loading was allowed as tolerated. The dressing was changed every week until the stitches were removed, 15–20 days after the operation. The patient continued to use the sandals until there were radiographic indications of consolidation of the arthrodesis of the MTP of the hallux (between 10 and 12 weeks after the operation), when the sandals were withdrawn and use of comfortable footwear was allowed. The Kirschner wires of the smaller toes were removed as outpatient procedures, eight weeks after the operation. The Kirschner wires of the MTP of the hallux were removed only after consolidation of the arthrodesis.

## Results

All the patients were evaluated by the same examiner, who did not participate in the treatment. The mean AOFAS score for the MTP joint of the hallux obtained in the final evaluation was 70 points out of a possible 90 points (range: 25–88). It was considered that the maximum AOFAS score for the MTP of the hallux was 90 points because of the loss of joint mobility in the first MTP after arthrodesis, which impeded the use of this parameter as a means of evaluating postoperative function. When the pain parameter of the AOFAS score for the MTP of the hallux was evaluated separately, the mean value was observed to be 34 out of the 40 points possible (range: 20–40).

We observed two cases (two feet) with deep infection in the operative wound in the dorsum of the foot and skin necrosis at the site of the arthrodesis of the MTP of the hallux. These cases occurred in patients who were smokers, and both underwent serial debridement and intravenous antibiotic therapy until the infectious condition had been resolved. There was also one case (one foot) with superficial infection, which was resolved by means of oral antibiotic therapy and serial dressings. One foot presented vascular complications during the immediate postoperative period and evolved with necrosis and amputation of the third toe.

We observed the presence of pseudarthrosis in three feet, as late complications. One of them underwent revision surgery, with subsequent consolidation. The other two feet in which consolidation of the arthrodesis of the MTP of the hallux was not achieved occurred in patients who presented deep infection of the operative wound and skin necrosis as early complications. One of these cases evolved with chronic osteomyelitis. The synthesis material and devitalized bone were removed, and prolonged intravenous antibiotic therapy was administered, which led to resolution of the infectious condition. However, this patient continued to present painful symptoms in the first MTP joint and there was recurrence of the valgus deformity of the hallux. In the other case, complete resolution of the infectious condition was achieved through debridement and antibiotic therapy, although pseudarthrosis was seen to be present later in the postoperative follow-up. Both of the cases that presented deep infection and pseudarthrosis occurred in patients who smoked.

In the most recent clinical examination, 14 patients (21 feet) (78%) did not have any complaints. Six patients (6 feet) (22%) presented some type of symptom. Three patients (3/27 feet;

**Table 1 – Mean angular correction among the patients with rheumatoid arthritis who underwent reconstruction of the forefoot by means of arthrodesis of the metatarsophalangeal joint of the hallux.**

	Pre-op (mean)	Post-op final (mean)	Angular correction (mean)
HVA	41°	17°	24°
IMA I-II	15°	11°	4°

HVA, hallux valgus angle; IMA I-II, intermetatarsal angle between the first and second metatarsals.

11%) were observed to present plantar metatarsal pain alone; two patients (2/27; 7%) presented pain and deformity in the hallux alone. One of these was one of the cases that evolved with pseudarthrosis. The other patient (one foot), who presented deep infection and pseudarthrosis of the MTP of the hallux, evolved with pain and deformity in the hallux in association with metatarsal pain and was a smoker.

Using the criteria of Mann and Thompson,<sup>4</sup> the results were classified as excellent in 19 feet (71%), good in two (7%), moderate in four (15%) and poor in two (7%). Regarding the patients' satisfaction with the surgical procedure according to the scale of Johnson et al.,<sup>12</sup> 10 patients (15 feet) were found to be completely satisfied with the results from the surgery, five (10 feet) were satisfied with slight reservations and two (two feet) were dissatisfied.

The angular correction obtained in the patients who underwent forefoot reconstruction is demonstrated in Table 1, along with the pre- and postoperative mean values for the HVA and IMA I-II.

We evaluated the fixation method used in arthrodesis of the MTP of the hallux and correlated the radiographic parameters with the clinical-functional results according to the AOFAS scale, as demonstrated in Table 2. We did not find any significant differences in AOFAS scores on comparing the fixation of the arthrodesis on the MTP of the hallux using a plate and screws versus Kirschner wires. Likewise, we did not find any differences in consolidation rates between these two fixation methods. The mean angular corrections were also similar.

The clinical-functional results expressed using the AOFAS scale were divided into two groups: scores lower than 70 points

**Table 2 – Comparison between the types of fixation in relation to the clinical and radiographic parameters of patients with rheumatoid arthritis who underwent forefoot reconstruction.**

	Plate/screws (18/26 feet)	Wires (8/26 feet)
AOFAS (MTP)	69/90	70/90
Consolidation	83%	87%
Pseudarthrosis	17%	13%
Correction IMA I-II (mean)	4°	3.5°
Correction HVA (mean)	23°	27°

MTP, metatarsophalangeal joint; IMA I-II, intermetatarsal angle between the first and second metatarsals; HVA, hallux valgus angle.



**Table 3 – Distribution of the feet operated according to the AOFAS criteria and comparison with the clinical and radiographic parameters of patients with rheumatoid arthritis who underwent forefoot reconstruction.**

	AOFAS < 70 points (10/27 feet)	AOFAS ≥ 70 points (17/27 feet)
Mean age in years	63	46
Consolidation of arthrodesis of the MTP of the hallux	70%	100%
Initial IMA I-II (mean)	15°	15°
Initial HVA (mean)	29°	48°

MTP, metatarsophalangeal joint; IMA I-II, intermetatarsal angle between the first and second metatarsals; HVA, hallux valgus angle.

and score greater than or equal to 70 points, as demonstrated in Table 3. We observed differences between these groups regarding the mean age at the time of the surgery and the consolidation rates assessed from the final radiographs. The mean age was 46 years in the group with AOFAS scores greater than or equal to 70 points, while the mean age among the feet with scores less than 70 points was 63 years. The feet with higher AOFAS scores also achieved 100% consolidation, whereas the group with scores less than 70 points achieved 70% consolidation in the final radiographic evaluation.

## Discussion

Many surgical procedures have been described for treating hallux valgus and deformities of the smaller toes in patients with rheumatoid arthritis. In 1912, Hoffman<sup>13</sup> described resection of all of the metatarsal heads by means of a single plantar incision. Other authors<sup>14-16</sup> modified the operative technique over time and demonstrated different results according to the type of incision (dorsal or plantar),<sup>14,15</sup> repositioning of the plantar pad or excision of the metatarsal heads or proximal phalanx of the toes.<sup>14,15</sup>

Initially, treatment of the first ray continued to be the most controversial point in forefoot reconstruction in rheumatoid patients.<sup>14</sup> Over time, resection of the base of the proximal phalanx (Keller procedure)<sup>15</sup> and resection of the head of the first metatarsal (Mayo procedure)<sup>17</sup> became popular. These procedures have demonstrated high recurrence rates for hallux valgus, metatarsal pain and plantar calluses.<sup>15,18</sup>

Henry and Waugh<sup>7</sup> and Mann and Thompson<sup>4</sup> demonstrated that stable realignment of the first ray is a determining factor for obtaining better results from reconstructing the forefoot in these patients, given that arthrodesis of the MTP of the hallux increases the plantar pressure on the medial column of the foot during gait and prevents the action of deforming forces on the MTP joints of the smaller toes, thereby helping to diminish metatarsal pain.

Through this, arthrodesis of the MTP joint of the hallux has become the treatment method most used for correcting deformities of the hallux and has led to better results in terms of pain relief, functional improvement, maintenance of alignment and patient satisfaction.<sup>6,8,9</sup>

In our study, we found among the 27 feet evaluated that 71% of the results were excellent and 7% were good, with a mean follow-up of 68 months, according to the criteria developed by Mann and Thompson.<sup>4</sup> This demonstrates the clinical-functional improvement and patients' satisfaction with this type of procedure. Mann and Thompson<sup>4</sup> found that 78% of their results were excellent among 18 feet that underwent arthrodesis of the MTP of the hallux and resection of the metatarsal heads, with a mean follow-up of 49 months. Using the same assessment criteria, but with resection arthroplasty of the heads of all the metatarsals, rather than arthrodesis of the MTP joint of the hallux, Thomas et al.<sup>19</sup> found that only 30% of their results were good or excellent in evaluating 37 feet with a mean follow-up of 65 months.

Most of the studies have evaluated the clinical-functional results from forefoot reconstruction surgery by means of the AOFAS scale for the MTP joint of the hallux. Coughlin<sup>6</sup> found a mean AOFAS score of 69 points among 47 feet that they evaluated; Kadambande et al.<sup>8</sup> studied 66 feet and reported a mean AOFAS score of 65 points; and Heitkemper et al.<sup>9</sup> obtained the best results: a mean score of 81 points among 20 feet that were evaluated with a mean follow-up of 42 months.

These authors' observations were confirmed in our study. We found a mean AOFAS score of 70 points for the MTP joint of the hallux, with a mean follow-up of 68 months. The factor that contributed toward the greatest loss of points was the mobility of the MTP joint of the hallux, since arthrodesis impedes the movement of this joint. This took away 10 points from the AOFAS score, thus preventing the maximum score from exceeding 90 points. Presence of some residual pain in the forefoot, which was observed in six of the 27 feet, and incapacity to use conventional closed shoes even in the absence of painful symptoms, as observed in two of the 27 feet, took away points regarding the issues of pain and function. These are expected conditions among patients with rheumatoid arthritis, because of the chronic and progressive nature of the disease, which impedes complete elimination of the symptoms, even when using a careful validated surgical technique.<sup>3</sup>

Although arthrodesis of the MTP of the hallux has gained popularity over recent years and has become the standard procedure for reconstructing rheumatoid forefeet, few studies have quantified the radiographic alignment of the first ray. Mann and Thompson<sup>4</sup> observed a mean correction of 23° for the hallux valgus angle, while the intermetatarsal angle I-II presented a mean correction of 4°. Coughlin<sup>6</sup> also observed similar values in his series of 47 feet, with a mean correction of 18° for the hallux valgus angle and 3° for the intermetatarsal angle I-II. Kadambande et al.<sup>8</sup> studied 66 feet and found a mean correction of 23° for the hallux valgus angle and 8° for the intermetatarsal angle I-II. We found results similar to those in the literature in the present study. In our series, the hallux valgus angle was corrected by a mean of 24°, while the intermetatarsal angle I-II was corrected by 4°.

Other studies have already correlated arthrodesis of the MTP of the hallux with correction of the intermetatarsal angle I-II<sup>20-22</sup> and have observed a mean correction of 3° to 8° in this angle. This demonstrates that arthrodesis of the MTP joint of the hallux improves the varus nature of the first ray and makes it unnecessary to associate basal osteotomy in order to correct the intermetatarsal angle.

The different fixation methods used for arthrodesis of the first MTP joint were also evaluated and compared with the clinical-functional and radiographic results. We observed that, independent of whether fixation had been done using a plate and screws or with Kirschner wires, the clinical results were similar according to the AOFAS score for the MTP joint of the hallux. Likewise, the consolidation rates and the mean angular correction did not demonstrate any significant differences between the groups. However, biomechanical studies have demonstrated the superiority of fixation using crossed screws between fragments or associations of plate and screws with other methods. Neufeld et al.<sup>23</sup> compared three stabilization methods for arthrodesis of the MTP of the hallux in cadavers and demonstrated that the assembly presented greater rigidity when crossed screws were used. Politi et al.<sup>24</sup> compared five types of fixation in biomechanical trials using synthetic bone and demonstrated that fixation with a plate in association with two screws between fragments was more stable than fixation with the plate alone, and that assemblies with two crossed Kirschner wires presented the least rigidity. Although the use of a plate and screws has demonstrated greater rigidity and stability in biomechanical studies, we did not find any clinical studies comparing the consolidation rates and clinical-functional results between different fixation methods. Moreover, it is known that factors relating to the patient may also influence the clinical-functional result. Appropriate collaboration during the postoperative period and care to avoid smoking and other risk factors are fundamental for achieving consolidation in any group of patients.<sup>25</sup>

In comparing the clinical-functional results according to the AOFAS score for the MTP joint of the hallux with the radiographic results, we observed that the consolidation of the arthrodesis influenced the results. The patients who presented pseudarthrosis at the final evaluation had worse results according to the AOFAS score.

Age at the time of the surgery also influenced the clinical-functional result according to the AOFAS score for the MTP joint of the hallux, since the patients included in the group with AOFAS scores greater than or equal to 70 presented a mean age of 46 years, whereas the group with scores less than 70 had a mean age of 63 years. The smaller number of musculoskeletal abnormalities and lower initial systemic involvement of the disease in the younger patients probably explain these findings, given that rheumatoid arthritis is a chronic and progressive disease and that the degree of osteoarticular involvement increases with the duration of the disease.<sup>3</sup>

Surgical treatment for patients with rheumatoid arthritis is a challenge for orthopedic surgeons because of the potential risk of postoperative complications.<sup>3</sup> These patients present higher risk of complications because of the systemic nature of the disease, use of immunosuppressant medications and severity of their deformities.<sup>26</sup> Typically, they present significant osteopenia, which boosts the risk of failure of bone fixation during surgical interventions, as well as frequently presenting associated vasculitis, which leads to fragility of the subcutaneous tissue and compromises the healing of surgical wounds.<sup>3</sup> The percentage of complications observed in our series was compatible with what has

been presented in the literature. The persistence or recurrence of metatarsal pain that was observed in four of the 27 feet (15%) was concordant with the percentage found in other studies, which has ranged from 10% to 36%.<sup>5,7-9</sup> This may be minimized through meticulous surgical technique: correct positioning is attained for the arthrodesis of the MTP of the hallux and all the fragments or bone spicules are removed during resection of the lateral metatarsal heads. However, the chronic and progressive nature of the disease prevents this complication from being completely eliminated.<sup>3</sup>

Pseudarthrosis from arthrodesis of the MTP of the hallux is also an expected complication among these patients.<sup>3</sup> In the literature, these rates may range from 0 to 26%,<sup>4-6,8,27</sup> which is compatible with the rate of 11% (3/27 feet) found in the present study. A careful surgical technique in preparing the arthrodesis and use of reliable fixation methods with greater rigidity and stability contribute toward diminishing these rates and increasing the percentage consolidation.

The great majority of these patients also use powerful immunosuppressant drugs, which theoretically boosts the risk of infection and problems with the healing of operative wounds.<sup>3</sup> In a review article, Nassar and Cracchiolo<sup>26</sup> demonstrated that the rate of problems with the healing of operative wounds in patients with rheumatoid arthritis who undergo surgical procedures in the forefoot may range from 0% to 11%, and also that superficial or deep infection of the operative wound may occur in 0% to 8% of the cases. In the present study, we found that 8% (2/27 feet) had problems with wound healing, which was characterized by deep skin necrosis and delayed healing of the operative wound. We also found infection in 12% (two feet with deep infection and one with superficial infection). These numbers were concordant with those published by Nassar and Cracchiolo<sup>26</sup> and demonstrated that the potential risk of complications was inherent to surgical treatment among patients with rheumatoid arthritis, because of the systemic nature of the disease, the chronic use of immunosuppressants and the severity of the deformities, which add difficulty to the surgical procedures.<sup>26</sup>

Although we found the expected complication rates for forefoot reconstruction surgery in patients with rheumatoid arthritis, and these rates were concordant with what was found in the previous literature;<sup>4-8,26,27</sup> we observed that smoking was a determining factor for complications to appear in our study, despite the small number of cases. The harmful effects of cigarettes on orthopedic surgery have already been widely studied and proven.<sup>28</sup> Thus, it has been demonstrated that smoking increases the risk of pseudarthrosis,<sup>29</sup> diminishes bone density,<sup>30</sup> causes problems relating to healing of operative wounds and increases the risk of infection.<sup>31</sup> In our sample, smoking was shown to have a negative influence on the results, given that the two cases (two feet) that presented infection, skin necrosis and pseudarthrosis occurred in patients who were smokers. This confirms the harmful effects of cigarettes and the potentially greater risk of complications. Today, we recommend that patients with rheumatoid arthritis who are candidates for forefoot reconstruction and who are smokers should completely stop their smoking habit before and just after the surgery.

## Conclusions

The technique of arthrodesis of the first MTP joint in association with resection arthroplasty of the heads of the lateral metatarsals and correction of the deformities of the smaller toes, which was used to reconstruct the severe forefoot deformities of these patients with rheumatoid arthritis, showed good long-term results with a high satisfaction rate among the patients and clinical-functional improvement according to the AOFAS scale for the MTP joint of the hallux and the evaluation criteria proposed by Mann.

## Conflicts of interest

The authors declare no conflicts of interest.

## REFERENCES

1. Jaakkola JI, Mann RA. A review of rheumatoid arthritis affecting the foot and ankle. *Foot Ankle Int.* 2004;25(12):866-74.
2. Jeng C, Campbell J. Current concepts review: the rheumatoid forefoot. *Foot Ankle Int.* 2008;29(9):959-68.
3. Trieb K. Management of the foot in rheumatoid arthritis. *J Bone Joint Surg Br.* 2005;87(9):1171-7.
4. Mann RA, Thompson FM. Arthrodesis of the first metatarsophalangeal joint for hallux valgus in rheumatoid arthritis. *J Bone Joint Surg Am.* 1984;66(5):687-92.
5. Mann RA, Schakel II ME. Surgical correction of rheumatoid forefoot deformities. *Foot Ankle Int.* 1995;16(1):1-6.
6. Coughlin MJ. Rheumatoid forefoot reconstruction. A long-term follow-up study. *J Bone Joint Surg Am.* 2000;82(3):322-41.
7. Henry AP, Waugh W, Wood H. The use of footprints in assessing the results of operations for hallux valgus. A comparison of Keller's operation and arthrodesis. *J Bone Joint Surg Br.* 1975;57(4):478-81.
8. Kadambande S, Debnath U, Khurana A, Hemmady M, Hariharan K. Rheumatoid forefoot reconstruction: 1st metatarsophalangeal fusion and excision arthroplasty of lesser metatarsal heads. *Acta Orthop Belg.* 2007;73(1):88-95.
9. Heitkemper S, Pingsman A, Quitmann A, Patsalis T. Correction of rheumatic forefoot. The value of a combined arthrodesis of the first toe and resection of metatarsal heads 2-5. *Orthopade.* 2007;36(5):478-83.
10. Coughlin MJ. Hallux valgus. *J Bone Joint Surg Am.* 1996;78(6):932-66.
11. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int.* 1994;15(7):349-53.
12. Fornell C, Johnson M, Anderson E, Cha J, Bryant B. The American Customer Satisfaction Index: nature, purpose, and findings. *J Marketing.* 1996;60(1):7-18.
13. Hoffmann P. An operation for severe grades of contracted or clawed toes 1911. *Clin Orthop Relat Res.* 1997;(340):4-6.
14. Barton NJ. Arthroplasty of the forefoot in rheumatoid arthritis. *J Bone Joint Surg Br.* 1973;55(1):126-33.
15. Vahvanen V, Piirainen H, Kettunen P. Resection arthroplasty of the metatarsophalangeal joints in rheumatoid arthritis. A follow-up study of 100 patients. *Scand J Rheumatol.* 1980;9(4):257-65.
16. Patsalis T, Georgousis H, Göpfert S. Long-term results of forefoot arthroplasty in patients with rheumatoid arthritis. *Orthopedics.* 1996;19(5):439-47.
17. Clayton ML, Leidholt JD, Clark W. Arthroplasty of rheumatoid metatarsophalangeal joints: an outcome study. *Clin Orthop Relat Res.* 1997;(340):48-57.
18. Goldie I, Bremell T, Althoff B, Irstam L. Metatarsal head resection in the treatment of the rheumatoid forefoot. *Scand J Rheumatol.* 1983;12(2):106-12.
19. Thomas S, Kinninmonth AW, Kumar CS. Long-term results of the modified Hoffmann procedure in the rheumatoid forefoot. *J Bone Joint Surg Am.* 2005;87(4):748-52.
20. Cronin JJ, Limbers JP, Kutty S, Stephens MM. Intermetatarsal angle after first metatarsophalangeal joint arthrodesis for hallux valgus. *Foot Ankle Int.* 2006;27(2):104-9.
21. Pydah SK, Toh EM, Sirikonda SP, Walker CR. Intermetatarsal angular change following fusion of the first metatarsophalangeal joint. *Foot Ankle Int.* 2009;30(5):415-8.
22. Costa MT, Lopes Neto DL, Kojima FH, Ferreira RC. Avaliação do ângulo intermetatarsal após a artrodese da primeira articulação metatarsofalangeana para tratamento do hálux valgo. *Rev Bras Ortop.* 2012;47(3):363-7.
23. Neufeld SK, Parks BG, Naseef GS, Melamed EA, Schon LC. Arthrodesis of the first metatarsophalangeal joint: a biomechanical study comparing memory compression staples, cannulated screws, and a dorsal plate. *Foot Ankle Int.* 2002;23(2):97-101.
24. Politi J, John H, Njus G, Bennett GL, Kay DB. First metatarsal-phalangeal joint arthrodesis: a biomechanical assessment of stability. *Foot Ankle Int.* 2003;24(4):332-7.
25. Bennett GL, Sabetta J. First metatarsal-phalangeal joint arthrodesis: evaluation of plate and screw fixation. *Foot Ankle Int.* 2009;30(8):752-7.
26. Nassar J, Cracchiolo III A. Complications in surgery of the foot and ankle in patients with rheumatoid arthritis. *Clin Orthop Relat Res.* 2001;(391):140-52.
27. Grondal L, Hedstrom M, Stark A. Arthrodesis compared to Mayo resection of the first metatarsophalangeal joint in total rheumatoid forefoot reconstruction. *Foot Ankle Int.* 2005;26(2):135-9.
28. Moller AM, Pedersen T, Villebro N, Munksgaard A. Effect of smoking on early complications after elective orthopaedic surgery. *J Bone Joint Surg Br.* 2003;85(2):178-81.
29. Castillo RC, Bosse MJ, MacKenzie EJ, Patterson BM, LEAP Study Group. Impact of smoking on fracture healing and risk of complications in limb-threatening open tibia fractures. *J Orthop Trauma.* 2005;19(3):151-7.
30. Law MR, Hackshaw AK. A meta-analysis of cigarette smoking, bone mineral density and risk of hip fracture: recognition of a major effect. *BMJ.* 1997;315(7112):841-6, 4.
31. Porter SE, Hanley Jr EN. The musculoskeletal effects of smoking. *J Am Acad Orthop Surg.* 2001;9(1):9-17.