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ORIGINAL ARTICLE

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Systematic treatment of charcot arthropathy of the midfoot

Tratamento sistematizado da artropatia de Charcot do mediopé

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ABSTRACT

Objective: The objective of this study was to evaluate the efficacy of the systematic protocol developed in our institution for the treatment of Charcot arthropathy (CA) of the midfoot, specifically for cases anatomically classified as Brodsky type II.

Methods: Sixty patients with type II CA were treated in the period between 1997 and 2017 following a systematic protocol adopted at our institution. Two patients (3%) were lost to follow-up, leaving a total of 58 patients with 64 feet (six had bilateral involvement). The mean follow-up time was 31 months (range 12 to 150), and the mean age was 55 years (range 27 to 73). Conservative treatment was indicated in 41/64 of the extremities (64%), and surgical treatment was indicated in 23/64 of the extremities (36%). We considered the result as satisfactory when the patient was able to walk independently, placing full body weight on the foot. The result was considered unsatisfactory when the affected extremity presented clear instability and was deformed to the point that it was not possible to fit it in a stabilizing orthosis or for the patient to place their weight on the foot during walking as well as when it was necessary to perform an amputation.

Results: We obtained a satisfactory outcome in 54/60 patients (90%) and in 58/64 feet (91%). In 19/23 of the operated feet (83%) and 39/41 of the conservatively treated feet (95%), the result was satisfactory.

Conclusion: The systematic treatment protocol developed at our institution allows achievement of a favorable prognosis regarding the clinical-functional outcome of type II CA, with conservative treatment being sufficient in most cases.

Level of Evidence IV; Prognostic Study; Retrospective study.

Keywords: Arthropathies; Diabetic foot; Treatment protocol; Prognosis.

RESUMO

Objetivo: O objetivo deste estudo é avaliar a eficácia do protocolo sistematizado desenvolvido na nossa instituição para o tratamento da artropatia de Charcot, localizada no mediopé, mais especificamente os casos classificados anatomicamente como tipo II de Brodsky.

Métodos: Sessenta pacientes com AC do tipo II foram tratados no período compreendido entre 1997 e 2017, seguindo protocolo sistematizado adotado na nossa instituição. Dois pacientes (3%) perderam o seguimento, restando 58, totalizando 64 pés (seis apresentavam afecção bilateral). O tempo médio de seguimento foi 31 meses (variação de 12 a 150) e a média de idade 55 anos (variação de 27 a 73). O tratamento conservador foi indicado em 41/64 das extremidades (64%) e o cirúrgico em 23/64 das extremidades (36%). Consideramos o resultado como satisfatório quando o paciente era capaz de caminhar de maneira independente, apoiando completamente o pé no solo; e insatisfatório quando a extremidade afetada apresentava instabilidade franca e encontrava-se deformada a ponto de não ser possível acomodá-la numa órtese estabilizadora nem apoiá-la durante a marcha; ou ainda quando foi necessário realizar a amputação.

Resultados: Obtivemos resultado satisfatório em 54/60 dos pacientes (90%) e em 58/64 dos pés (91%). Em 19/23 dos pés operados (83%) e em 39/41 dos pés tratados conservadoramente (95%) o resultado foi satisfatório.

Conclusão: Utilizando o protocolo sistematizado de tratamento desenvolvido na nossa instituição é possível estabelecer prognóstico favorável com relação ao resultado clínico-funcional da AC do tipo II, ressaltando que o tratamento conservador foi suficiente na maioria dos casos.

Nível de Evidência IV; Estudos Prognósticos; Estudo Retrospectivo.

Descritores: Artropatias; Pé diabético; Protocolo de tratamento; Prognóstico.

Trabalho realizado na Santa Casa de São Paulo, São Paulo – SP, Brazil

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INTRODUCTION

Charcot arthropathy (CA) is a progressive, noninfectious inflammatory process that destroys the bones and joints of the foot and ankle that have lost protective sensitivity[1,2]. Described in 1868 in patients with tertiary syphilis[3], CA is currently very common in diabetic patients due to the presence of peripheral neuropathy, a late complication of this disease[4-7].

Loss of protective foot sensitivity due to peripheral neuropathy[5, 8, 9] and bone deformity triggered by CA can lead to a series of consequences with negative effects on patients' quality of life, including pressure ulcers[10, 11].

Once CA is diagnosed, it is necessary to classify it to adequately treat it[12,13]. The two most relevant classifications consider the anatomical location of the affected regions in both the foot and the ankle[14] and the evolutionary stage of the repair process[15], which is subdivided into three distinct and identifiable phases on radiographs: 1) initial phase of fragmentation; 2) intermediate phase of coalescence; and 3) late phase of sequela.

Regarding the location of the lesion, the bones and joints of the midfoot are often the most frequently affected[4,5,9,10,16]. The most common midfoot lesions compromise the tarsometatarsal joints (Lisfranc) and receive the anatomical designation of type I lesions[14]. Less frequent, but more prone to complications during the course of the disease, are the lesions affecting the talonavicular (TN) and calcaneocuboid (CC) joints, which may extend to the subtalar (ST) joint, characterizing type II disease[14].

Characteristically, type II lesions lead to collapse of the plantar arch, resulting in the formation of bony prominences located in the foot support areas[17], related to the following sequence of events: 1) plantar bone prominence; 2) lack of protective sensitivity; 3) pressure ulcer; 4) secondary infection of ulcers; 5) foot amputation; 6) septicemia; and 7) death due to multiple organ failure[10, 16].

The purpose of this study was to evaluate the efficacy of the systematic protocol developed in our institution for the treatment of type II CA. Our hypothesis is that the use of the proposed treatment protocol can achieve a high rate of satisfactory clinical-functional outcomes to obtain stable, sufficiently aligned plantigrade feet capable of fitting into footwear suitable for insensitive feet. A secondary objective of this study was to determine the factors related to poor prognosis during the treatment of these lesions.

METHODS

This study was approved by the Research Ethics Committee with registration in the Brazil Platform under CAAE number: 69126917.5.0000.5479. It fulfilled the requirements regarding the rights of humans and animals.

In our systematic treatment protocol, whenever possible, we use non-invasive treatment using a total contact cast (TCC) and crutches to avoid supporting the body weight on the affected extremity during walking until regression of edema occurs. The TCC is changed fortnightly in the first six weeks and then monthly until clinical and radiographic progression to phase II, coalescence[15]. After this phase, we replace the TCC with a rigid orthosis of type *AFO* (ankle-foot orthosis), used until the progression of the disease to phase III, sequela[15]. In cases where bone healing occurs and the foot achieves stability without major deformation, the orthosis is replaced by extra-deep protective footwear for insensitive feet and a custom insole (Figure 1).

Surgical treatment is indicated when the non-surgical treatment fails[18,19] or if 1) there is a presence of a recurrent ulcer caused by bony prominence located in the support area, and 2) an active infection from a previously contaminated ulcer is present.

The modalities of surgical treatment are as follows: 1) simple exostectomy (figure 2): to remove bony prominences in support areas, indicated for the stable foot at the end of the coalescence phase; 2) reconstructive bone surgery (figure 3): to realign deformed and/or unstable bones and joints, indicated for extremities with adequate circulation and without active infection; 3) debridement with removal of infected bones (figure 4): indicated in the presence of contaminated deep ulcers, with bone exposure and osteomyelitis; and 4) amputation of the extremity (figure 5): indicated for uncontrolled infections, extremities with compromised circulation or extremely severe deformities.

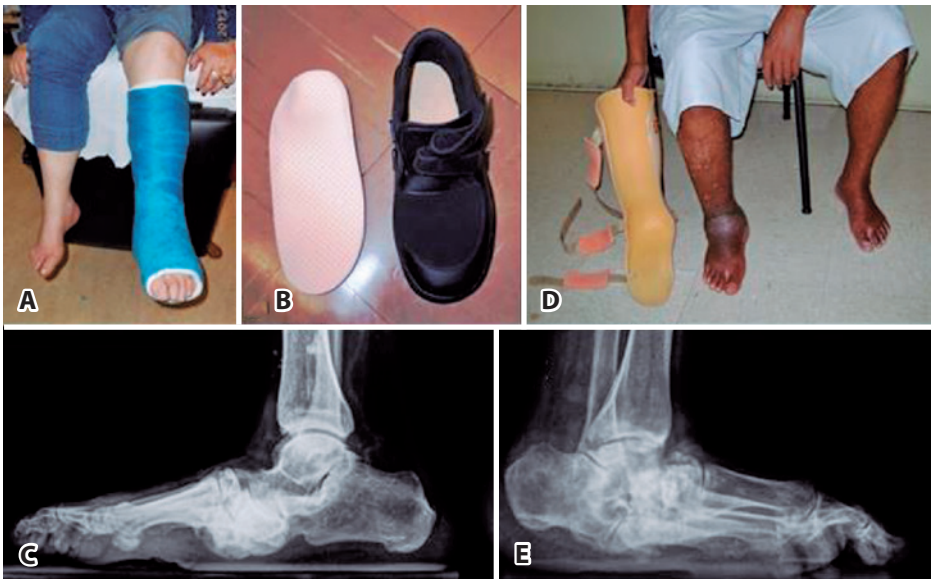

Figure 1. Photograph of the total contact cast used for conservative treatment (1A). Lateral radiograph of the foot with bone healing (1C). Extra-deep protective footwear and molded insole (1B). Molded polypropylene orthosis of the AFO type (1D) indicated when there is instability of the hindfoot, as in the lateral radiograph of the foot (1E).
Source: SAME.

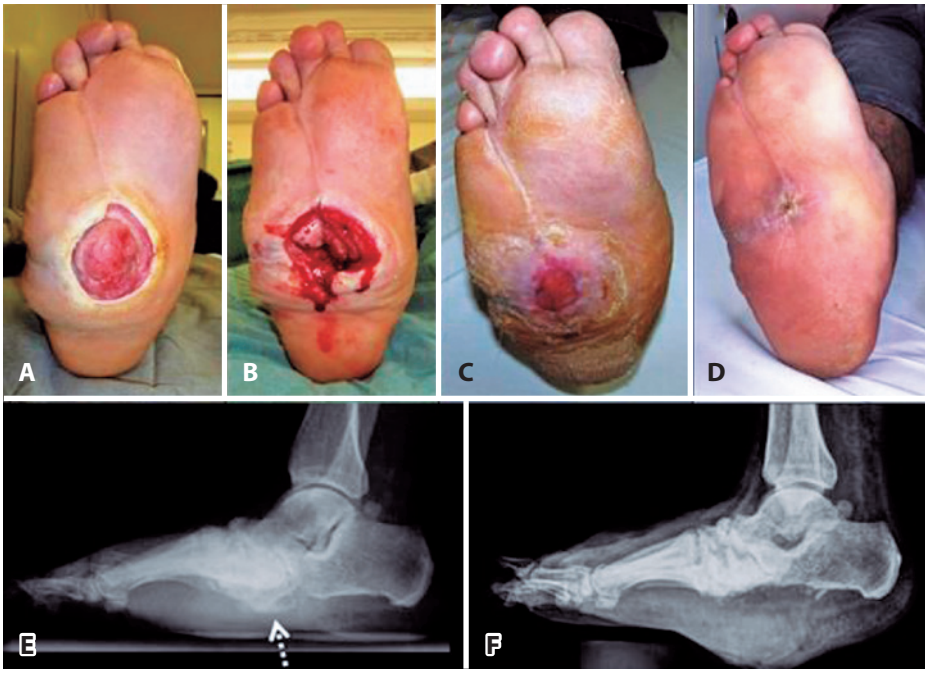

Figure 2. Plantar image of an extensive vegetative ulcer (2A) after surgical debridement and removal of plantar bony prominences (2B) using a total contact cast with progressive healing (2C and 2D). Lateral radiograph of the foot (2E) with plantar bony prominence of the cuboid bone (light dotted arrow). Radiography after plantar exostectomy (2F).
Source: SAME.

To analyze the efficacy of the treatment, we use as an evaluation criterion the ability of the patient to place his/her full body weight on the affected extremity for independent walking. We considered three possible outcomes: 1) good outcome: plantigrade and aligned foot that fits into extra-deep footwear, stable enough to support and place the full body weight during walking; 2) acceptable outcome: plantar, but unstable, foot that is aligned for fitting in a rigid *AFO*, capable of performing independent walking while placing weight on the affected extremity; 3) poor

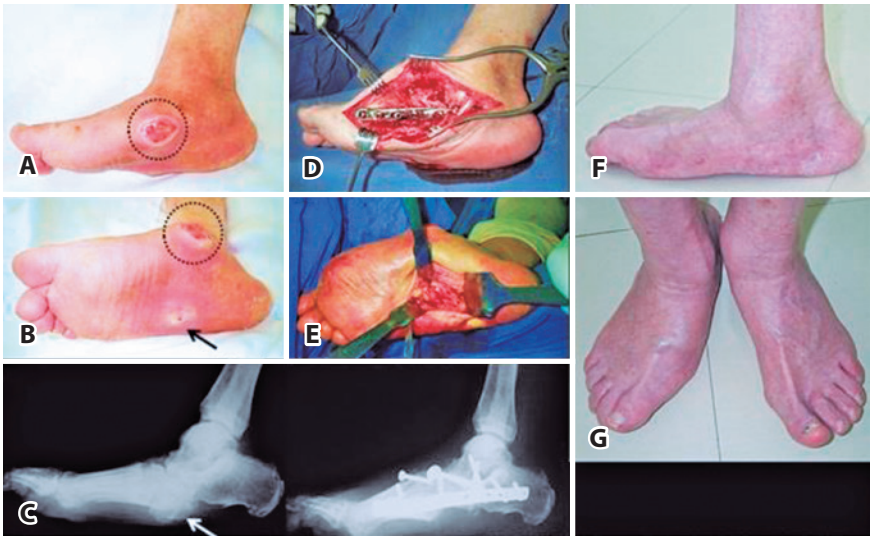

Figure 3. The presence of pressure ulcers under bony prominences (dark dotted circle and dark arrow) is observed in the medial (3A) and plantar (3B) photographic images of the right foot. In the lateral radiographic image of the foot (3C), it is possible to notice the plantar prominence of the cuboid bone (light arrow). The reconstructive surgical treatment consisted of plantar exostectomy of the cuboid bone (3E) and modeling arthrodesis of the medial column of the foot (3D). Postoperative radiographic image of the lateral foot (3F) shows bone healing, while the photographs (3G and 3H) show good alignment of the right foot.
Source: SAME.

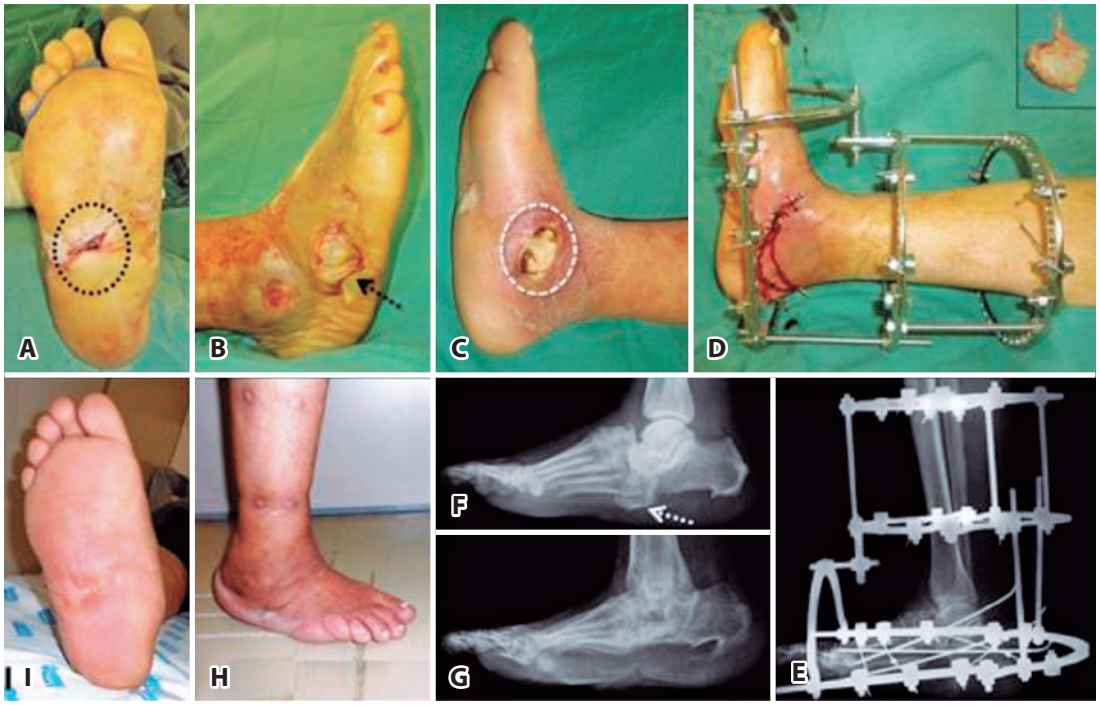

Figure 4. Photographs with plantar (4A), lateral (4B) and medial (4C) views of the foot showing ulcers (dark dotted circle, dark arrow and light dashed circle) with bone exposure. Surgical treatment with debridement, resection of infected bones and placement of the circular external fixator (CEF) (4D). Lateral radiograph of the foot and ankle showing bone alignment after CEF placement (4E). Preoperative radiograph showing a prominent cuboid bone (light dotted arrow) (4F). Late postoperative radiograph showing bone healing (4G). Photographs at the end of the treatment showing good alignment of the foot (4H) and absence of plantar ulcers (4I).
Source: SAME.

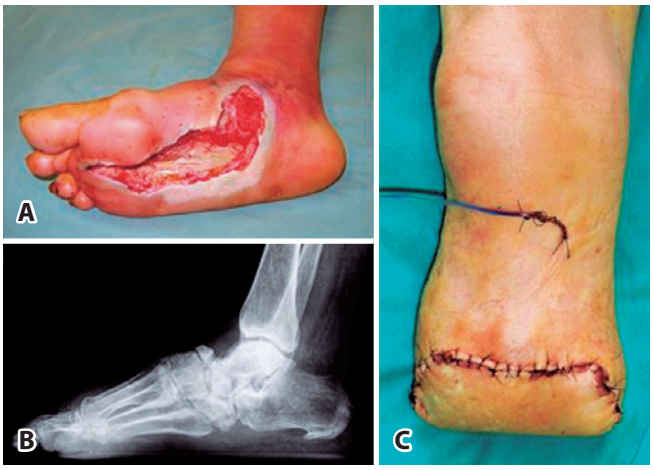

Figure 5. Photograph showing a deep and extensive area of foot necrosis, in addition to hyperemia and edema in the ankle region (5A). Lateral radiograph of the foot with osteoarticular fragmentation in the midfoot (5B). In this case, treatment with transtibial amputation was required (5C).
Source: SAME.

outcome: amputation of the extremity or preservation of a non-plantigrade, unstable foot with severe deformity, which prevents fitting of an orthosis, being unable to bear body weight during walking.

In the final analysis of the outcomes of this study, we considered the extremities classified as having good or acceptable outcomes to be satisfactory, while the extremities with poor final outcomes were considered unsatisfactory.

Included in this study were patients with a clinical and radiographic diagnosis of Brodsky type II CA[20], according to the evaluation of the photographs and radiographs recorded in our database. Sixty patients were available; 16 patients had bilateral involvement (27%), but only six patients had a diagnosis of type II CA in both extremities, resulting in 66 extremities. It was possible to find information for a complete analysis within the established parameters for 58 patients (97%), totaling 64 treated extremities.

According to our treatment protocol, 43/64 of the extremities (67%) were managed exclusively with closed treatment. At the beginning of the treatment, 5/43 of the extremities (12%) already had pressure ulcers (three in the lateral plantar region under the cuboidal bone, one in the medial plantar region under the navicular bone, and one in the dorsomedial region, under the navicular bone). None of the ulcers were infected, and all were treated with debridement, dressing, and TCC.

A total of 21/64 of the extremities (33%) required some type of surgical procedure throughout the treatment. At the beginning of the treatment, 16/21 of the extremities (76%) already presented pressure ulcers (ten in the lateral plantar region under the cuboidal bone, four in the medial plantar region under the navicular bone, one in the lateral malleolar region, and one in the digital pulp). In 6/16 of the extremities (37%), the ulcers were infected and hospitalization was necessary for broad debridement and systemic antibiotic therapy. In 3/6 of the extremities (50%) with infected ulcers, we used circular external fixation (CEF). In 1/6 of the extremities, we used internal fixation with plaque and screws after removal of infected bones, whereas in 2/6 of the extremities, primary transtibial amputation was required.

In the group of patients who underwent surgery, the surgical modalities were as follows: simple exostectomy in 10/21 extremities (48%); reconstructive bone surgery and attempted salvage of the limb in 9/21 of the extremities (43%); and transtibial amputation in 2/21 of the extremities (9%). Among the nine extremities that were operated on in a limb-salvage attempt by means of multiple osteotomies and modeling arthrodesis, the two different modalities used for bone fixation were 1) internal fixation with plates and screws in 5/9 of the extremities (56%); and 2) CEF in 4/9 of the extremities (44%). The amputation of two extremities was indicated primarily due to uncontrolled severe infection due to pressure ulcers.

RESULTS

In the 20-year period between September 1997 and September 2017, we analyzed data from the medical charts of 864 diabetic patients enrolled in our group. We identified 252/864 patients (29%) with a confirmed diagnosis of CA, and 60/252 of the patients (24%) presented type II CA. The mean age of the 28 male and 30 female patients was 55 years (range 27 to 73).

At the time of the evaluation, we obtained a satisfactory outcome of type II CA in 58/64 of the extremities (91%), 44/58 (76%) of which obtained a good outcome and 14/58 (24%) of which had an acceptable outcome.

Regarding the treatment modality used, the result was considered unsatisfactory in 2/43 of the extremities (5%) undergoing conservative treatment and in 4/21 of the extremities (19%) undergoing surgical treatment.

Regarding outcomes, in the group treated conservatively, 32/41 of the extremities (78%) were classified as having a good outcome and 9/41 as having an acceptable

outcome (22%); while in the group treated surgically, the outcome was classified as good in 12/17 of the extremities (71%) and acceptable in 5/17 of the extremities (29%).

Ulcer was present during early treatment in 21/64 of the extremities (33%), while the final outcome of the treatment was satisfactory for 15/21 of the affected extremities (71%). Among the six infected ulcers requiring hospitalization for surgical treatment, the final outcome was satisfactory for 4/6 of the extremities (66%), while 2/6 of the extremities (33%) required primary amputation.

Among the surgical modalities required in the treatment of type II CA, exostectomy was performed for 10/21 of the extremities (48%) and showed a satisfactory outcome in 9/10, with the outcome for six being classified as good. However, the reconstructive surgeries performed in 9/21 of the extremities (43%) showed a satisfactory outcome in 8/9, with the outcome for six being classified as good.

When we considered the type of bone fixation technique used in the nine limbs that required limb-salvage reconstructive surgery, internal fixation was used in 5/9 of the extremities and showed a satisfactory outcome overall, while the CEF required in 4/9 of the extremities showed a satisfactory outcome in 3/4 (75%).

At the time of the evaluation, 2 of the 58 patients died. One of the patients had undergone primary transtibial amputation due to uncontrollable infection, and the other patient was undergoing follow-up, using a circular external fixator, after surgical treatment to reconstruct the deformities when he suffered a stroke, dying approximately one week after the incident. The results obtained are similar to those of previously published studies.

DISCUSSION

The aim of CA treatment is to preserve an ulcer-free functional extremity that is capable of fitting into protective footwear or a stabilizing orthosis allowing weight-bearing and independent walking[20]. Therefore, it is necessary to resolve the inflammation resulting from the local destructive process triggered by CA, thereby preventing the worsening of the deformities and instability of the joints that can cause secondary ulceration[4,10,21]. The treatment most used and referenced in most of the publications cited is conservative treatment[4,5,16,18,22,23]. The interpretations are in line with the current literature on the subject. In our case series, we obtained a satisfactory outcome in 95% of the conservatively treated extremities, a result superior to that presented by Pinzur et al.[23], who reported a success rate of approximately 59% in a series of 144 patients (147 of the extremities). This difference can be explained by the fact that this author used subjective criteria, as he reported that he uses "his own perception to interpret what a plantigrade foot is" and used this standard to classify the results. In our case series, we used more objective criteria to interpret the results, such as radiographic parameters, considering that the possibility of obtaining a stable and aligned extremity capable of fully bearing the body weight during walking using protective shoes or a molded orthosis would provide the patient with sufficient independence for walking.

Lowery et al.[5] indicated the use of surgical treatment in cases of CA affecting the midfoot when collapse of the plantar arch predisposes a patient to the development of bony prominence(s), which results in recurrent ulceration. According to these authors, the frequency of these events is approximately 59%. According to Catanzariti[24], the performance of exostectomy, without the need for larger surgeries to correct extensive deformities found from CA sequelae, is more likely to be successful when indicated for extremities where the bony prominence is located in the medial column of the foot. We believe that the fitting of the foot in suitable footwear and molded insoles is easier when the collapse of the arch affects the medial column of the foot. This is because there is more space in the medial column to allow the collapse of the navicular bones and wedges toward the ground than in the lateral column when the cuboid collapses toward the ground.

In our case series, surgical treatment was indicated when we identified a plantar bony prominence in the lateral column of the midfoot, caused by the collapsed cuboidal bone. Schon et al.[12] clinically classified the degree of arch collapse and recommended correction of the deformities responsible for the appearance of the rocker bottom foot due to the high rate of complications, mainly recurrent ulceration[12, 25]. Following our treatment protocol, whenever possible, in cases of minor deformity, we chose plantar exostectomy, a procedure with less complexity and risk, which was performed successfully in 9/10 of the extremities (90%). Severe and unstable deformities may require more elaborate osteoarticular reconstruction, requiring removal of bone wedges and arthrodesis of multiple joints of the midfoot. Although it is a large surgery and is subject to greater complications, we were successful in 8/9 of the extremities in which osteoarticular reconstruction was necessary.

If we exclude the two primary amputated limbs from the evaluation of the surgical treatment outcomes, we can conclude that only 2/20 of the operated extremities obtained an unsatisfactory outcome. This result indicates that

the surgical treatment provided by our treatment protocol is associated with a highly favorable prognosis.

Myerson et al.[26] reported that approximately 43% of the extremities diagnosed with CA of the midfoot developed pressure ulcers. Wukich et al.[10] reported that the risk of limb amputation in patients with CA is six times higher in those with an ulcer at the first visit. Saltzman et al.[27] performed transtibial amputation in 28% of patients with CA with ulcers, compared with 7% of those without ulcers. A patient's delay in arriving at a specialized medical service and initiating appropriate treatment favors the infection of the ulcer, which increases the need for surgical treatment[28]. In our case series, we already identified the presence of ulcers in 21/64 of the extremities (33%) at the beginning of the type II CA treatment. In these cases, the treatment outcome was unsatisfactory in six (29%), indicating that ulcers are a predictor of poor prognosis. However, 6/21 of the ulcers presented active infection at the beginning of treatment, requiring hospitalization and surgical intervention in all cases. The treatment outcome was considered unsatisfactory in 2/6 of the extremities (33%), requiring transtibial amputation in both. Thus, it is possible to conclude that type II CA with infected ulcers is associated with a high risk of amputation of the extremity.

The mortality of diabetic patients diagnosed with CA is considered high compared with that of the general population of diabetics, reaching rates ranging from 19% to 45%[10, 29, 30]. Only two patients in our case series died. Both patients were surgically treated: one due to uncontrolled septicemia, not even controlled with primary transtibial amputation; and the other during an attempt to salvage the extremity by means of modeling arthrodesis.

According to Ferreira et al.[16], in a study performed at our institution, the early diagnosis and the adequate treatment of CA in the midfoot contribute to the prevention of pressure ulcers and minimize the chance of developing secondary infection, thus reducing the cost of treatment and the risk of amputation. Such measures may contribute to the depletion of the health system, especially in countries where public network funding relies on government resources. The development of public policies aimed at informing the population of the risks and complications of diabetes for the feet would be important for prevention. Continuing medical education, emphasizing the systematic prophylactic examination of the feet and encouraging other health professionals to act proactively, can have a significant effect with minimal resource investment.

CONCLUSION

Using the systematic treatment protocol developed at our institution, it is possible to establish a favorable and effective prognosis regarding the clinical-functional outcome of type II CA, noting that conservative treatment is sufficient in most cases.

Authors' contributions: Each author contributed individually and significantly to the development of this article: MPCF *(https://orcid.org/0000-0003-4300-3677) wrote the article and interpreted the results of the study; MTC *(https://orcid.org/0000-0001-9411-9376) participated in the review process and approved the final version; RCF *(https://orcid.org/0000-0002-9886-5082) wrote the article, participated in the review process and approved the final version. *ORCID (Open Researcher and Contributor ID).

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