

Salvage surgery for Charcot arthropathy of the diabetic hindfoot

Cirurgia de salvamento no tratamento da artropatia de Charcot do retropé nos pacientes diabéticos

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ABSTRACT

Objective: This study evaluated the effectiveness of Charcot arthropathy (CA) surgery to align and stabilise the severely deformed hindfeet of patients with diabetes so that the affected limb would be able to support patients' body weights and restore walking independence.

Methods: A total of 25 patients with cases of CA compromising the ankle (type IIIA) or hindfoot (type IV) underwent a procedure to salvage their affected limbs via tibiocalcaneal arthrodesis fixed with an interlocking intramedullary nail. The mean follow-up period was 49 (6-169) months, and the mean age of patients was 54 (30-83) years. The outcome was considered as satisfactory in cases where the patients were able to walk independently and maintain their repaired foot on the ground; the outcome was considered as unsatisfactory when the affected limb presented with frank instability or deformity.

Results: The outcomes were satisfactory in 19 of the 25 (76%) repaired limbs, although 11 of the 25 (44%) limbs presented with complications.

Conclusions: The salvage of a severely deformed and markedly unstable limb due to CA complications involving the ankle (type IIIA) or hindfoot (type IV) should be considered for patients with diabetes because the prognosis is favourable in cases where the affected limb is surgically treated using tibiocalcaneal arthrodesis and an interlocking intramedullary nail.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Arthropathy, neurogenic; Arthropathy, neurogenic / complications; Diabetic foot; Arthrodesis; Fracture fixation, intramedullary, Prognosis.

RESUMO

Objetivo: Avaliar a eficácia do tratamento cirúrgico da artropatia de Charcot (AC) com vistas a alinhar e estabilizar o retropé gravemente afetado nos pacientes diabéticos, possibilitando o restabelecimento de uma extremidade capaz de permitir o apoio do peso corporal e propiciar condições para a marcha independente.

Métodos: Vinte e cinco pacientes portadores de AC comprometendo o tornozelo (tipo IIIA) ou o retropé (tipo IV) foram submetidos à tentativa de salvamento da extremidade, empregando-se artrose modelante fixada com haste intramedular bloqueada. O tempo médio de seguimento foi de 49 meses (variação de 6 a 169) e a média de idade de 54 anos (variação de 30 a 83). 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.

Resultados: Obtivemos resultado satisfatório em 19/25 extremidades operadas (76%). Complicações foram identificadas em 11/25 extremidades (44%).

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Conclusão: A tentativa de salvamento de uma extremidade gravemente deformada e acentuadamente instável devido às complicações da AC envolvendo o tornozelo (tipo IIIA) ou o retropé (tipo IV) nos pacientes diabéticos deve ser considerada, uma vez que possui prognóstico favorável quando tratada cirurgicamente pelo método de artrodese modelante fixada com haste intramedular bloqueada.

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

Descritores: Artropatia neurogênica; Artropatia neurogênica/complicações; Pé diabético; Artrodese; Fixação intramedular de fraturas; Prognóstico.

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INTRODUCTION

Deformities caused by Charcot arthropathy (CA) that change bone architecture and promote joint instability often predispose patients to the development of areas of hyperpressure that are directly responsible for causing ulcers⁽¹⁻⁷⁾. Secondary infection of ulcers is the leading cause of amputations among patients with diabetes⁽⁸⁻¹²⁾.

In cases in which CA affects the ankle (Brodsky classification type IIIA),⁽¹⁾ the occurrences of the axial misalignment of the leg relative to the foot and marked instability with varus or valgus deformity are common^(3,10). A prominent malleolus is a risk factor for the formation of pressure ulcers, especially when severe deformities and instabilities are present, leading to the abnormal support of the body weight by the hindfoot while walking.

By contrast, cases of severe CA that extend from the midfoot to the hindfoot, secondarily compromising the ankle, are classified as Trepman type IV⁽²⁾. This type of arthropathy usually significantly impairs walking because of the severe instability associated with fixed varus or valgus deformities in addition to its frequent combination with the collapse of the medial arch^(10,11).

Surgical correction might be indicated as an attempt to avoid the amputation of the affected limb. Tibiocalcaneal arthrodesis, with the resection of large bone wedges of the ankle, subtalar, and/or midtarsal joints, is used to correct gross deformities and stabilise highly unstable joints; however, the procedure is labourious and not free of risk, especially among patients whose limb blood flow and sensitivity are compromised⁽¹²⁻¹⁴⁾. This surgery should be considered as an attempt to salvage the affected limb^(11,13,15-19).

The objective of this study was to evaluate the ability of tibiocalcaneal arthrodesis of the hindfoot to restore the alignment and stability of the affected limb to enable body weight support and walking independence. The primary goal of surgery is to restore a markedly unstable and seve-

rely deformed limb due to type IIIA and IV CA among patients with advanced diabetes.

METHODS

This study was approved by the Research Ethics Committee with registration in the Brazil Platform under CAAE number: 03701518.6.0000.5479.

Between November 1997 and May 2013, 25 patients with advanced diabetes, peripheral neuropathy, and the loss of the protective sensitivity of the feet underwent surgery for CA of the hindfoot and/or ankle. Surgery was indicated for 1) frank instability of the ankle or 2) severe deformities that prevented the use of ankle-foot orthosis (AFO) or protective shoes for insensitive feet.

Salvage surgery involved correcting Charcot deformities and stabilising the affected limb via tibiocalcaneal arthrodesis and eventual talectomy. In all cases, a retrograde interlocking intramedullary nail was employed for internal fixation. Additional fixation with cannulated large-fragment screws or shaped plates were used to increase stability when necessary. A total of 14 limbs (56%) presented with the involvement of the ankle joints and were classified as Brodsky type IIIA⁽¹⁾, whereas the remaining 11 limbs (44%) showed diffuse involvement of the ankle, hind foot, or midfoot and were classified as Trepman type IV⁽²⁾. The mean patient age at the time of surgery was 54 (30-83) years, the mean body mass index was 28.3 (18.7-37.9) kg/m², and 18 of the 25 patients (72%) in this series were dependent on insulin.

Immediate postoperative complications

During the postoperative follow-up period, immediate complications were observed in three of 25 patients (12%), including 1) skin infection in both limbs that was treated by debridement and broad-spectrum intravenous antibio-

tic therapy; 2) the deep infection of one limb, leading to the early loosening of the interlocking intramedullary nail, which needed to be removed, as well as chronic osteomyelitis and death due to complications secondary to infection despite extensive surgical debridement and systemic antibiotic therapy.

Criteria for assessing surgical outcomes

Three clinical parameters were used as criteria to evaluate the results: 1) lower limb alignment, 2) stability of the foot during ground contact, and 3) the ability to maintain the foot on the ground while walking. Four radiographic parameters were analysed with the clinical examination: 1) the complete bone consolidation of the arthrodesis based on the crossing of the joint line by the structurally intact trabecular bone; 2) stable fibrous ankylosis as characterised by joint stability on clinical examination, even when it was possible to identify the joint line on the radiographic images; 3) unstable fibrous ankylosis marked by joint mobility together with the identification of the joint line on radiography; and 4) frank pseudarthrosis as characterised by marked instability on clinical examination and the complete absence of bone consolidation on the radiographic images. The treatment outcome was considered as satisfactory when the following parameters were reached: 1) the foot was aligned and stable under the leg, thereby enabling the use of footwear suitable for insensitive feet or polypropylene AFO (in these cases, the patients were able to support their body weight on the ground and walk independently); and 2) complete bone consolidation or stable fibrous ankylosis as observed from the lateral radiographic view of the foot and ankle supported on the ground. The final result was considered as unsatisfactory in the following cases: 1) the operated limb remained unstable and could not support the patient's body weight during walking without angular deformation (i.e., knee buckling); or 2) the presence of unstable fibrous ankylosis or frank pseudarthrosis of the arthrodesis on the lateral radiographic view of the foot and ankle performed with support.

Statistical analyses

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS), and the chi-square test with confidence intervals were applied.

RESULTS

The mean postoperative follow-up period in our series was 49 months (6-169 months), and the outcome was con-

sidered as satisfactory in 19 of 25 evaluated limbs (76%) (Figures 1, 2, and 3). The mean time between surgery and the stabilisation of the operated joints was 11 months. The mean number of surgical procedures per patient until the expected outcome was 1.6 (Table 1).

Late complications were observed in nine of the 25 (36%) operated limbs. These cases required the removal of the intramedullary nail because of 1) the exposure of the nail in the plantar region of the foot (three of nine limbs) or 2) unstable pseudarthrosis with CA recurrence (six of nine limbs). Of the six patients with unstable pseudarthrosis, three had type IIIA CA, and the other three had type IV CA. One patient with type IV CA did not undergo surgical revision because he developed a severe infection and died during the early postoperative period. The other five patients were received a surgical revision of the arthrodesis. However, only one patient with type IV CA had a satisfactory outcome with adequate lower limb stabilisation. The



Figure 1. Case 11. Radiographic images from the frontal (1A) and posterior views (1B) showing a varus deformity of the right ankle and hindfoot. Note the severe deformity in the ankle joint from the anteroposterior view (1C). Perioperative images showing the transfibular lateral approach of salvage surgery (1D and 1E) and the medial dislocation of the foot (1F) before alignment. Radiographic images after 143 months of surgery showing adequate alignment (1G and 1H) and the complete consolidation of the tibiototalcalcaneal arthrodesis (1I).

Source: SAME.

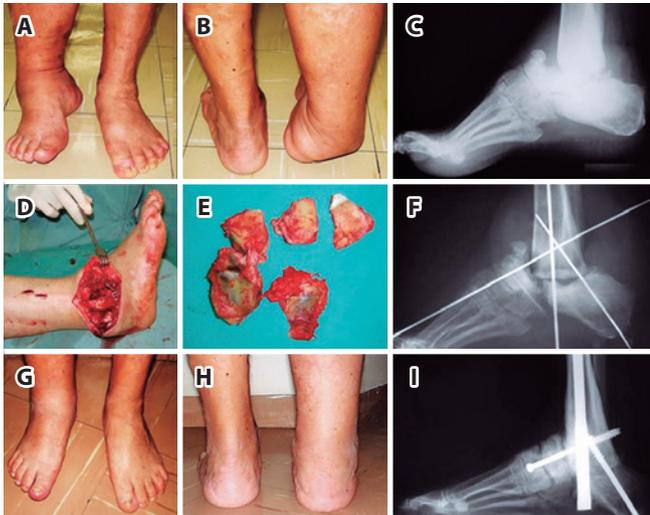


Figure 2. Case 17. Radiographic images from the frontal (2A) and posterior views (2B) showing severe varus deformity of the right ankle and hindfoot. Lateral view (2C) showing hindfoot bone and joint deformities, with the anterior dislocation of the foot relative to the leg. During surgery (2D), alignment was achieved after extensive bone resection (2E), which is visible on the perioperative image (2F). Postoperative images showing the complete correction of the deformities with the correct alignment of the foot relative to the leg (2G and 2H) and the lateral view showing hindfoot stability (2I). Note that, in addition to the interlocking intramedullary nail, two large-fragment screws were used to improve fixation (2I).

Source: SAME.

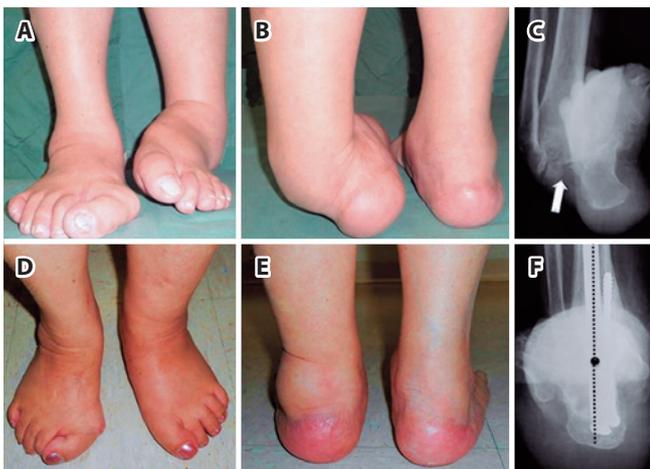


Figure 3. Case 25. Radiographic images from the frontal (3A) and posterior views (3B) showing severe varus deformity of the left ankle and hindfoot. The medial dislocation of the subtalar joint (white arrow) is visible in the axial image of the foot and leg (3C). Frontal (3D) and posterior views (3E) of the correct alignment of the foot under the leg after surgery. Axial image (posterior view) (3F) showing the proper alignment between the calcaneal axis and tibial axis (dotted line) as well as the complete correction of the varus deformity.

Source: SAME.

mean number of surgical procedures among the six patients with late complications who received follow-up operations was 2.8.

Eleven of 25 patients (44%) died before the outcome evaluation. The mean survival time from surgery to the clinical and functional evaluation of the outcome was 28 (6-93) months. Ten of 25 patients (40%) died from clinical complications including lymphoma (1), stroke (1), acute myocardial infarction (2), chronic renal failure (3), and metabolic decompensation (3). Only one patient died during the course of treatment because of complications from infection of the limb after orthopaedic surgery.

Of the 11 patients who died before the outcome reassessment, six whose outcomes were satisfactory lived an average of 34 (6-93) months after surgery, whereas five whose outcomes were unsatisfactory lived an average of 17 (9-40) months after surgery.

A correlational analysis between the anatomical classification of CA and the outcome indicated that the outcome was satisfactory in 10 of the 14 (71%) limbs, with injuries in the ankle (type IIIA) alone. In turn, the outcome was considered as satisfactory in nine of the 11 (82%) limbs with injuries in the hindfoot and midfoot (type IV).

The analysis of the possible effect of talectomy on the outcome indicated that complete stabilisation was achieved all seven of the limbs in which panarthrodesis was performed after the complete removal of the talus. By contrast, complete stabilisation was obtained in 12 of the 18 (67%) limbs in which the talus was preserved. This difference was significant.

The placement of a bone graft to fill the cavities identified during surgery was considered as necessary by the surgeon for 21 of the 25 limbs (84%). When considering the possible effect of a bone graft on the surgical outcome, the stability of the arthrodesis was achieved in 16 of the 21 limbs (76%) in which a bone graft was used (Figure 4). In turn, arthrodesis stability was reached in three of the four limbs where no bone graft was used during surgery. This difference was significant.

When trying to establish a relationship between the extent of arthrodesis and stabilisation, the complete stability of the arthrodesis was achieved in seven of the 10 (70%) limbs subjected to panarthrodesis (hindfoot and midfoot) and in 12 of 15 (80%) limbs whose arthrodesis was performed exclusively in the hindfoot. This difference was not significant.

The possibility of improving arthrodesis stability via additional fixation combined with interlocking intrame-

Table 1. Distribution of patients with CA of the hindfoot receiving surgical arthrodesis

Case	Gender, age, side	Anatomical classification	Talectomy, panarthrodesis additional fixation, bone graft	Postoperative complications	Follow-up period (months)	Bone consolidation on radiography	Outcome; Death
1	M, 49, RL	TYPE IV	BG	None	6 months	Stable ankylosis	Satisfactory; death
2	F, 52, RL	TYPE IV	T; BG	None	169 months	Bone consolidation	Satisfactory
3	F, 57, RL	TYPE IV	T; P; AF	None	26 months	Stable ankylosis	Satisfactory; death
4	F, 45, LL	TYPE IV	P; AF; BG	Pseudarthrosis (removal of the interlocking intramedullary nail)	17 months	Pseudarthrosis	Unsatisfactory
5	M, 45, LL	TYPE IV	BG	None	93 months	Bone consolidation	Satisfactory; death
6	M, 51, LL	TYPE IIIA	P; AF; BG	Pseudarthrosis (removal of the interlocking intramedullary nail)	14 months	Pseudarthrosis	Unsatisfactory; death
7	F, 30, LL	TYPE IIIA	BG	None	14 months	Stable ankylosis	Satisfactory; death
8	M, 53, LL	TYPE IIIA	BG	Removal of the interlocking intramedullary nail	129 months	Bone consolidation	Satisfactory
9	M, 54, RL	TYPE IV	P; AF	Pseudarthrosis (removal of the interlocking intramedullary nail)	9 months	Pseudarthrosis	Unsatisfactory; death
10	F, 41, RL	TYPE IV	T; BG	None	76 months	Bone consolidation	Satisfactory; death
11	M, 33, RL	TYPE IIIA	BG	None	143 months	Bone consolidation	Satisfactory
12	F, 53, RL	TYPE IIIA	P; AF; BG	None	36 months	Bone consolidation	Satisfactory; death
13	F, 58, RL	TYPE IIIA	P; AF	Removal of the interlocking intramedullary nail	8 months	Stable ankylosis	Satisfactory
14	M, 61, RL	TYPE IIIA	BG	Skin infection	7 months	Bone consolidation	Satisfactory
15	M, 59, RL	TYPE IIIA	BG	Pseudarthrosis (removal of the interlocking intramedullary nail) and infection	40 months	Pseudarthrosis	Unsatisfactory; death
16	F, 63, LL	TYPE IIIA	BG	None	91 months	Stable ankylosis	Satisfactory
17	F, 54, RL	TYPE IV	T; P; AF; BG	None	44 months	Bone consolidation	Satisfactory; death
18	F, 51, LL	TYPE IIIA	BG	Pseudarthrosis (removal of the interlocking intramedullary nail)	6 months	Pseudarthrosis	Unsatisfactory; death
19	F, 68, LL	TYPE IIIA	BG	Pseudarthrosis, sepsis, and death	16 months	Infected pseudarthrosis	Unsatisfactory
20	F, 48, RL	TYPE IV	T; P; AF; BG	None	61 months	Bone consolidation	Satisfactory
21	F, 62, RL	TYPE IV	T; BG	None	128 months	Bone consolidation	Satisfactory
22	M, 58, LL	TYPE IIIA	P; AF	None	51 months	Stable ankylosis	Satisfactory
23	F, 83, LL	TYPE IIIA	BG	Removal of the interlocking intramedullary nail	7 months	Stable ankylosis	Satisfactory
24	M, 68, RL	TYPE IIIA	BG	None	31 months	Bone consolidation	Satisfactory
25	F, 62, LL	TYPE IV	T; P; AF; BG	None	17 months	Stable ankylosis	Satisfactory

Source: SAME.

Legends: M: male; F: female; RL: right limb; LL: left limb; T: talectomy; P: panarthrodesis; AF: additional fixation; BG: bone graft.

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

dullary nailing was analysed. For this purpose, plates and screws were used according to the judgement of the surgeon at the time of operation, and the outcome was satisfactory in 12 of the 15 (80%) limbs fixed only with an interlocking intramedullary nail and in seven of the 10 (70%) limbs fixed using additional plates and/or screws. This difference was not significant.

DISCUSSION

Diabetic CA of the foot and ankle is challenging^(1,5,15,20-22). The primary objective of salvage surgery is to enable the patient to wear protective shoes and use moulded polypropylene orthosis to walk independently^(23,24). The results of this series were promising given that 76% of the patients benefited from surgery and were able to support their body weight during independent walking.

The location and extent of bone and joint involvement might also affect the prognosis of salvage surgery. Nonetheless, the outcome of deformity correction in the hindfoot and midfoot (type IV) tended to be satisfactory compared with injuries in the ankle (type IIIA). Similarly,

the need to completely remove the talus to allow adequate alignment of the limb might be associated with the increased rate of complications and decreased foot stabilisation in a satisfactory position. However, the results in the limbs where the talus was preserved were considerably better than those where the talus was removed. This result was significant. A possible explanation for this finding is that the maintenance of the devascularised bone limits the consolidation of the arthrodesis. The fact that lesions related to type IV CA present with larger injuries than those related to type II CA might have enabled the elimination of the negative effect caused by the presence of devascularised bone on the joints that should be arthrodesed by removing the talus to enable adequate limb alignment. Among the other factors that might have influenced arthrodesis consolidation, patients treated with a bone graft did not significantly differ from those without a bone graft. By contrast, the arthrodesis that extended to the hindfoot and midfoot (panarthrodesis) showed a mild improvement compared with arthrodesis restricted to the hindfoot. However, these differences in improvement were not significant. Because the extension of the arthrodesis to the midfoot was directly associated with more severe bone destruction in type IV CA than type IIIA CA and the consequent need for talectomy to achieve adequate limb alignment was greater, the same explanation regarding the favourable prognosis of arthrodesis using talectomy can be applied in this case. Moreover, the benefits of plates and/or screws as a strategy to improve the fixation provided by an interlocking intramedullary nail were not significant, and the outcome regarding the limbs fixed only with a retrograde intramedullary nail showed only a slight improvement.

Furthermore, it was possible to restore function in 76% of patients with severe deformities and marked hindfoot instability due to diabetic CA; this problem is related to late complications in people with diabetes mellitus (DM). At present, the success rate of the salvage of limbs affected by CA using this surgical technique is often higher than 80%⁽²⁵⁻²⁹⁾. In our case series, the surgery consisted of salvaging the limb using extensive bone and joint reconstruction via tibiocalcaneal arthrodesis of the ankle, subtalar joint, and (eventually) the other joints of the middle tarsus. The complete removal of the talus to achieve the desired alignment was often necessary. The clinical and functional outcomes were favourable given the extreme severity and limited prognosis of the CA-associated lesions corrected in this series.

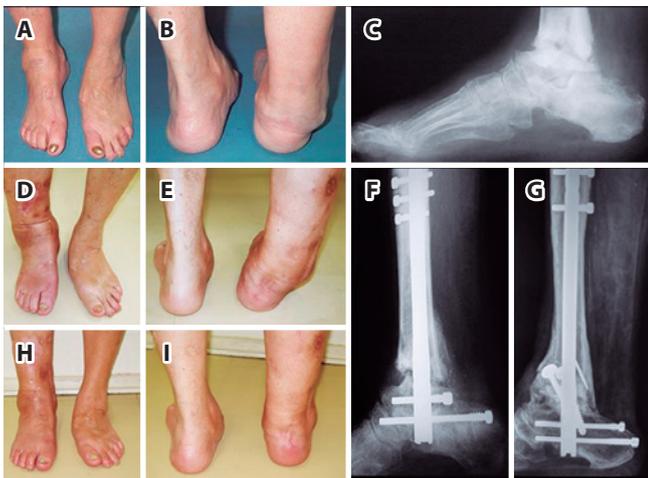


Figura 4. Case 12. Radiographic images from the frontal (4A) and posterior views (4B) showing a varus deformity of the right hindfoot. Lateral view (4C) showing deformities in the ankle and subtalar joint. Lateral view (4F) showing the lack of consolidation of the arthrodesis and the persistence of the varus deformity of the hindfoot (4E) after surgery. Images showing the consolidation of the tibiotalocalcaneal arthrodesis after surgical revision and the placement of a bone graft (4G). Images from the frontal (4H) and posterior views (4I) showing the correction of the deformity.

Source: SAME.

The mean survival time of patients with satisfactory outcomes was twofold higher than that of the other patient groups whose operation did not provide adequate alignment or stabilisation of their severely deformed limbs due to hindfoot CA. This factor should be considered when discussing this surgery with these patients. Importantly, literature reviews have demonstrated that the treatment outcomes of diabetic CA are favourable; nonetheless, these results do not apply to hindfoot lesions (types IIIA and IV)^(26,28,29,30). The management of the deformities and stabilisation of the foot and ankle can restore patients' abilities to walk using com-

mercially available footwear and considerably improve their quality of life⁽³¹⁾.

CONCLUSIONS

The attempt to salvage severely deformed and markedly unstable limbs due to CA complications of the ankle (type IIIA) or hindfoot (type IV) should be considered for patients with diabetes because the prognosis is favourable when the affected limb is surgically treated via tibiocalcaneal arthrodesis and an interlocking intramedullary nail.

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