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How to Improve the Outcome of Charcot Foot: Results of Five Years Follow-up Prospective Study

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Abstract

Background: Egypt is among the world's top 10 countries in terms of the highest number of people with diabetes. Delayed presentation and lack of appropriate foot care could account for different outcomes of Charcot-foot.

Aim of Study: Study the impact of nullification of the suggested risk factors on the outcome of Charcot-foot.

Patients and Methods: We did a prospective analysis of the impact of compliance with the nullified suggested risk factors on both feet as compliance with 1- Wearing the removable-cast-walkers, 2- The regular follow-up visits, 3- Nullified leg-length discrepancy induced by the removable-cast-walker, and 4- Slowing of the gait speed (24 steps ±3/min). 43 patients presented ≥5 years ago with unilateral chronic Charcot and normalcontralateral foot were included and subdivided into (Group-A) compliant with all nullified risk factors and (Group-B) non-compliant with ≥1 of the risk factors, of matched age, sex, BMI, HbA1c and diabetes duration. Both feet are then examined for any complications that happened since January/2010 till February/2016.

Results: Our results showed statistically significant difference regarding the complications happened in the Charcot-foot, 11.1% (n=2) vs. 44% (n=11) and in the contralateral foot, 16.7% (n=3) vs. 48% (n=12) in group A vs group B respectively. Adherence to nullification of the suggested risk factors decreases the occurrence of complications by >6 folds in the Charcot-foot (odds ratio 6.3, p=0.03) and >4 folds in the contralateral foot (odds ratio 4.6, p=0.04).

Conclusion: Nullification of leg-length-discrepancy, slowing of the gait speed, compliance with the removable-cast-walker and regular follow-up visits greatly improved the outcome of Charcot foot in our foot clinic.

Key Words: *Gait speed – Leg length discrepancy – Charcot – Contralateral foot – Removable cast walker.*

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Introduction

EGYPT ranks amongst the world's top 10 countries with the highest number of people with diabetes **[1]**. Charcot foot is a devastating complication of diabetes with inevitable deformity when left untreated **[2]**. Delayed presentation Fig. (1) and lack of appropriate foot care could account for different presentation and outcome of Charcot foot in Egypt [3]. Charcot could have deleterious effect on gait due to neuropathy, deformity and leg length discrepancy induced by offloading devices Fig. (2) [4].

Fig. (1): Patient with delayed presentation, seeking medical advice for the first time with deformed disorganized foot joints.

Fig. (2): Leg length discrepancy between the removable cast walker and the other foot.

In 2010, 140 patients with Charcot foot offloaded by Removable Cast Walkers (RCW) were regularly attending our clinic, and during that year we noticed that 8 (5.7%) of them developed Charcot neuropathy in the contralateral foot [4]. At that time, we tried to identify the different risk factors that led to that deterioration. In 2011, El-Nahas et al., declared that the short leg of diabetic patients with neuropathic foot ulcers would be subjected to greater pressure load, as such, care should be taken to avoid minor leg length discrepancy [5].

It is well known that during weight bearing activities, such as standing and walking, the plantar surface of the foot is exposed to ground reaction forces. During standing, this force equals the body weight and each foot bears ~50% of body weight distributed over the whole plantar surfaces [6]. While during walking, thestress applied to the feet are much higher than when standing [7]. At a self-selected walking speed, the vertical peaks are ~1.2 times body weight, but this increases with fast walking to 1.5 times body weight [8].

In diabetes, several factors can affect the stress applied to the feet. Loss of protective sensation can be dramatic with the effect that patients cannot feel pain or discomfort when the plantar surface is injured or overloaded [9]. It has been demonstrated that plantar pressures, particularly in the forefoot, is considerably reduced during a shuffling gait [10].

Rosenbaum et al., demonstrated that when walking speed is reduced from an average of 1.19m/s (normal) to 0.83m/s (slow), peak planter pressure is reduced on the heel (5%-18%), on the medial forefoot (9%-11 %), and on the hallux (1 1 %) [11].

We were interested in determining if slowing of gait speed together with compliance with the follow-up visits and wearing the RCW after nullification of the leg length discrepancy between the RCW and the contralateral foot could improve the outcome of Charcot. Our primary aim was to ensure our patients compliance with their follow-up visits, wearing their offloading devices and slowing of their gait speed and our secondary aim was to determine the impact of such compliance on the outcome of Charcot in the 5 years duration of the study. We undertook a prospective cohort study to compare outcomes on both feet in patients who are compliant versus those who are not.

Patients and Methods

A prospective cohort study was designed to include all diabetic subjects presented with unilateralchronic Charcot foot to Mansoura Foot Clinic before January 2011 (≥5 years ago) and up to-February 2016 to study the impact of nullification of the suggested risk factors: 1- Compliance with the RCW, 2- Compliance with the regular monthly follow-up visits, 3- Nullified leg length discrepancy between the RCW and the contralateral foot Fig. (3), 4- Slowing of gait speed (24 steps ±3/min) for better outcomes of the disease on both feet.

Fig. (3): Nullified leg length discrepancy between the removable cast walker and the other foot.

Compliance with RCW and nullified leg length discrepancy was based on asking the patients and their relatives and examining the walker and the nullified leg length discrepancy shoe status, taking into consideration the non-paved muddy roads of the villages where most of the patients came. If the patient is compliant with the walker, he will be compliant with then ullifying leg length discrepancy shoe to avoid pelvic pain and difficulty of walking induced by this leg length discrepancy. More than 2 missed monthly follow-up visits per year or 2 consecutive missed visits was enough to define non-compliance with regular follow-up visits.

We see that observing (ordinary walking gait he used during normal day life) without attractingthe patient's attention that we are checking his gait speed will be more reliable although less accurate than using electronic gait analyzer, where most of the patients take care of their steps and not using their usual gait or speed.

To confirm their compliance, we observed their gait during entrance and exit of our clinic every visit; we consider them compliant if we registered-slow gait speed in at least 70% of their visits. A total of 153 patients were referred to our foot clinic with Charcot before January 2011, 81.7% (n=125) presented with chronic Charcot and 18.3% (n=28) presented with acute Charcot. Out of these patients we included 43 patients who presented ≥5 years ago with unilateral chronic Charcot foot offloaded by RCW with custommade insole and normal contralateral foot with custom made insole. They are

subdivided into 2 groups of matched age, sex, BMI, HBA1c, diabetes duration, degree of diabetic neuropathy and site of Charcot in the foot (i.e. Mid-foot or hind-foot) at the end of the 5 years.

Group A: Compliant with nullified suggested risk factors.

Group B: Non-compliant with ≥1 of the nullified suggested risk factors.

We excluded cases with acute Charcot, bilateral Charcot, Charcot offloaded with any offloading devices other than RCW, Charcot with contralateral foot deformity, ulceration and minor or major amputation, cases referred for arthrodesis, developed major amputations, with extreme values of BMI or HBA1C and finally, cases that died before the end of the study. Both feet of the 2 groups were examined and we take initial images (X-ray or MRI) for the Charcot foot inaddition at the time of inclusion before January 2011 and 5 years later (February 2016). The study design was approved by the Institutional Research Board of the Faculty of Medicine, Mansoura University. Statements of consent to participate and publish from the participants are available.

Results

The Charcot foot showed no significant difference between both groups regarding history of ulcers 28% (n=5) vs. 44% (n=11), recurrent ulceration 11% (n=2) vs. 12.5% (n=3), deformity (rocker bottom mid-foot deformity, mid-foot flattening of the foot arch with or without hind-foots welling) 66.7% (n=12) vs. 68% (n=17), and minor amputation (one or more of the lateral fourtoes) 16.7% (n=3) vs. 16% (n=4), in group A vs. group B respectively, *p*-value in all was >0.05 [as shown in (Table 1), Fig. (4)].

Table (1): Comparison between compliant and non-compliant groups 5 years ago.

	The Charcot foot			
	History of Ulceration	Deformity	Minor amputation	Recurrent ulceration
Group A (N=18)	28% (N=5)	66.7% (N=12)	16.7% (N=3)	11% (N=2)
Group B (N=25)	44% (N=11)	68% (N=17)	16% (N=4)	12.5% (N=3)
p-value	0.22	0.59	0.63	0.64

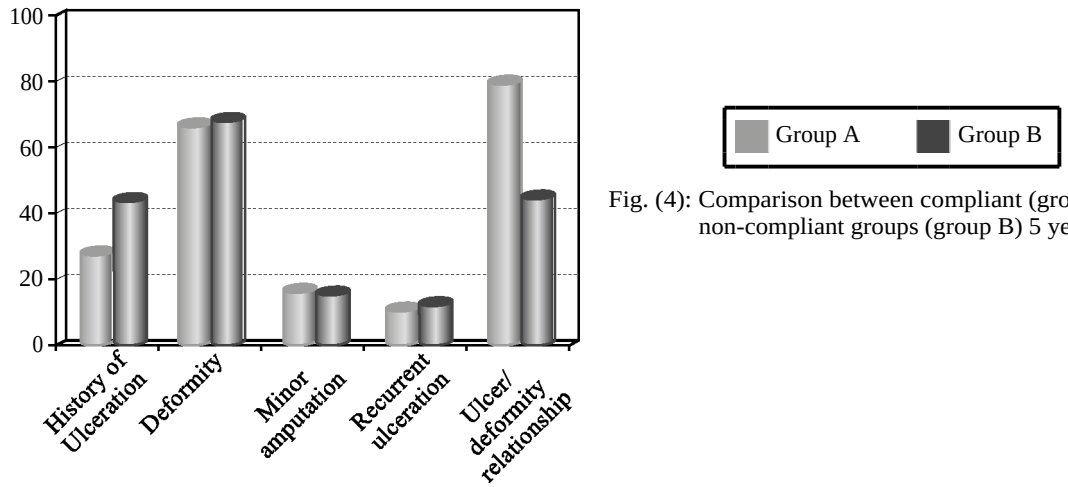

Fig. (4): Comparison between compliant (group A) and non-compliant groups (group B) 5 years ago.

"Statistical significance was defined at the 5% (p<.05) level". After >5 years, in group A vs. group B, 5.6% (n=1) vs. 20% (n=5) in Charcot foot, 0% vs. 20% (n=5) in the contralateral foot had new ulcers, 5.6% (n=1) vs. 28% (n=7) in Charcot foot, 11% (n=2) vs. 4% (n=1) in the contralateral foot had new deformity (mid-foot flattening of the foot arch with or without hind-foot swelling), and 0% vs. 4% (n=1) in Charcot foot, 5.6% (n=1) vs. 4% (n=1) in the contralateral foot had minor amputation (one or more of thelateral four toes), and 16.7% (n=3) vs. 24% (n=6) in the contralateral foot developed Charcot [(as shown in (Table 2), Figs. (5,6)].

Table (2): Comparison between compliant and non-compliant groups after 5 years duration.

	The Charcot foot			The Contralateral foot			
	New Ulcers	New Deformity	New Minor amputation	Ulcers	Deformity	Minor amputation	Charcot
Group A (N=18)	5.6% (n=1)	5.6% (n=1)	0% (n=0)	0% (n=0)	11% (n=2)	5.6% (n=1)	16.7% (n=3)
Group B (N=25)	20% (n=5)	28% (n=7)	4% (n=1)	20% (n=5)	4% (n=1)	4% (n=1)	24% (n=6)
p-value		0.02			0.034		

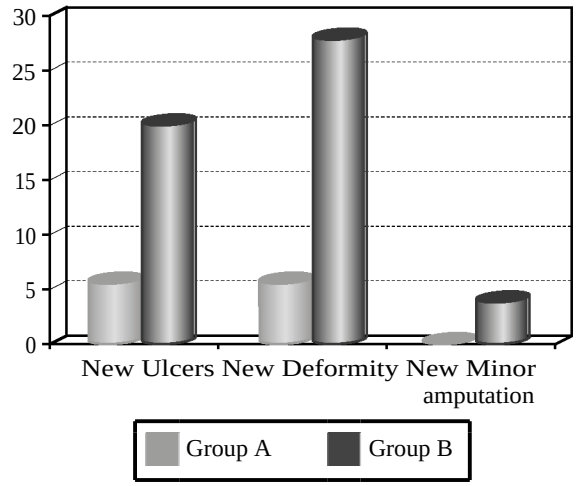

Fig. (5): Comparison between compliant (group A) and non-compliant groups (group B) after ›_5 years duration at the Charcot foot.

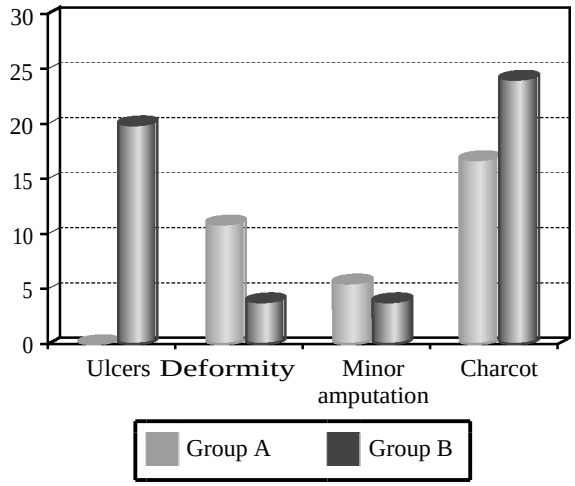

Fig. (6): Comparison between compliant (group A) and non-compliant groups (group B) after ›_5 years duration at the contralateral foot.

In conclusion we found that there is statistically significant difference regarding the complications that happened in the Charcot foot 11.1% (n=2) in group A vs. 44% (n=11) in group B and in the contralateral foot, 16.7% (n=3) in group A vs. 48% (n=12) in group B, (p<0.05 in both). Logistic regression analysis for predicting the occurrence of complications reveals that, adherence to nullification of the suggested riskfactors decreases the risk of occurrence of complications by >6 folds in the Charcot foot (odds ratio 6.3, p=0.03) and >4 folds in the contralateral foot (odds ratio 4.6, p=0.04).

Discussion

Charcot foot is one of the complications that have deleterious effect on the gait that can lead tojoint displacement or foot amputation [2]. The offloading devices (i.e., RCW) used in chronic Charcot has a well-known pressure relieving effect on the foot. Although it is notthe gold standard for the treatment of Charcot, it has a big role in chronic Charcot especially for those with gross foot deformity after resolution of the acute stage (i.e., rocker bottom mid-foot deformity or swollen ankle) [1,2].

Those who had foot deformity, we asked them to wear RCW as aprimary lifelong prosthetic, as we do not have resources in the primary treating country forcustom devices such as Charcot Restraint Orthotic Walkers. Although we did not objectively measure this, we did not notice any significant muscle wasting with their use.

We included 43 patients who presented ›_5 years ago with unilateral chronic Charcot foot offloaded by RCW with custom made insole and normal contralateral foot with custom made insole. They are subdivided into 2 groups of matched age, sex, BMI, HBA1c, diabetes duration, degree of diabetic neuropathy and site of Charcot in the foot (i.e. Mid-foot or hind-foot) at the end of the 5 years.

- *Group A:* Compliant with nullified suggested risk factors.
- *Group B:* Non-compliant with ≥1 of the nullified suggested risk factors.

After ›_5 years, the development of new ulcer in the same foot was 5.6% (n=1) vs. 20% (n=5) in group B (p<0.05) and development of new deformity 5.6% in group A vs. 28% in Group B and there was no development of minor Amputation in Group A vs. 4% in Group B.

This finding agreed with Larsen K there is a four-fold risk of ulcers in diabetic Charcot deformity compared with the overall risk of foot ulcers in diabetic feet **[11]**.

According to the contra lateral foot the development was noticed in 5 patients in Group B only and this cope with Felix W et al., who proved that almost 20% of patients developed contralateral CN. Nearly half of people with CN developed a contralateral foot ulceration. We thought that larger number of patients will be needed to confirm this result **[12]**.

The minor amputation was in one case in Group B and this confirmed by Sohn et al., who suggested that Charcot arthropathy by itself does not pose a serious amputation risk, but ulcer complication multiplicatively increases the risk **[13]**.

The Charcot foot showed no significant difference between both groups regarding history of ulcers 28% (n=5) vs. 44% (n=11), recurrent ulceration 11% (n=2) vs. 12.5% (n=3), deformity (rocker bottom mid-foot deformity, mid-foot flattening of the foot arch with or without hind-foot swelling) 66.7% (n=12) vs. 68% (n=17), and minor amputation (one or more of the lateral four toes) 16.7% (n=3) vs. 16% (n=4), in group A vs. group B respectively, p-value in all was >0.05 [(as shown in (Table 1), Fig. (4)].

In our diabetic foot clinic, we asked our patients to be compliant with wearing the RCW and try to nullify leg length discrepancy shoes during walking indoors and outdoors, and to have a monthly follow-up visits to our clinic, so, we can pick early any minor changes unnoticed by the patient.

However, the compliance of patients on RCW is moderately accepted as these devices have high rigid outsoles that lead to the appearance of leg length discrepancy with shortening of the contralateral foot with application of more stress on this foot; so, we have tried to nullify this risk factor.

Furthermore, it is now well-known that during walking, the stress applied to the feet are much-higher than when standing, and this stress increases with rising gait speed, that is why weadvised our patient to slow their gait speed to be near shuffling gait **[8,14]**.

Conclusion:

Based on the results of our study, we noticed that patients with Charcot foot disease in Egypt usually seek medical advice in the chronic stage. Despite the delayed presentation of the disease, nullification of leg length discrepancy, slowing of gait speed, compliance with the RCW and regular follow-up visits greatly improved the outcome of Charcot foot in Mansoura Diabetic Foot Clinic. We have no effect on those who develop bilateral Charcot as anormal progression pathway of the disease, but at least we can prevent its occurrence in those with pressure overload is the precipitating factor.

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كيفية تحسين نتائج القدم الشاركوتى: نتائج متابعة ٥ سنوات دراسة مستقبلية

خلفية البحث: تعد مصر من أكثر عشر دول فى العالم من حيث أكبر عدد من المصابين بداء السكرى. يمكن لتأخر عرض المريض على الطبيب فى المراحل الأولى وعدم وجود رعاية مناسبة للقدمين سبباً فى قدوم حالات مفصل الشاركو للبحث عن علاج فى مراحل متأخرة.

الهدف من البحث: دراسة تأثير إلغاء عوامل الخطر المقترحة المسؤولة عن نتائج أفضل لحالات مفصل الشاركو.

خطة البحث: لقد أجرينا تحليلاً مستقبلياً لتأثير الإمتثال لإبطال عوامل الخطر المقترحة على كلا القدمين كالتوافق مع ١- إرتداء المشايات القابلة للإزالة، ٢- زيارات المتابعة المنتظمة، ٣- التناقض فى طول الساقين الناجم عن جهاز المشى المصبوب القابل للإزالة، و٤- إنخفاض سرعة المشى (٢٤ خطوة ±٣/دقيقة). تم تضمين ٤٣ مريضاً مصابين بمفصل شاركو فى جانب واحد تم تقديمهم قبل ≤٥ سنوات والقدم المقابل طبيعى وتقسيمهم إلى (مجموعة أ) ملتزمة بجميع عوامل الخطر الملغاة و (مجموعة ب) غير ملتزمة مع واحد أو أكثر من عوامل الخطر الملغاه، وكانت المجموعتين متوافقين من حيث العمر والجنس ومؤشر كتلة الجسم ومدة مرض السكرى ومعدلات السكر ثم يتم فحص كلا القدمين لمعرفة أى مضاعفات حدثت منذ يناير/٢٠١٠ حتى فبراير/٢٠١٦.

النتائج: أظهرت نتائجنا فروق ذات دلالة إحصائية فيما يتعلق بالمضاعفات التى حدثت فى مفصل شاركو، (n=12) مقابل ٤٨٪ (n=3) وفى القدم المقابل، ١٦.٧٪ (n=11) مقابل ٤٤٪ (n=2) ١١.١٪ فى المجموعة (أ) ضد المجموعة (ب) على التوالى. الإلتزام بإلغاء عوامل الخطر المقترحة يقلل من 4> و (p=0.03) نسبة الأرجحية ٦.٣)، أضعاف فى مفصل شاركو 6> حدوث المضاعفات بمقدار (p=0.04) نسبة الأرجحية ٤.٦)، أضعاف فى القدم المقابل.

الإستنتاج: أدى إلغاء تباين طول الساق، وتباطؤ سرعة المشى، والإمتثال لجهاز المشى القابل للإزالة، وزيارات المتابعة المنتظمة إلى تحسين نتائج مرضى شاركو فى عيادة القدم لدينا بشكل كبير.