The definition of acute Charcot foot

William Jeffcoate

ARTICLE POINTS

1 The published results of treatment of the acute Charcot foot often seem at variance to clinical experience. Some of this relates to differences in population selection.

2 There is a clear need for more research in the field but this is hampered by the lack of a working definition.

3 The definition should include reference to acute inflammation, and unexplained fracture and dislocation. Consideration should be given to the inclusion of isolated fractures.

4 Osteomyelitis cannot be reliably excluded if there is, or has been, ulceration of the skin adjacent to the inflamed area.

5 The term 'acute Charcot foot' may be preferable to more complicated options, such as 'diabetic neuropathic osteoarthropathy'.

KEY WORDS
- **Charcot**
- **Osteomyelitis**
- **Inflammation**
- **Fracture/dislocation**
- **Working definition**

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Introduction

The acute Charcot foot is a condition which fascinates many who work in the field – partly because so little is known of its causes, its prognosis or of its best management. While a number of large series have been reported, some of the conclusions drawn concerning response to treatment and ultimate prognosis seem to be at variance with clinical experience. Some of these differences relate to population selection, but there is a clear need for more scientific data. Research and comparative audit is, however, hampered by the lack of working definition. The acute Charcot foot is a condition that we can recognise, but not define.

The Charcot foot may occur in a number of disorders complicated by peripheral neuropathies, including tabes dorsalis, leprosy and other causes of peripheral neuropathy. It was first described in diabetes in 1936 (Jordan, 1936), and although well recognised, is a relatively rare complication. Estimates of its incidence vary widely. Nabarro found an overall cumulative incidence of 0.3% in a large personal series (Nabarro, 1991), while Fabrin et al (2000) reported an *annual* incidence of 0.3%. The annual incidence in different racial groups in Texas appears to be even higher (Lavery et al, 2003). Nevertheless, the Charcot foot is a condition which affects only a minority of people with neuropathy, and for reasons that remain obscure. While new ideas are emerging concerning its pathogenesis, and there is increased awareness of the many factors that may be involved, research has been hampered by the lack of a working definition. The purpose of this article is to explore the structure of a definition of the (acute) Charcot foot in diabetes which may be used in future audit and research. It is intended as a platform for debate.

Pathogenesis

While the presentation that we recognise is associated with (relatively painless) fracture/dislocation of one or more bones and joints of the foot, a cardinal feature is the increased blood flow on the affected side: the foot is inflamed. It is not, however, clear to what extent this inflammation is the cause, or the consequence, of the condition.

Part of the increased blood flow results from underlying sympathetic denervation, but sympathetic denervation is symmetrical and yet the flow in acute Charcot is asymmetrical, and very much greater on the affected side (*Figure 1*). While it is possible that this secondary increase in blood flow represents an inflammatory response to the destruction of bone and joint which has already occurred – possibly mediated through a disordered vasomotor reflex, or the local release of vasoactive cytokines – it is well-recognised that the inflammation may come first, and that there may be no detectable radiological changes in bone or joint in the earliest phases of the acute hot, red, Charcot foot. This raises the question of how much of the increased blood flow on the affected side is the cause of any changes to bone and joint, and how much it is the consequence.

Another area of uncertainty lies in the extent to which pre-existing reduction in bone density is responsible for the onset and the progression of the condition. It has long been recognised that while type 1 diabetes is associated with a tendency to bone thinning (of the upper limb and axial skeleton, as much as of the foot), this is

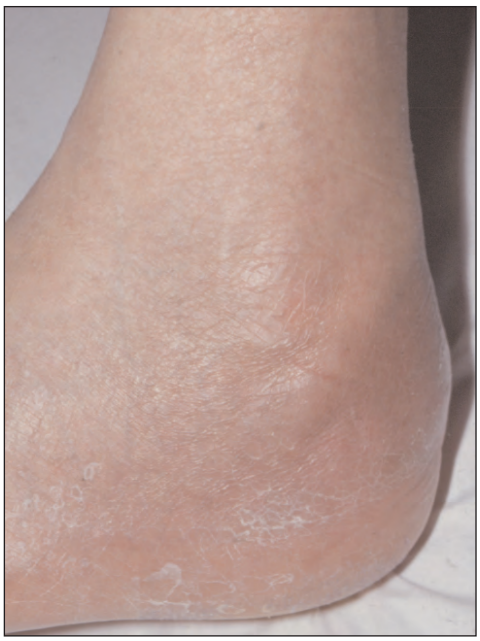

Figure 1. The acute Charcot foot presents with inflammation of the affected side. The cause of this asymmetrical hyperaemia is not known.

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1 It would be expected that the presentation of Charcot in people with type 1 versus type 2 diabetes would be fundamentally different, yet we do not currently recognise this to the case.

2 It is accepted that effective off-loading and, possibly, therapy with agents such as bisphosphonates may slow or halt the destructive process and improve the ultimate prognosis.

3 A definition of Charcot is needed in order to facilitate future research.

4 The definition must include reference to fracture and/or dislocation of one or more bones and joints of the foot.

5 These may not be apparent at presentation, but most regard them as essential for the later confirmation of the diagnosis.

not a feature of type 2 disease (Ziegler, 1992). Petrova and colleagues have recently reported that, in contrast to type 1 disease, bone density is not reduced *at presentation* of acute Charcot in those with type 2 diabetes (Petrova et al, *in press*). Since Herbst and colleagues (2004) have shown that patients with acute Charcot foot who have osteopenia at presentation are more likely to have fractures, while those without have dislocations, it would be expected that the presentation in type 1 and type 2 disease would be fundamentally different, and yet we do not currently recognise this to be the case.

It is also known that bone density in the affected foot decreases after initial presentation in both types of diabetes (Young et al, 1995), and this again suggests that a factor such as blood flow may contribute to the worsening of the condition once it is established. The importance of this increase in blood flow in the early phases was emphasised by Charcot himself – even though he, of course, was describing changes which occur in tertiary syphilis, and not diabetes (Charcot and Féré, 1883).

Recent discoveries in the field of bone cell physiology and pathophysiology have increased awareness of the possible involvement of a variety of cytokine and hormonal pathways. Specifically, the elucidation of the RANKL/OPG system has suggested explanations for the links between bone breakdown and altered vascular function, as well as a possible mechanism whereby this system might be disturbed in neuropathy (Jeffcoate, 2004). Nevertheless, it is equally apparent that the evolution of the Charcot foot is dependent on changes in more than one cytokine system and the clinical presentation is the result of a highly complex interaction of many different factors – both metabolic and biomechanical. The need for such interaction may explain why the acute Charcot foot is a rather rare complication of neuropathy in diabetes.

Whatever the precise pathogenesis, it is accepted that effective off-loading and, possibly, therapy with agents such as bisphosphonates (Jude et al, 2001) may slow or halt the destructive process and improve the ultimate prognosis.

Towards a definition

It is against this background that we need a clear picture of what exactly it is we refer to when we decide that someone has an 'acute Charcot foot'. There are no histological features that will reliably distinguish all cases of acute Charcot from osteomyelitis, and so there is no criterion standard upon which to base the diagnosis. A definition is needed in order to facilitate future research. In constructing such a definition, it would be important to include as few cases of non-Charcot as possible (higher specificity), while accepting that this may be achieved only by excluding some cases of true disease, especially when acute Charcot and osteomyelitis co-exist (lower sensitivity).

Diabetes, neuropathy and inflammation of the foot

It can be accepted (for these purposes) that the person should have diabetes, with neuropathy and inflammation of part or all of one or (less commonly) both feet. The working definition might therefore be based on:

Acute or subacute inflammation of all or part of the foot in people with diabetes complicated by distal symmetrical neuropathy

Fracture and dislocation

However, the definition must include reference to fracture and/or dislocation of one or more bones and joints of the foot. These may not be apparent at presentation, but most regard them as essential for the later confirmation of the diagnosis. Hence the working definition now reads:

> ***Acute or subacute inflammation of all or part of the foot in people with diabetes complicated by distal symmetrical neuropathy, accompanying fracture or dislocation that cannot be explained by recent trauma***

Implicit in this definition is acceptance of the fact that those with dense sensory neuropathy might not be aware of trauma which would not generally be recognised as minor. It also begs the question about whether or not isolated fractures (e.g. of metatarsals, 'stress fractures') or dislocations should be included. It could certainly be argued that they should be when they are associated with signs of inflammation, although some will disagree. For the purposes of this debate, it will be taken that they are included.

Exclusion of osteomyelitis

The acute Charcot foot cannot be reliably distinguished from osteomyelitis by any investigational tool. Bone biopsy (aiming to define or exclude infection both microbiologically and histologically) has not actually been systematically evaluated. Moreover, it is unlikely to be 100% reliable and, in any case, is not used in routine clinical practice. Imaging (especially MRI [magnetic resonance imaging] and labelled white cell scanning) may sometimes be helpful. Similarly, others have described the value of comparing concentrations of different bone turnover markers, such as osteocalcin and bone-specific alkaline phosphatase (Ulyanova et al, 2004). The presence of infection may be indicated by a very high erythrocyte sedimentation rate (ESR) but there is, in general, no reliable method of distinguishing between the two conditions (Jeffcoate and Lipsky, 2004). So much so, that it is not impossible that some patients currently diagnosed as having osteomyelitis (particularly of the forefoot) may in fact be cases of Charcot.

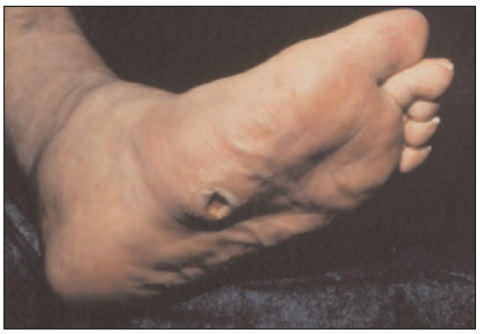

Figure 2. If there is an ulcer adjacent to the area of inflammation, it is rarely possible to exclude osteomyelitis and to make a diagnosis of uncomplicated Charcot foot.

Bone will only become infected if there is an adjacent ulcer – which acts as a portal of entry for bacteria. Cases of haematogenous (blood borne) infection are very rare. It follows that osteomyelitis is both most likely, and most difficult to exclude, when the area of inflammation is close to a pre-existing ulcer – or to where a pre-existing ulcer once was. If, therefore, there is (or has been) an ulcer adjacent to the area of inflammation, it is rarely possible to make a confident diagnosis of uncomplicated Charcot foot (*Figure 2*).

Working definition

On the basis of these arguments, it is suggested that the following is considered as the basis for a working definition of the acute Charcot foot.

> ***Acute or subacute inflammation of all or part of the foot in people with diabetes complicated by distal symmetrical neuropathy, accompanying fracture or dislocation that cannot be explained by recent trauma, and without preceding ulceration of the adjacent skin***

Inevitably, this will exclude some patients in whom the condition is associated with a neuropathic ulcer (especially, perhaps, in the forefoot), as well as those who have *both* Charcot *and* osteomyelitis. It also will exclude – as indicated above –

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1 The acute Charcot foot cannot be reliably distinguished from osteomyelitis by any investigational tool.

2 If there is (or has been) an ulcer adjacent to the area of inflammation, it is rarely possible to make a confident diagnosis of uncomplicated Charcot foot.

3 Inevitably, the proposed working definition will exclude some patients in whom the condition is associated with a neuropathic ulcer, as well as those who have both Charcot and osteomyelitis.

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1 When debating the name of the condition, the word 'osteoarthropathy' highlights the involvement of bone and joints but makes no reference to changes in blood flow and soft tissue.

2 Unexplained self-limiting inflammation of the lower limb may represent part of a common spectrum of disorders, linked by abnormalities of vasomotor control.

3 For this reason, the simpler term 'acute Charcot foot' may be preferable, though, superficially, it may seem less precise.

the involvement of bones and joints other than in the foot, and applies only to Charcot which occurs as a complication of diabetes.

Towards a name: acute Charcot foot, or acute (diabetic) neuropathic osteoarthropathy?

The term neuropathic osteoarthropathy is generally taken to be the correct name of the condition, but it suffers from being a bit of a mouthful. The abbreviated form, DNOA, has little to commend it apart from brevity, and the use of such initials alienates readers who are less familiar with the field. Moreover, the word 'osteoarthropathy' highlights the involvement of bone and joints, while making no reference to changes in blood flow and soft tissue which may be central to the development and progression of the disorder.

Indeed, it is even possible that some patients may develop the soft tissue manifestations of the disorder (or of the same pathological processes which might lead to it), without ever suffering damage to the bones and joints of the foot. Unexplained episodes of self-limiting inflammation of the lower limb have been described in patients with profound neuropathy (Jeffcoate et al, 2004). While these are usually treated as cellulitis, they may represent part of a common spectrum of disorders, linked by abnormalities of vasomotor control. It is for this reason that the simpler term, acute Charcot foot, may be preferable even though, superficially, it seems less precise. ■

Charcot J-M, Féré C (1883) Affections osseuses et articulaires du pied chez les tabétiques (Pied tabétique). *Archives de Neurologie* **6**: 305–19

Fabrin J, Larsen K, Holstein PE (2000) Long-term follow-up in diabetic Charcot feet with spontaneous onset. *Diabetes Care* **23**: 796–800

Herbst SA, Jones KB, Saltzman CL (2004) Pattern of diabetic neuropathic arthropathy associated with the peripheral bone mineral density. *Journal of Bone and Joint Surgery* **86**(3): 378–83

Jeffcoate W (2004) Vascular calcification and osteolysis in diabetic neuropathy – is RANK-L the missing link? *Diabetologia* **47**: 1488–92

Jeffcoate W, Lipsky BA (2004) Controversies in diagnosing and managing osteomyelitis of the foot in diabetes. *Clinical Infectious Diseases* **39** (Suppl 2): S115–22

Jeffcoate WJ, Idris I, Game FL (2004) Erythromelia, or Mitchell's syndrome – new names for unexplained signs of inflammation in distal symmetrical neuropathy in diabetes. *Diabetic Medicine* **21**: 1334–38

Jordan W (1936) Neuritic manifestations in diabetes mellitus. *Archives of Internal Medicine* **57**: 161–78

Jude EB, Selby PL, Burgess J, Lilleystone P, Mawer EB, Page SR et al (2001) Bisphosphonates in the treatment of Charcot neuropathy: a double-blind randomised controlled trial. *Diabetologia* **44**: 2032–37

Lavery LA, Armstrong DG, Wunderlich RP, Tredwell J, Boulton AJ (2003) Diabetic foot syndrome: evaluating the prevalence and incidence of foot pathology in Mexican Americans and non-Hispanic whites from a diabetes disease management cohort. *Diabetes Care* **26**:1435–38

Nabarro JD (1991) Diabetes in the United Kingdom: a personal series. *Diabetic Medicine* **8**: 59–68

Petrova N, Foster AV, Edmonds ME. Calcaneal bone mineral density in patients with Charcot neuropathic osteoarthropathy: differences between type 1 and type 2 diabetes. *Diabetic Medicine* (in press)

Ulyanova I, Tokmakova A, Arbusova M, Dedov I (2004) Bone changes in patients with diabetic foot syndrome. Paper presented to the Diabetic Foot Study Group of the EASD, Regensburg, September 2004

Young MJ, Marshall A, Adams JE, Selby PL, Boulton AJ (1995) Osteopenia, neurological dysfunction, and the development of Charcot neuroarthropathy. *Diabetes Care* **18**(1): 34–38

Ziegler R (1992) Diabetes mellitus and bone metabolism. *Hormone Metabolism Research Supplement* **26**: 90–94

This article is intended to be a platform for debate – if you have any comments or questions on this important topic or the issues raised herein, please contact the editorial team at:

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