

Acute Charcot Neuropathy Versus Osteomyelitis - The Great Clinical Dilemma In Diabetic Foot- A Clinical Research Analysis Using “Ghost Sign” In Mri

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Abstract:

Background: Charcot's Neuropathy (CN) and Osteomyelitis (OM) are debilitating and potentially limb threatening complications of diabetic foot and is difficult to differentiate one from the other both clinically and radiologically. But tackling this diagnostic dilemma is of utmost clinical importance as the management differs accordingly. This study aims to analyse the sensitivity and specificity of “The Ghost Sign” as a tool for differentiating OM from CN in diabetic foot Magnetic Resonance Imaging (MRI).

Materials and Methods: This original clinical research study was conducted at Sree Uthradom Thirunal Academy of Medical Sciences (SUTAMS), Thiruvananthapuram, India from December 2021 to December 2023 after obtaining Institutional Ethical committee approval. An informed consent was obtained from all patients before conduct of MRI imaging. The “MRI Ghost sign” was applied in 120 patients in age bracket of 50-75 years with diabetic foot with acute pain without any previous intervention or diagnostic work up who underwent MRI as part of present management. The MRI findings obtained were then correlated with histopathology / culture reports.

Results: In our original clinical research study, the MRI Ghost sign was detected in all but 5 of the osteomyelitis patients (93%), while none of the Charcot patients showed the sign.

Conclusion: “The Ghost Sign” in MRI can be utilized as a reliable diagnostic tool in distinguishing OM versus CN in diabetic foot, thereby providing diagnostic clarity which will aid better clinical management of this very common but complex complication.

Keyword: Diabetic Charcot Neuroarthropathy, Diabetic foot Osteomyelitis, Osteomyelitis, Magnetic Resonance Imaging, MRI Ghost Sign

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I. Introduction

Diabetic neuropathies are a group of neuropathies that can be caused by diabetes complications, such as nerve damage due to progressive neurodegeneration neovascularization and apoptosis. Diabetic Charcot Neuroarthropathy (DChN) is the most common form of neuropathy caused by diabetes accounting for approximately 50% of the cases ^[1]. The underlying causes of DChN are unknown, but it is likely due to the damage that diabetes causes to the peripheral nerves.

Diabetic Charcot Neuroarthropathy (DChN) is a complication of Diabetes Mellitus type 1 or type 2 that affects the peripheral nerves. In late stages, it can cause weakness, wasting and atrophy of the limbs ^[2]. Symptoms usually develop slowly over several years, but can rapidly develop in some cases. Early diagnosis and treatment are essential to prevent serious long-term consequences.

Osteomyelitis (OM) is a rare infection of the bone that most often affects the foot. It is more common in people with diabetes, who are at risk for more wound infections and called Diabetic Foot Osteomyelitis (DFO)^[3]. There are several causes of osteomyelitis. One is a type of bacterial infection. Osteomyelitis can also develop after a fall or as a result of a traumatic injury to the bone. In about 60% of the cases, the cause is unknown.

The symptoms of osteomyelitis vary depending on the part of the body that is affected. In about 60% of the cases, the person with osteomyelitis will have fever and swelling in the area around the infection. The infection will also cause pain and inflammation. The person may also have difficulty moving the infected area. DFO can be treated with antibiotics. In some cases, surgery may be necessary to remove the infected bone.

Charcot's Neuropathy (CN) and Diabetic foot Osteomyelitis (DFO) are debilitating and potentially limb threatening complications of diabetic foot which are difficult to differentiate from the other clinically. But tackling this diagnostic dilemma is of utmost importance as the management differs accordingly and various imaging techniques like conventional radiography, Ultrasonography (US), and Computed tomography (CT) have shown to have only limited sensitivity, mainly due to suboptimal assessment of soft-tissue or bone edema^[4]. The introduction of magnetic resonance (MR) imaging has been a life saver and has helped us overcome this short coming. MR imaging is the imaging modality of choice for diabetic foot evaluation, with high sensitivity and high specificity (90% and 79%, respectively) in the diagnosis of osteomyelitis ^[4].

Many MRI features help in differentiating CN and OM, but none more than the Ghost sign. "The Ghost Sign" refers to the poorly defined bone margins in a non-contrast T1W sequence (due to bleeding with surrounding soft tissue inflammatory change) becoming much more well defined in Gadolinium enhanced T1 contrast images ^[5-7].

II. Aims and Objectives

To analyse the sensitivity and specificity of "The Ghost Sign" as a fool proof method of differentiating OM from CN in diabetic foot Magnetic Resonance Imaging (MRI).

III. Material And Methods

This original clinical study was conducted on patients of Department of Radiodiagnosis at Sree Uthradom Thirunal Academy of Medical Science (SUTAMS), Trivandrum, Kerala from December 2021 to December 2023 after obtaining Institutional Ethical committee approval. A total 120 adult subjects (both male and females) were included in this study.

Study Design: Prospective open label observational study

Study Location: This was a tertiary care teaching hospital based study done in Department of Radiodiagnosis at Sree Uthradom Thirunal Academy of Medical Science (SUTAMS), Trivandrum, Kerala.

Study Duration: December 2021 to December 2023.

Sample size: 120 patients.

Sample size calculation: The sample size was estimated on the basis of a single proportion design. Based on the results on the sensitivity and accuracy of MRI with histopathology/culture from earlier publications, and assuming a confidence interval of 10%, confidence level of 95% and 20% allowable error, a sample size of 120 patients for each group was obtained.

Subjects & selection method: The study population was drawn from consecutive diabetic patients with suspected diabetic foot syndrome who presented to the Department of Radiodiagnosis at Sree Uthradom Thirunal Academy of Medical Science (SUTAMS) from December 2021 to December 2023 till the targeted sample size was reached.

Inclusion criteria:

1. Diabetic patients with suspected diabetic foot syndrome (ie erythematous, swollen foot with acute pain) from history
2. Either sex
3. Aged between 50-75 years
4. Without any previous intervention or diagnostic work up

Exclusion criteria:

1. Foot pain / ulcers caused by trauma or other non-diabetic causes
2. Contraindications for MRI such as MRI incompatible implants / stents / pacemakers / foreign body and claustrophobic patients were exempted.
3. Patients with chronic kidney disease (CKD) or with eGFR (Glomerular Filtration Rate) <35mL/min/1.73m² were also excluded for fear of Gadolinium induced Nephrogenic Systemic Fibrosis (NSF).

Procedure methodology

An informed consent was obtained from all participants after explaining the procedure, scope of the study and its objectives along with their permission for any images presented.

Image acquisition-

Images were acquired using Siemens Magnetom Sempra 1.5 T (1.5 Tesla) MRI machine. Small field of view (FOV), thin sections were obtained with the patient lying supine and foot positioned in extremity coil in neutral position. Gadodiamide (Omniscan) was used as contrast at a dose of 0.1mmol/kg. Images acquisition technique are elaborated in Table 1.

Table no 1: Shows Sequences used in MRI.

SEQUENCE	TR	TE	FOV	ST
T1 AXIAL	614	11	274	3
T1 SAGITTAL	624	12	200	3
STIR AXIAL	4925	50	274	3
STIR SAGITTAL	3500	22	200	3
STIR CORONAL	3000	33	160	3
T2 SAGITTAL	4350	88	200	3
GAD T1+C	614	11	251	3

TR: Repetition time; TE: Time of echo; FOV: Field of view; ST: Slice Thickness ;STIR: Short tau inversion recovery; GAD: Gadolinium;

Image interpretation -

To declutter the study, only the “Ghost sign” was applied in the MRI interpretation ie whether the same was present or absent.

Statistical analysis

Data was analyzed using International Business Machines (IBM) Statistical Package for the Social Sciences SPSS version 20 (SPSS Inc., Chicago, IL). Student's *t*-test was used to ascertain the significance of differences between mean values of two continuous variables. Chi-square and Fisher exact tests were performed to test for differences in proportions of categorical variables between two groups. The level $P < 0.05$ was considered as the cutoff value or significance. MRI findings were later correlated with histopathology / culture reports.

IV. Result

120 consecutive patients who satisfied the inclusion criteria were included in the study. Out of the 120 patients, 70 patients (58%) showed Ghost sign (osteomyelitis) and 50 patients (41%) did not show Ghost sign (Charcot’s cases). Among these patients MRI using Ghost sign (Figure I) could rightly diagnose osteomyelitis in 65 out of 70 (93%) proven cases of osteomyelitis and Charcot’s in all 50 patients (100%) of Charcot’s as shown in Table 2.

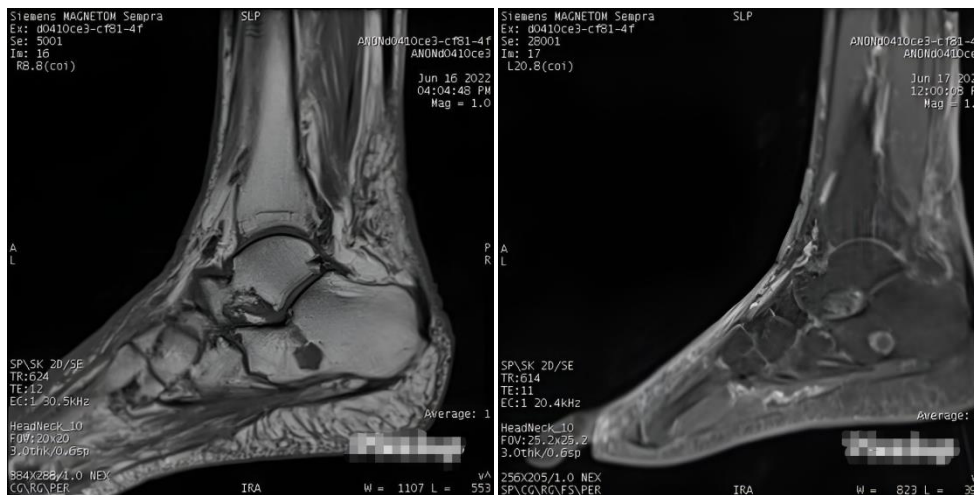


Fig 1a

Fig 1b

Figure 1a - T1 weighted sagittal image of the foot where parts of talus, navicular and cuneiform bones are missing. Figure 1b - T1+Contrast sagittal image where the missing bone parts become visible. A case from our study illustrating the “Ghost Sign” in a case of diabetic foot with clinically suspected OM.

Table no 2 : shows “Ghost sign “in Diabetic foot MRI

Diagnosis	Yes, n (%)	No, n(%)	p-value
Charcots Neuropathy	0 (0%)	50(100%)	P<0.001
Osteomyelitis	65 (93%)	5(7%)	

Fisher’s-exact test; p-value <0.05 is statistically significant

V. Discussion

Review of past literature related to our study showed huge gaps in relevant data pertaining to Charcot neuropathy and Osteomyelitis in diabetic foot and MRI Ghost sign which we intend to fill with this study of ours.

A study by Rosskopf et.al in 2019 [2] showed multiparametric MRI findings in charcot and osteomyelitis joints but there was no word on Ghost sign and the study was not conducted on diabetic foot. There was no mention on number of cases included in the study, while our study was based in applying MRI Ghost sign to differentiate between CN versus OM in diabetic foot with pur study being conducted on 120 subjects in a post graduate medical college.

Another study conducted by Martin Noguerolet al [4] for differentiating neuropathic arthropathy from Osteomyelitis in diabetic foot was using advanced MRI techniques like DWI, MRA etc, targeting more at functional aspects and to determine differences between vascularization patterns and extent of the disease rather than in differentiating between the two entities which is the crux of our study and the nub of the clinical dilemma the world presently face in differentiating Charcots and Osteomyelitis in a diabetic foot.

Our study has thus piloted the use of Ghost sign in Diabetic foot - a simple, cost-effective, less time consuming unparametric study that improves radiology departmental throughput, patient compliance without compromise on study accuracy. The precise differentiation and early diagnosis of osteomyelitis and Charcot’s neuroarthropathy in a patient with painful Diabetic foot is considered as a holy grail in radiology and clinical orthopaedics/surgery and medicine. Our study has shown that using the Ghost sign in MRI, we are able to reliably distinguish between the two, thereby enhancing patient care and ensuring better treatment outcome. The use of multiparametric imaging findings as seen in available literature on the topic only leads to cluttering and indecisive radiological reports and thereby result in poor clinical confidence, we say the diligent application of Ghost sign of MRI puts an end to all this confusion.

The only limitation of the study are the inherent contraindications of MRI and those diabetics with low e-GFR who could not be taken up for CE-MRI.

VI. Conclusion

MRI Ghost sign in diabetic foot MRI is a reliable diagnostic tool in detecting osteomyelitis in diabetic foot with acute symptoms, thereby excluding the close imaging and clinical differential diagnosis of Charcot’s neuroarthropathy. The high sensitivity and specificity of the MRI Ghost sign alleviates this imaging and clinical dilemma of OM versus CN, thereby enabling early precise diagnosis and in turn better patient management and treatment outcome.

References

- [1]. Elafros Ma, Andersen H, Bennett DI, Savelieff Mg, Viswanathan V, Callaghan Bc Et Al Towards Prevention Of Diabetic Peripheral Neuropathy: Clinical Presentation, Pathogenesis, And New Treatments. *The Lancet Neurology*. 2022 Oct 1;21(10):922-36.
- [2]. Rosskopf Ab, Loupatatzis C, Pfirmann Cw, Böni T, Berli Mc. The Charcot Foot: A Pictorial Review. *Insights Into Imaging*. 2019 Dec;10(1):1-3.
- [3]. Lázaro Martínez JI, García Álvarez Y, Tardáguila-García A, García Morales E. Optimal Management Of Diabetic Foot Osteomyelitis: Challenges And Solutions. *Diabetes, Metabolic Syndrome And Obesity: Targets And Therapy*. 2019 Jun 21:947-59.
- [4]. Martín Noguerolet T, Luna Alcalá A, Beltrán Ls, Gómez Cabrera M, Broncano Cabrero J, Vilanova Jc. Advanced Mr Imaging Techniques For Differentiation Of Neuropathic Arthropathy And Osteomyelitis In The Diabetic Foot. *Radiographics*. 2017 Jul;37(4):1161-80.
- [5]. Enderle Md, Coerper S, Schweizer Hp, Kopp Ae, Thelen Mh, Meisner C, Et Al. Correlation Of Imaging Techniques To Histopathology In Patients With Diabetic Foot Syndrome And Clinical Suspicion Of Chronic Osteomyelitis. *The Role Of High-Resolution Ultrasound*. *Diabetes Care*. 1999 Feb 1;22(2):294-9.
- [6]. Zampa V, Bargellini I, Rizzo L, Turini F, Ortori S, Piaggese A, Bartolozzi C. Role Of Dynamic Mri In The Follow-Up Of Acute Charcot Foot In Patients With Diabetes Mellitus. *Skeletal Radiology*. 2011 Aug;40:991-9.
- [7]. Donovan A, Schweitzer Me. Use Of Mr Imaging In Diagnosing Diabetes-Related Pedal Osteomyelitis. *Radiographics*. 2010 May;30(3):723-36