



ISSN (P): 2521-3466  
 ISSN (E): 2521-3474  
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 www.orthoresearchjournal.com  
 2019; 3(4): 08-15  
 Received: 06-08-2019  
 Accepted: 10-09-2019

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## Distribution and analysis of Charcot foot in diabetes through Amit Jain's extended "SCC" classification

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DOI: <https://doi.org/10.33545/orthor.2019.v3.i4a.173>

#### Abstract

**Objective:** To analyze and distribute the Charcot foot in diabetes through the new Amit Jain's classification for Charcot foot (E "SCC") and to predict outcomes associated with this new classification.

**Materials and Methods:** A descriptive retrospective analysis was conducted at 2 different centers in Bengaluru city, India. The study period was for 2 years. An IEC clearance was obtained prior to the study. Statistical analysis was done using SPSS 22 and R environment Ver.3.2.2.

**Results:** A total of 16 patients were studied who fulfilled inclusion criteria. Majority were males accounting for 68.85% of the cases. 31.3% had acute Charcot foot. Majority of the patients were in type 1 Charcot foot. Midfoot was most commonly involved with pattern III being most common affecting 75% of the patients. Major amputation occurred in 12.5% of the cases and osteomyelitis was significantly associated with major amputation (P=0.008). TCC and Removable cast walker were significantly used in acute Charcot foot.

**Conclusion:** In this validation study, it is seen that majority of the Charcot foot in clinical practice were of simple type and surgeries were done in type 3 Charcot foot. All the major amputation occurred in type 3 Charcot foot and osteomyelitis had significant association with amputation. There was no mortality in this study. Amit Jain's classification for Charcot foot is a simple, practical, easy to remember focal classification that guides therapy, serves a good teaching and communicative tool.

**Keywords:** Diabetes, charcot, amit jain, ulcer, amputation, classification, foot

#### Introduction

Charcot foot, which is also known as Charcot neuropathic arthropathy, is a progressive, inflammatory, noninfectious, destructive disease that affects foot and ankle. [1, 2, 3] This condition can result in fractures, subluxation, dislocation, deformities and can result in limb loss [1, 3, 4, 5].

This condition was first described by Jean Martin Charcot in 1868 in case of tabes dorsalis and in the year 1936, William Riley Jordan noticed its association with diabetes [2, 5, 6].

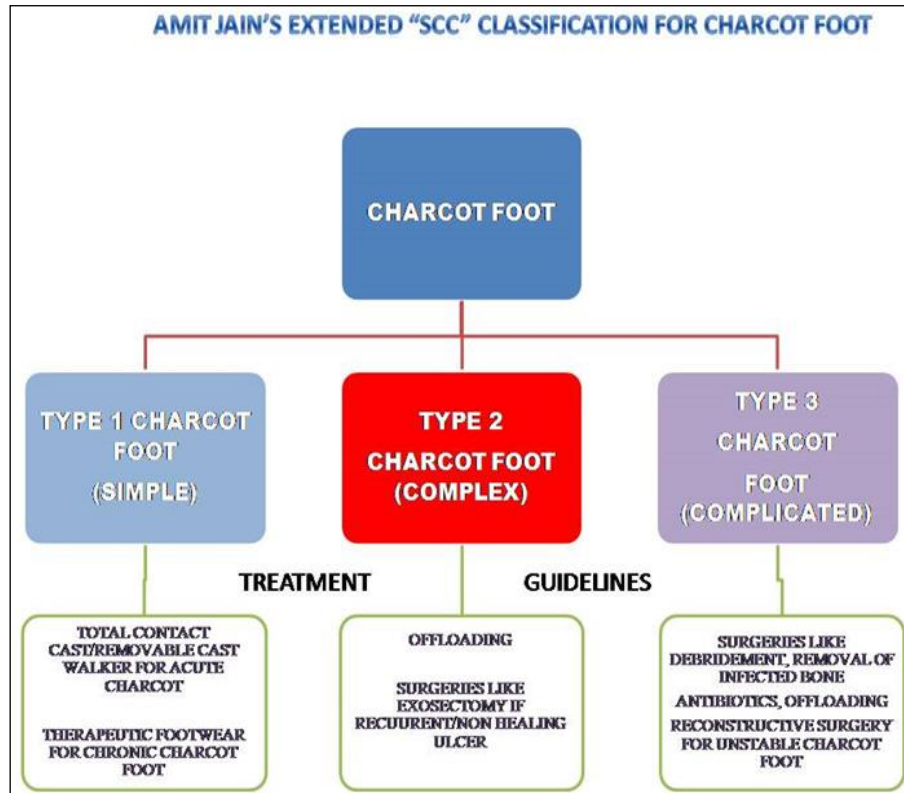
There are various different classifications for Charcot foot based on radiological features, Clinical, anatomical involvement, etc. [2, 6, 7, 8] Some of the well-known Charcot foot classifications are Eichenholtz, Dounis, Roger's- Bevilacqua, Sander's- Frykberg's, Sella-Barrette classification, etc [2, 6, 7, 8, 9]. All of these novel classifications have their own different merits and are used in different parts of the world.

Amit Jain's classification for Charcot foot is a newly proposed classification for Charcot foot (Table 1) which is an extension of "SCC" classification concept that was first proposed for diabetic foot ulcer in 2014 [8, 10, 11]. This concept of "Simple, Complex, Complicated" classification system was later extended to Amit Jain's classification for diabetic foot classifications, offloading, callosity, therapeutic foot wear, toe deformities, foot amputations and Charcot foot [8, 12, 13, 14].

The e "SCC" classification concept is a component of Amit Jain's system of practice which is a modern diabetic foot surgery concept that was developed by the primary author [8, 15]. The objective of this present study was to analyze the Amit Jain's extended "SCC" classification for Charcot foot [Figure 1] and describe the results and outcomes associated with this new classification.

**Table 1:** Showing the Amit Jain's e"SCC classification for Charcot foot

Type of Charcot foot	Description	Clinical characteristics	Treatment guidelines
Type 1 Charcot foot	Simple Charcot foot	Charcot foot without ulcer [acute/chronic]	TCC/RCW → Acute Charcot foot , Modified footwear → Chronic Charcot foot
Type 2 Charcot foot	Complex Charcot foot	Charcot foot with ulcer	Offloading, Standard wound care, Surgery like Exostectomy if recurrent ulcer
Type 3 Charcot foot	Complicated Charcot foot	Charcot foot with infection or instability	Surgery like debridement, removal of infected bone, antibiotics, Reconstructive surgery for unstable Charcot foot, Offloading, Standard wound care

**Fig 1:** Showing the Amit Jain's classification for Charcot foot

## Materials and Methods

A descriptive retrospective analysis was carried out at 2 center's namely Amit Jain's Institute of Diabetic Foot and Wound Care, Brindhavvan Areion hospital and at Department of Surgery of Rajarajeswari medical college, Bengaluru, India. The study period was from May 2017 to April 2019. The charts and records were reviewed to obtain demographic profile, radiological features and surgeries done. The following were inclusion and exclusion criteria.

### Inclusion criteria

1. All patients who were treated for Charcot foot in Diabetes

### Exclusion criteria

1. Non-diabetics with Charcot foot
2. Patients admitted in other departments
3. Patients who refused treatment
4. Patients with insufficient data

IEC approval was obtained for this study from Rajarajeswari medical college ethics committee [RRMCH-IEC/43/2018-19]

### Statistical analysis [16, 17, 18, 19]

Data was analyzed using statistical software SPSS 22 and R environment Ver. 3.2.2. Microsoft word and excel were used for general graphs and tables. Both descriptive and inferential statistical analysis was carried out in this study. Results on

continuous measurements are presented on Mean SD (Min-Max) and results on categorical measurements are presented in number (%). Significance is assessed at 5% level of significance. The assumptions made on data are that the dependent variables should be normally distributed, samples drawn from the population should be random and cases of the samples should be independent. Student t test (two tailed, independent) has been used to find the significance of study parameters on continuous scale between two groups (Inter group analysis) on metric parameters. Leven's test for homogeneity of variance has been performed to assess the homogeneity of variance. Chi-square/ Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups, Non-parametric setting for Qualitative data analysis. Fisher exact test was used when samples were very small.

### Significant figures

1. Suggestive significance (P value:  $0.05 < P < 0.10$ )
2. Moderately significant (P value:  $0.01 < P < 0.05$ )
3. Strongly significant (P value:  $P \leq 0.01$ ).

### Results

The demographic features are presented in table 2. During this study period, 16 patients were included [11 males and 5 females (Figure 2) with mean age of  $57.31 \pm 9.88$  years, the mean duration of diabetes mellitus being  $15.16 \pm 7.61$  years]. Left foot was most commonly involved (43.8%). The prevalence of

hypertension was 75%, chronic kidney disease was 12.5% and ischemic heart disease was 18.8%. 31.3% had acute Charcot foot. 68.8% had single Joint involvement on radiographs (Figure 3) with pattern 3 of Charcot being commonest anatomic pattern (Sander's- Frykberg's classification) affecting 75% of the cases (Figure 4). Majority of the patients in this study had Amit Jain's

type 1 Charcot foot (50%). 37.5% had some form of infection in Charcot foot thereby complicating the Charcot foot and leading to surgeries. 12.5% had underlying osteomyelitis and equal percentage resulted in major amputation. 81.3% were on some offloading (Table 2).

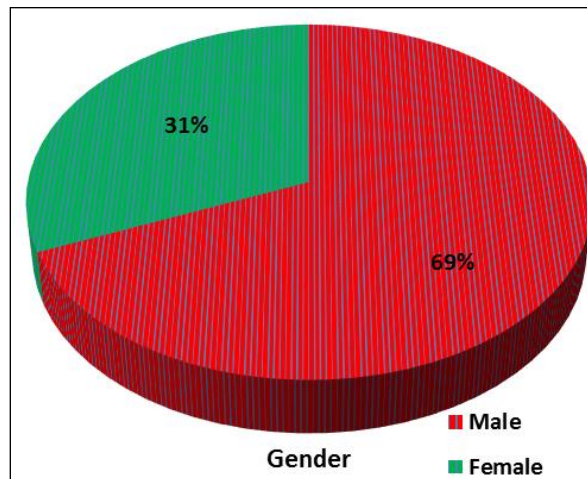


Fig 2: showing gender distribution

Table 2: showing demographic and characteristic profile

Characteristics	Number	Percentage
Age	57.31±9.88	
<b>Gender</b>		
Male	11	68.8
Female	5	31.3
<b>Diabetes duration (Years)</b>		
< 10	2	12.5
10-20	13	81.3
>20	1	6.3
<b>Hypertension</b>		
Yes	12	75
No	4	25
<b>Side of the foot</b>		
Right	5	31.3
Left	7	43.8
Bilateral	4	25
<b>X ray pattern of Charcot foot</b>		
Single	11	68.8
Mixed	5	31.3
<b>Anatomical pattern of Charcot foot</b>		
Pattern I	0	0
Pattern II	3	18.8
Pattern III	12	75
Pattern IV	1	6.3
Pattern V	0	0
<b>Amit Jain's type of Charcot foot</b>		
Type 1 (Simple)	8	50
Type 2 (Complex)	2	12.5
Type 3 (Complicated)	6	37.5
<b>Major Amputation</b>		
Yes	2	12.5
No	14	87.5
<b>Osteomyelitis</b>		
Present	2	12.5
Absent	14	87.5
<b>Types of Offloading</b>		
Total contact cast (TCC)	2	12.5
Removable Cast Walker (RCW)	3	18.8
Footwears	4	25
Amit Jain's Offloading	4	25

No Offloading	3	18.8
<b>Clinical type of Charcot</b>		
Acute	5	31.3
Chronic	11	68.8
<b>Surgery Done</b>		
Yes	6	37.5
No	10	62.5
<b>Resurgeries Done</b>		
Yes	2	12.5
No	14	87.5
<b>Chronic kidney disease</b>		
Yes	2	12.5
No	14	87.5
<b>Ischemic Heart disease</b>		
Yes	3	18.8
No	13	81.3

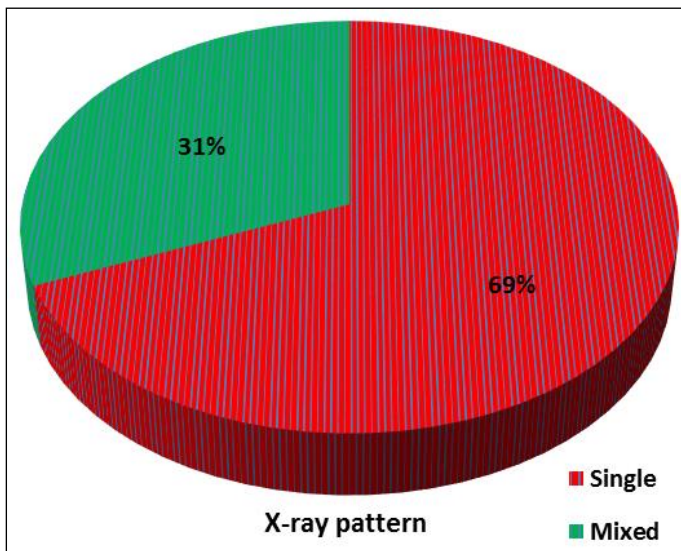


Fig 3: showing X-ray pattern distribution

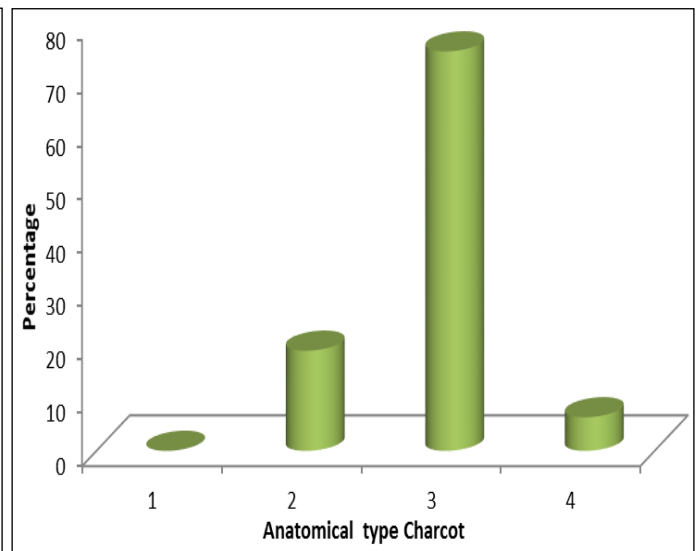


Fig 4: showing the anatomical pattern of Charcot foot

No association was noted between age, gender, diabetes duration, hypertension, side of foot, x-ray pattern, anatomical pattern, osteomyelitis or major amputation with Amit Jain’s type of Charcot foot (Table 3). Significant association was seen with type of offloading used (P-0.003), clinical type of Charcot foot (P-0.038) and surgery done (P<0.001) with Amit Jain’s type of

Charcot foot. Removable cast walker (RCW) and therapeutic footwear was most commonly used offloading method in type 1 Charcot foot [Simple] whereas Amit Jain’s offloading system was most commonly used offloading in type 3 Charcot foot (P-0.003). All the type 3 Charcot foot were chronic Charcot foot and surgeries were done only in type 3 Charcot foot (Figure 5).

Table 3: showing Association of clinical variables in relation to Amit Jain’s (AJ) Classification for Charcot foot

Variables	AJ Type of Charcot foot			Total (n=16)	P value
	Simple (n=8)	Complex (n=2)	Complicated (n=6)		
<b>Age in years</b>					
41-50	3 (37.5%)	1 (50%)	2 (33.3%)	6 (37.5%)	0.880
51-60	3 (37.5%)	0 (0%)	3 (50%)	6 (37.5%)	
61-70	1 (12.5%)	0 (0%)	0 (0%)	1 (6.3%)	
71-80	1 (12.5%)	1 (50%)	1 (16.7%)	3 (18.8%)	
<b>Gender</b>					
Male	5 (62.5%)	1 (50%)	5 (83.3%)	11 (68.8%)	0.615
Female	3 (37.5%)	1 (50%)	1 (16.7%)	5 (31.3%)	
<b>Diabetes Duration</b>					
<10	1 (12.5%)	0 (0%)	1 (16.7%)	2 (12.5%)	0.319
10-20	7 (87.5%)	1 (50%)	5 (83.3%)	13 (81.3%)	
>20	0 (0%)	1 (50%)	0 (0%)	1 (6.3%)	
<b>Hypertension</b>					
Yes	6 (75%)	2 (100%)	4 (66.7%)	12 (75%)	1.000
No	2 (25%)	0 (0%)	2 (33.3%)	4 (25%)	
<b>Side of Foot</b>					
Right	3 (37.5%)	1 (50%)	1 (16.7%)	5 (31.3%)	0.107
Left	5 (62.5%)	0 (0%)	2 (33.3%)	7 (43.8%)	

Bilateral	0 (0%)	1 (50%)	3 (50%)	4 (25%)	
<b>X-ray pattern</b>					
Single	6 (75%)	2 (100%)	3 (50%)	11 (68.8%)	0.462
Mixed	2 (25%)	0 (0%)	3 (50%)	5 (31.3%)	
<b>Anatomical pattern of Charcot foot</b>					
Pattern I	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0.407
Pattern II	2 (25%)	0 (0%)	1 (16.7%)	3 (18.8%)	
Pattern III	6 (75%)	1 (50%)	5 (83.3%)	12 (75%)	
Pattern IV	0 (0%)	1 (50%)	0 (0%)	1 (6.3%)	
Pattern V	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
<b>Major Amputation</b>					
Yes	0 (0%)	0 (0%)	2 (33.3%)	2 (12.5%)	0.233
No	8 (100%)	2 (100%)	4 (66.7%)	14 (87.5%)	
<b>Osteomyelitis</b>					
Yes	0 (0%)	0 (0%)	2 (33.3%)	2 (12.5%)	0.233
No	8 (100%)	2 (100%)	4 (66.7%)	14 (87.5%)	
<b>Types of offloading</b>					
TCC	2 (25%)	0 (0%)	0 (0%)	2 (12.5%)	0.003**
RCW	3 (37.5%)	0 (0%)	0 (0%)	3 (18.8%)	
Footwear	3 (37.5%)	1 (50%)	0 (0%)	4 (25%)	
Amit Jain's offloading	0 (0%)	1 (50%)	3 (50%)	4 (25%)	
None	0 (0%)	0 (0%)	3 (50%)	3 (18.8%)	
<b>Clinical type of Charcot</b>					
Acute	5 (62.5%)	0 (0%)	0 (0%)	5 (31.3%)	0.038+
Chronic	3 (37.5%)	2 (100%)	6 (100%)	11 (68.8%)	
<b>Surgery done</b>					
Yes	0 (0%)	0 (0%)	6 (100%)	6 (37.5%)	<0.001**
No	8 (100%)	2 (100%)	0 (0%)	10 (62.5%)	
<b>Resurgeries</b>					
Yes	0 (0%)	0 (0%)	2 (33.3%)	2 (12.5%)	0.233
No	8 (100%)	2 (100%)	4 (66.7%)	14 (87.5%)	

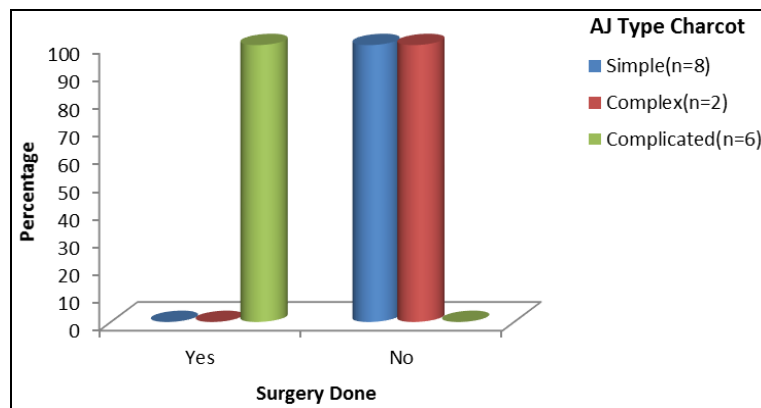


Fig 5: showing distribution of surgeries done according to type of Charcot foot

Major amputation occurred in type 3 Charcot foot and it had significant association (P-0.008) with osteomyelitis (Table 4).

Table 4: showing association of variables of interest in relation to Major Amputation

Variables of interest	Major Amputation		Total (n=16)	P value
	Yes (n=2)	No (n=14)		
<b>Anatomical type of Charcot</b>				
Pattern I	0 (0%)	0 (0%)	0 (0%)	1.000
Pattern II	0 (0%)	3 (21.4%)	3 (18.8%)	
Pattern III	2 (100%)	10 (71.4%)	12 (75%)	
Pattern IV	0 (0%)	1 (7.1%)	1 (6.3%)	
Pattern V	0 (0%)	0 (0%)	0 (0%)	
<b>Osteomyelitis</b>				
Yes	2 (100%)	0 (0%)	2 (12.5%)	0.008**
No	0 (0%)	14 (100%)	14 (87.5%)	
<b>Chronic kidney disease</b>				
Yes	0 (0%)	2 (14.3%)	2 (12.5%)	1.000
No	2 (100%)	12 (85.7%)	14 (87.5%)	
<b>Ischemic heart disease</b>				
Yes	0 (0%)	3 (21.4%)	3 (18.8%)	1.000

No	2 (100%)	11 (78.6%)	13 (81.3%)	
<b>Resurgeries</b>				
Yes	1 (50%)	1 (7.1%)	2 (12.5%)	0.242
No	1 (50%)	13 (92.9%)	14 (87.5%)	
<b>Clinical type of Charcot</b>				
Acute	0 (0%)	5 (35.7%)	5 (31.3%)	1.000
Chronic	2 (100%)	9 (64.3%)	11 (68.8%)	
<b>X-Ray Pattern</b>				
Single	1 (50%)	10 (71.4%)	11 (68.8%)	1.000
Mixed	1 (50%)	4 (28.6%)	5 (31.3%)	

Significant association was also seen between anatomical type of Charcot foot and x ray pattern (P=0.018) wherein 90.9% of pattern 3 Charcot had single joint involvement (Table 5). Significant association was seen between type of offloading used and clinical type of Charcot foot (P<0.001) and surgery (P=0.007). Removable cast walker and total contact cast was significantly used in acute Charcot foot whereas therapeutic

footwear and Amit Jain's offloading system was commonly used in chronic Charcot foot. Amit Jain's offloading was frequently used in Charcot foot patients who underwent surgeries (Table 5). One patient had history of failed Charcot reconstruction in the past. There was no case of any peripheral arterial occlusive disease and there was no mortality in this study.

**Table 5:** showing association among different variables of interest

Variables of Interest	Osteomyelitis		Total (n=16)	P value	
	Yes (n=2)	No (n=14)			
<b>X-Ray Pattern</b>					
Single	1 (50%)	10 (71.4%)	11 (68.8%)	1.000	
Mixed	1 (50%)	4 (28.6%)	5 (31.3%)		
<b>Surgery Done</b>					
Yes	2 (100%)	4 (28.6%)	6 (37.5%)	0.125	
No	0 (0%)	10 (71.4%)	10 (62.5%)		
<b>Anatomical type of Charcot foot (Sander's- Frykberg's)</b>	<b>X-Ray pattern</b>			0.018*	
		<b>Single (n=11)</b>	<b>Mixed (n=5)</b>		
	Pattern I	0 (0%)	0 (0%)		0 (0%)
	Pattern II	0 (0%)	3 (60%)		3 (18.8%)
	Pattern III	10 (90.9%)	2 (40%)		12 (75%)
	Pattern IV	1 (9.1%)	0 (0%)		1 (6.3%)
Pattern V	0 (0%)	0 (0%)	0 (0%)		
<b>Types of offloading used</b>					
Total contact cast	1 (9.1%)	1 (20%)	2 (12.5%)	0.495	
Random cast walker	2 (18.2%)	1 (20%)	3 (18.8%)		
Footwear	4 (36.4%)	0 (0%)	4 (25%)		
Amit Jain's offloading	3 (27.3%)	1 (20%)	4 (25%)		
None	1 (9.1%)	2 (40%)	3 (18.8%)		
<b>Type of offloading used</b>	<b>Clinical type of Charcot</b>			0.001**	
		<b>Acute</b>	<b>Chronic</b>		
	Total Contact Cast	2 (40%)	0 (0%)		2 (12.5%)
	Removable cast walker	3 (60%)	0 (0%)		3 (18.8%)
	Footwear	0 (0%)	4 (36.4%)		4 (25%)
	Amit Jain's offloading	0 (0%)	4 (36.4%)		4 (25%)
None	0 (0%)	3 (27.3%)	3 (18.8%)		
<b>Type of offloading used</b>	<b>Surgery Done</b>			0.007**	
		<b>Yes</b>	<b>No</b>		
	Total Contact Cast (TCC)	0 (0%)	2 (20%)		2 (12.5%)
	Removable cast walker (RCW)	0 (0%)	3 (30%)		3 (18.8%)
	Footwear	0 (0%)	4 (40%)		4 (25%)
	Amit Jain's offloading	3 (50%)	1 (10%)		4 (25%)
None	3 (50%)	0 (0%)	3 (18.8%)		

## Discussion

Charcot foot in diabetes is a rare condition with lifetime prevalence ranging from 0.1% to 10% [1]. It is invariably associated with peripheral neuropathy in diabetes [6, 20]. Although, there is no gender predilection in Charcot foot, there are studies where male gender was considered to be a risk factor for Charcot foot [21]. It is seen often that Charcot foot develops in diabetes usually after 10 years of duration [21]. The mean duration of diabetes in our study was 15.56 years.

Although Charcot foot is seen frequently in one-foot, bilateral presentation is also seen ranging from 9 to 75% in different studies [21, 22]. In Salini *et al.* study [21], bilateral involvement was seen in 18% whereas in our study around 25% had bilateral Charcot foot. In Thewjitcharoen *et al.* series [23], acute Charcot foot was seen in 33% and chronic Charcot was seen in 67%. In our study, 31.3% had acute and 68.8% had chronic Charcot foot (Figure 6).



**Fig 6:** Showing a chronic Charcot foot. This is Amit Jain's type 1 Charcot foot (Simple)

According to Sander-Frykberg's anatomical classification for Charcot foot, there are 5 different patterns of which commonest is pattern II (40%) followed by pattern III (30%) [6]. Even in Thewjitcharoen *et al* series [23], pattern II was commonest seen in 50% of cases followed by pattern III (27.5%). In our study, 75% of the cases had pattern III and only 18.8% had pattern II. In Varma *et al.* study [21], 38% of the cases had single joint involvement radiologic ally. In our study, 68.8% had single joint involvement and 90.9% of the pattern III was significantly associated with single pattern involvement.

It is seen that ulcerations and infection are common in Charcot foot. As per Amit Jain's classification for Charcot foot, presence of ulcer renders a Charcot foot (Figure 7) as a complex Charcot foot (type 2) and once infection sets in, the Charcot foot becomes type 3 (complicated). Our study showed 37.5% of Charcot foot is of complicated type. Around 5% to 51% of the Charcot foot patients may require some form of surgery [22]. The surgical options are debridement, exostectomy, arthrodesis and amputation [22, 23]. There are evidence that <5% of the cases require major surgical correction although in some series it can be as high as 33% [23]. In Varma *et al.* series [22], around 9% of the cases of Charcot foot required reconstructive foot surgeries. In our series, none of the patients required any reconstructive surgeries although one patient had past history of failed reconstruction in acute Charcot foot. Studies have shown that presence of ulcer in Charcot foot increased risk of major amputation to more than 6 times compare to Charcot foot without ulcer [23]. Around 37.5% of the patients underwent surgeries in this series and all were done in type 3 Charcot foot (significant association).

There were 2 major amputations (12.5%) and they were done in type 3 Charcot foot (Complicated type). In Thewjitcharoen *et al.* series [23], 13% of patients had osteomyelitis in Charcot foot. Studies have shown that osteomyelitis is a major risk factor for amputation [7]. In our study, 12.5% had osteomyelitis and it was significantly associated with major amputation as osteomyelitis is seen in type 3 Charcot foot.



**Fig 7:** Showing Amit Jain's type 2 Charcot foot (Complex)

Offloading remains mainstay of treatment in Charcot foot [1]. In Thewjitcharoen *et al.* series [23], 85.7% of acute Charcot foot and 34.6% of chronic Charcot foot were on total contact cast. In our series, total contact cast (40%) and removable cast walker (60%) were used in acute Charcot foot and 36.4% of patients with chronic Charcot foot had Amit Jain's offloading system and foot wear as offloading modality. Amit Jain's offloading system was significantly used as deflective offloading [13] in our patients who underwent surgeries.

### Conclusion

Charcot foot is a destructive disease which is uncommon and frequently misdiagnosed. Majority of the cases in this study were on simple type (Type 1). Total contact cast and Removable cast walkers were most commonly used only in acute Charcot foot whereas Amit Jain's offloading system and Therapeutic footwear were commonly used in chronic Charcot foot especially in those patients who underwent surgery. All major amputations were done in type 3 Charcot foot and osteomyelitis was a significant contributing factor for major amputation as it renders Charcot foot to a complicated type (Type 3). None of the patients required reconstructive surgeries. Amit Jain's extended "SCC" classification for Charcot foot is a simple, practical, easy to remember, focal classification of Charcot foot. It can serve as an excellent teaching tool and also a good communicative tool. It also helps in categorizing Charcot foot and provides a good guide to treatment.

### Acknowledgement

Authors would like to thank Dr. K.P. Suresh, Scientist (Biostatistics), National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI), Bangalore, India, for reviewing the research methodology and statistical results of the study and the Institutional ethics committee of RRMCH for approving this study.

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