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Review Article

# Radiographic Evaluation of Charcot Foot Involving the Lateral Column

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**Abstract**

In the study of Charcot foot, the lateral column has been largely neglected in previous research. The purpose of the current study is to radiographically characterize the lateral column in Charcot midfoot collapse.

**Keywords:** Charcot; Lateral column; Radiology; Cuboid height

## Introduction

Charcot foot deformities are a difficult, malignant complication of peripheral neuropathy. Although "rocker bottom" feet were originally described in patients with syphilis [1], today's Charcot deformities are mostly due to diabetic neuropathy [2] combined with trauma to the foot.

Numerous surgical and non-surgical treatments are available, and should aim to reduce risk of complications or amputation in the future, and ideally, surgically create a plantigrade, biomechanically stable foot [3].

Outcomes without adequate treatment include diabetic ulcers, osteomyelitis, amputation, permanent disability, and lower patient quality of life. Literature review predicts five-year mortality rates after initial ulceration to be 40% [4], and any type of lower limb amputation five-year mortality to be 53-100 % [5].

In his 1966 book, Eichenholtz postulated that the reflex muscle spasm following a fracture, without reduction, would cause angulations and/or overriding of the bones involved, leading to misunion in the healing process [6]. Literature has proposed that Charcot is a result of demineralized bone and weakened ligaments [7]. Grant and colleagues showed that patients with midfoot dislocations had near normal central bone density, and increased regional bone density. They concluded that the midfoot dislocation "may signify an aberration of capsule/tendon, which is unable to withstand the bending moments of gait and thus resulting in dislocation" [8]. Furthermore, the authors of the current study hypothesize that midfoot Charcot deformity is characterized by ligamentous failure.

When considering a surgical Charcot reconstruction, the medial column has been well studied and emphasized, such as the relationship between the 1st metatarsal and talus, otherwise known as Meary's angle. This 0-degree angle is used to measure outcomes of numerous studies and surgical procedures. However, such characterization of the lateral column has not been as well studied in previous research. Previous research has shown that a positive correlation exists between cuboid height and calcaneal-fifth metatarsal angle [9]. Additionally, patients with Charcot neuropathy and ulcers exhibit significantly greater deformity in respects to calcaneal-fifth metatarsal angle and lateral column involvement than their non-ulcer counterparts [10]. Therefore, characterization of the "ideal" lateral column is imperative to significantly improving patient outcomes.

The aim of the current study is to radiographically characterize the lateral column in Charcot midfoot collapse.

## Methods

Patients were identified using ICD-10 codes through the DMU Foot and Ankle Clinic records (M14672 and M14671). Lateral radiographs were deidentified and presented to an experienced, third party podiatrist to measure. Angles of interest were Calcaneal Inclination Angle (CIA), Critical Angle of Gissane (CAG), Bohler's Angle (BA), and a Calcaneal-5$^{th}$ metatarsal bisection angle (C5$^{th}$). Additionally, the authors were interested in the distance that the cuboid falls below the horizontal line between the lowest aspect of the calcaneus and 5$^{th}$ metatarsal head, hereafter referred to as "Cuboid Height" (CH).

Furthermore, x-rays were visually inspected to determine lateral column involvement, cuboid plantarflexion, and forefoot subluxation over the tarsals. Radiographic angles and qualitative observations were then correlated with ulceration presence and location.

## Results

Six patients were excluded due to poor visualization, or too extensive of destruction to measure angles accurately, leaving 47 patients and 50 feet to be analyzed. 18 participants were female (38.3%) and 29 males (61.7%). Average age was 60.8 years old at the

**Table 1:** Ulceration locations.

| Location | Frequency |
|---|---|
| Lateral Plantar | 14 |
| Medial Plantar | 7 |
| Heel | 3 |
| Ankle | 3 |
| Central Midfoot | 1 |
| Central Forefoot | 3 |
| Dorsal Foot | 2 |
| Total Ulcers | 33 |
| Total Feet with Ulcerations | 31 |




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**Table 2:** Data Summary.

| | CAA (*) | | | MAA (*) | | | CIA (*) | | | C5th (*) | | | CAG (*) | | | BA (*) | | | CH (*) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range |
| All Patients | 16.9 | 12.91 | -21.4-48.2 | 14.5 | 10.26 | -6.0-34.8 | 9.2 | 8.27 | -10.3-26.1 | 10.3 | 10.28 | -15.3-30.4 | 128.4 | 24.41 | 97.9-180.0 | 36.3 | 16.86 | 21.2-129.7 | 0.5 | 7.57 | -13.9-15.5 |
| No Ulceration | 19.8 | 11.1 | 0.0-43.5 | 15.9 | 11.15 | -6.0-33.9 | 12.9 | 9.29 | -5.1-26.1 | 14.6 | 10.57 | -4.2-30.4 | 1332.5 | 28.92 | 97.8-159.8 | 36 | 10 | 27.8-65.5 | 4.6 | 7.19 | -5.2-15.5 |
| All Ulceration | 15.5 | 13.66 | -21.4-40.4 | 13.7 | 9.9 | -1.4-34.8 | 7.1 | 6.98 | -10.3-22.2 | 7.8 | 9.43 | -15.3-29.0 | 126.3 | 22.16 | 99.0-180.0 | 36.4 | 19.6 | 21.2-129.7 | -1.8 | 6.87 | -13.9-15.4 |
| Lateral Planter Ulcer | 10.7 | 14.3 | -21.4-40.4 | 17.2 | 11.75 | 0.9-34.8 | 5.7 | 5.37 | -10.3-12.1 | 3.5 | 8.02 | -15.3-13.7 | 132 | 20.5 | 99.0-180.0 | 33.3 | 5.19 | 25.3-41.7 | -5.7 | 4.8 | -13.9-2.9 |
| Medial Ulcer | 21.7 | 15.74 | 0.7-48.2 | 10.1 | 5.49 | 3.1-19.7 | 6 | 5.44 | -2.5-14.8 | 7.9 | 8.25 | -6.5-15.4 | 111.2 | 9.2 | 101.3-125.8 | 33.2 | 3.86 | 29.8-38.7 | -0.4 | 6.17 | -11.8-4.9 |
| Accepted Range | 0-5 | | | 0-15 | | | 18-21 | | | None^ | | | 120-145 | | | 25-40 | | | Positive^ | | |

*CAA: Cuboid Abduction Angle; MAA: Metatarsus Adductus Angle; CIA: Calcaneal Inclination Angle; C5th: Bisection of Calcaneus and 5th Metatarsal; CAG: Critical Angle of Gissane; BA: Bohler's Angle; CH: Cuboid Height Relative to Lowest Point of 5th Metatarsal Head and Calcaneus.
^No accepted range of normal previously described.

**Table 3:** P-values comparing.

| | CAA | MAA | CIA | C5th | CAG | BA | CH |
|---|---|---|---|---|---|---|---|
| Ulceration/No Ulcer | 0.16009 | 0.25279 | 0.00904 | 0.01392 | 0.23187 | 0.47062 | 0.00213 |
| Lateral/Medial Ulcer | 0.6757 | 0.07863 | 0.44632 | 0.13258 | 0.02413 | 0.48916 | 0.02602 |

CAA: Cuboid Abduction Angle; MAA: Metatarsus Adductus Angle; CIA: Calcaneal Inclination Angle; C5th: Bisection of Calcaneus and 5th Metatarsal; CAG: Critical Angle of Gissane; BA: Bohler's Angle; CH: Cuboid Height Relative to Lowest Point of 5th Metatarsal Head and Calcaneus); in patients with an ulceration and no ulceration, and ulcerations located medial or laterally.

**Table 4:** Radiographic Characteristics on Visual Inspection.

| | Lateral Column Involvement | | Cuboid Plantarflexion | | Forefoot Subluxation | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| All Feet | 27 | 54 | 28 | 56 | 17 | 34 |
| No Ulceration | 8 | 42.1 | 6 | 31.6 | 5 | 26.3 |
| All Feet with Ulcerations | 19 | 61.3 | 22 | 71 | 12 | 38.7 |
| Lateral Plantar Ulcer | 13 | 92.9 | 13 | 92.9 | 7 | 50 |
| Medial Plantar Ulcer | 2 | 28.6 | 3 | 42.9 | 1 | 14.3 |

time of data collection, with a range of 43-84 years old, and with four patients confirmed deceased at the time of the current study.

Radiographically, the lateral column was involved in 27/50 feet (54%), cuboid plantarflexion was seen in 28/50 (56%), and forefoot subluxation in 17/50 feet (34%).

Of the 50 feet analyzed, ulcerations occurred in 31 feet (62%), with two feet studied having multiple ulcerations, further described in Table 1. Mean, standard deviation, and range of the measurements previously described are outlined in Table 2 for all patients, those with or without ulceration, lateral ulcerations, medial ulcerations, as well as a comparison to the previously described accepted normal ranges of these measurements.

When comparing Charcot feet with ulcerations versus no ulcerations, CIA, C5th, and CH were all statistically significantly different ($p<0.05$). With attention drawn towards ulceration location, comparing measurements in feet with laterally or medially located ulcerations, CAG and CH were all statistically significant ($p<0.05$) (Table 3).

## Discussion

Charcot feet with ulcerations had significantly different measurements in the sagittal plane, but failed to have significant differences in the transverse plane, or in angles associated with calcaneal fracture. This is consistent with previous research that has described sagittal plane deformity such as negative cuboid height as best predictors of Charcot ulceration [10].

When considering location of ulcerations, CH and CAG were the only statistically significant measurements that were different between medial and lateral ulcerations. CH was negative in all but two lateral ulcer feet (85.7%), with one foot having a positive CH of 2.9mm, and another being 0mm.

Logically this could predispose a patient to a lateral ulceration sub-cuboid prominence. Medial ulcerations had only 3 feet that had negative CH measurements (42.9%). This supports previous research by Hastings that Charcot deformities start medially and extend laterally with time [11].

As for CAG, average angle for lateral ulcerations (132.0°) was in the normal range of 120-145°, while the average for medial ulcerations fell below the normal range (111.2°). Additionally, only 6/14 (42.9%) lateral ulceration feet had a CAG outside of the accepted range, while only 1/7 (14.3%) medial ulceration feet had a normal CAG.

A novel consideration of the current study is the evaluation of lateral column involvement, cuboid plantarflexion, and forefoot

subluxation in clinical outcomes. All of the feet with lateral ulcerations (100%), and 33 feet overall (66%), had at least one of these clinical features (Table 4). Lateral column involvement and cuboid plantarflexion were highly prevalent in all groups. Highest incidence of all three qualitative measures was seen with lateral plantar ulcerations, with all but one foot having lateral column involvement and cuboid plantarflexion (92.9%), and half having forefoot subluxation so that the metatarsal were sitting on top of the tarsal bones (50.0%).

In a previous study by Bevan, the author also investigated the presence of ulceration with radiographic angles in 24 feet. However, in that study, ulcerations were only described as being at the midfoot, and the only statistically significant measurement was Talar-1$^{st}$ Metatarsal angle on a lateral radiograph [11].

The current study adds to previous, similar work by adding clinical manifestations of radiographic angles impact such as ulceration location, as well as further describing specific qualitative risk factors for ulcerations. By looking at these measures, clinicians can gauge a patient's risk of ulceration due to the position of the lateral column by inspecting CH, C5$^{th}$, and CIA, as well as lateral column changes, cuboid plantarflexion, and forefoot subluxation.

The current study has its limitations, such as being retrospective in nature, with a limited sample size at one institution. Many patients were referred to the clinic for exacerbations of Charcot foot, not initial treatment, so age of onset is unknown for each patient in the current study. Additionally, radiographs available for several patients had their limits, including many non-weight bearing images [12], previous internal fixation [1], and severe anatomic destruction from advanced disease [6]. However, these are all obstacles one will observe in practice with these cases. More research should be conducted at a higher level.

## Conclusion

CIA, C5$^{th}$, and CH changes increase a patient's risk for ulceration significantly, and merit attention by the physician when evaluating a Charcot foot case. Charcot is a complex deformity with high morbidity and mortality. Effective treatment has continued to perplex physicians. Risk of ulceration with Charcot is 65-83%, with 26% amputation [13,14]. Future research should be directed toward how to better treat Charcot involving the lateral column in limb salvage.

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