Rocker bottom foot in diabetic patients - a severe deformity of the diabetic Charcot´s joint with serious sequelae

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**Learning objectives**

We present information on the imaging of the rocker bottom foot in diabetic patients - a severe deformity of the diabetic Charcot’s joint in the Chopart’s and Lisfranc’s joints.

Its basic pathophysiology, distribution and morphology of the changes with respect to the classical Eichenholtz’ and new MRI classifications will be discussed. We shall further focus on the problem of the collapse of the longitudinal arch with prominence of tarsal bones into the plantar contour, causing abnormally increased pressure on soft tissues resulting in their ischemia, with the risk of development of skin ulcers and consequently phlegmon, potentially extending into septic arthritis and osteomyelitis.

**Background**

The musculoskeletal system - and specifically the foot - is one of the major regions, where changes caused by diabetes mellitus are often encountered, up to 18% in the musculoskeletal system [1] and ranging from 0.8 % to 8% in the foot [2], causing severe impairment of the quality of patients’ lives. This condition, known as the Charcot’s joint arthropathy, is being explained by the most acknowledged theory as a combination of peripheral sensitive neuropathy leading to repeated microtraumas and autonomic neuropathy leading to local hyperemia, soft tissue swelling and osteoporosis [3,4]. The frequent minor traumas due to impaired proprioception may become (together with surgery or local inflammation) the triggers of an acute uncontrolled inflammation mediated by proinflammatory cytokines, several nuclear factors and osteoclasts. These lead to continual local osteolysis and joint destruction. At first mild, later severe dislocations of tarsal bones can be encountered, with a progressive collapse of the plantar arch, resulting in a chronic deformity of the foot, characterized by the typical plantar (usually medioplantar) prominence - the rocker bottom foot. The concave plantar surface then leads to an abnormally increased pressure and ischemia of the plantar soft tissues with the development of skin ulcers and consequently phlegmon, with potential extension into septic arthritis and osteomyelitis. The malalignment is further worsened by shortening of the Achilles tendon due to glycosylation of collagen, by inflammatory infiltration of ligaments and by impaired renal functions [2]. The Charcot’s joint of the foot complicated by soft tissue changes is called by the clinicians the "diabetic foot". The foot of the patient is markedly swollen, deformed, often erythematous, but associated with only mild to moderate pain or discomfort.
Imaging findings OR Procedure Details

Plain radiography is of low sensitivity in the initial stages but might be used by the orthopedic surgeons in later stages for preoperative planning. In those cases dorsoplantar and lateral weight-bearing radiographs are recommended for measurement of the talus - first metatarsal angle, the lateral calcaneus - fifth metatarsal angle and the calcaneal inclination angle (Fig.1).

The tarsal skeletal and joint changes in diabetes progressing from initial to severe can be well displayed by CT and MRI. At first short subcortical fractures and subtle subluxations are revealed by CT (Fig.2) accompanied by soft tissue edema and joint fluid revealed by MRI (Fig.3). With the ongoing disease, the microfractures and subluxations become visible in MRI as well (Fig.4). The findings in both methods progress to transosseous fractures, erosions and subluxations (Fig.5), which in turn progress to widespread coalescent erosions and destructions, leading to severe dislocations of the tarsal bones (Fig.6), associated in the acute phase with joint fluid and edema of the bones, joints and periarticular soft tissues (Fig.7). The malalignment takes place typically in the Chopart’s and Lisfranc’s joints, most commonly with medial and plantar dislocation of the navicular bone, the cuboid bone and cuneiforme bones, forming thus a plantar prominence - the fully developed "rocker bottom foot" (Fig. 8). This can be accompanied by other skeletal findings, such as pencil formed osteolysis of the tarsal bones (Fig.9), fragmentation of the metatarsal heads, periostitis, osteophytes, (subchondral) osteosclerosis or neuropathic arthropathy in the talocrural joint. The bizarre calcifications, which had been considered pathognommonic for Charcot’s joint in the pre-CT and pre-MRI era, appear only in very late stages (Fig.10) and are extremely difficult to display on MRI.

Based on the progressing musculoskeletal changes 2 classification systems have been introduced till now - the older Eichenholtz’ classification and the recent MRI classification [5]. The traditional Eichenholtz´ classification (1966) divides the disintegration and following reparatory process into 3 stages: Stage I.: Development and fragmentation, Stage II.: Coalescence (represented by osteosclerotic processes with fragment ankylosis and bone debris absorption) and Stage III: Reconstruction and consolidation (represented by bone remodeling and decrease of inflammatory changes, but with possible ulceration appearance due to bony prominences). The recently developed classification based on MRI findings is becoming more and more appreciated, due to the combination of morphological and inflammatory activity assessment: It describes the findings by Grades (0/1) and Stages (A/B) in 4 possible combinations: A0: Microfractures and MRI edema with a normal radiograph, A1: Macrofractures in radiography and MRI, skeletal deformities, MRI edema, B0: Microfractures without MRI edema and B1: Macrofractures and skeletal deformities without MRI edema [5].
The rocker bottom foot can be an A1 or B1 stage. The crucial feature is the plantar bony prominence adjacent to the Chopart’s joint, with the dislocation of the navicular bone being the most common. The bone might be impinged in between the talus and the cuneiforme bones, or might be totally expelled into the planta, very often rotated. The talus then articulates with the cuneiforme bones (Fig.8). Less frequently the dislocation of one of the cuneiforme bones or the cuboid bone in the Lisfranc´s joint can be encountered (Fig.6a). The skeletal and soft tissue hyperintensity in the T2 weighted sequences of MRI can be both reactive and caused by septic inflammatory infiltration and the two conditions are difficult to distinguish if not associated with morphologic inflammatory changes such as periostitis, osteosclerosis and bone destruction. The larger the hyperintense zone, the more likely it is inflammatory. The skin ulceration adjacent to the hyperintensity, which is one of the most important clinical complications, is a reliable indicator of soft tissue septic inflammation - phlegmon. The localization of the ulcer on the convexity of the rocker bottom plantar surface of the foot is typical (Fig.11) and is the sequelae of the aforementioned increased pressure and ischemia of soft tissues. The development of septic arthritis and osteomyelitis can be more specifically identified on repeated radiographs, unfortunately with a delay of approximately 3 weeks (Fig.12). MRI with contrast medium administration cannot distinguish the reactive hyperemia and septic inflammation in all cases, but will delineate necrotic fragments of bone and soft tissue abscesses as defects in opacification lined by a hyperemic border (Fig.13).

Images for this section:
Fig. 1: Preoperative planning on plain radiography of the foot. a: AP radiography of the foot with the talus-1st metatarsal angle displayed. b: Lateral radiography of the foot with the lateral talus - 1st metatarsal angle (2), the calcaneus-5th metatarsal angle (3) and the calcaneal inclination angle (3) displayed.
Fig. 2: Early skeletal changes in the Charcot’s foot in CT a: Short subcortical fracture of the dome of the talus (#) b: Short subcortical fracture of the sustentaculum tali of the calcaneus (#) and asymmetrical widening of the joint space of the dorsal talocalcaneal joint (#).
Fig. 3: Early soft tissue changes in the Charcot´s foot in MRI (T2 weighted with fat saturation, transverse). a: Joint fluid (#) in the tarsal joints. b: Edema (*) of the periarticular plantar soft tissues.
Fig. 4: Early skeletal changes in the Charcot’s foot in MRI (T2 weighted with fat saturation, coronal). a: Initial subluxation in the posterior talocalcaneal joint (#) together with soft tissue edema (*). b: Subchondral fracture of the 2nd cuneiforme bone (#).
**Fig. 5:** Moderate skeletal changes in the Charcot’s foot in MRI (T2 weighted with fat saturation). a: sagittal: Large erosions (#) in the posterior talocalcaneal joint. b: coronal: Vertical fracture (#) of the dome of the talus with slight subluxation.
**Fig. 6:** Severe dislocation of the tarsal bones in the Charcot’s foot.  

a: MRI dess 3D sagital: Locked dislocation of the Lisfranc’s joint between the cuboid bone and the 4th metatarsal bone.  
b,c: CT transverse image: Marked erosions and disorganization of the tarsal bones.
Fig. 7: Skeletal changes accompanied by marked inflammation in the Charcot’s foot in MRI. a: coronal T2 weighted with fat saturation: Transosseous fractures of the cuneiforme bones (#) and severe edema of the soft tissues due to acute inflammatory response (**). b: sagital dess 3D: Ventral subluxation of the talus (#), joint fluid in the TC joint and calcaneonavicular joint (*) and marked edema of the articulating bones (**).
Fig. 8: Typical medial and plantar dislocation of tarsal bones causing the Charcot’s rocker bottom foot. a,b: MRI dess 3D sagital (a) and transverse reconstruction (b): The navicular bone (*) is dislocated medially and plantarly leaving the talus to articulate with the cuneiforme bones. Edema of the soft tissues and 1st cuneiforme bone. c: CT sagital reconstruction: The cuneiforme bones dislocated in the plantar direction (**), totally disintigrated, the navicular bone (*) articulates directly with the 1st metatarsal bone. Large periostal appositions on the base of the metatarsal.
**Fig. 9:** Additional findings in the metatarsals and MTP joints in the Charcot’s foot in plain radiography (AP). a: Pencil formed osteolysis of the 2-4th metatarsal bones with dislocations in the MTP joints. b-e: Fragmentation and consequent fragment coalescence of the base of the basal phalanx of the 2nd toe with residual remodeling and subluxation, but with progressive osteolysis of the metatarsal head.
Fig. 10: Typical radiographic features of the Charcot’s foot in diabetes. Total disintegration of the Lisfranc’s joint, large destruction of the cuneiforme bones and cuboid bone, medial displacement of the navicular bone and bizarre calcifications.
Fig. 11: Skin ulcer with septic complications of the Charcot’s foot. a: CT sagittal reconstruction: Skin ulceration (#) on the convexity of the rocker bottom foot with adjacent infiltration of the subcutaneous soft tissues (*). b: MRI T1 weighted sagittal image with fat saturation after Gadolinium administration: Skin ulceration (#) on the heel of the foot with a narrow channel of inflammation surrounding it. Centrally a large abscess (*) in between the destroyed tarsal bone is visible with edema in the cuneiforme bones and calcaneus (**).
Fig. 12: Osteomyelitis in radiographic follow up in the course of 7 months. a-e: Gradual destruction of the periphery of the distal phalanx of the great toe of the right foot together with a large soft tissue defect on the tip of the great toe (e).
Fig. 13: Abscess demarcation in MRI (T1 weighted fat saturation images after i.v. Gadolinium contrast administration). a: coronal: The whole talus has turned into an abscess (**) with a sinus tracking into the soft tissues on the lateral side of the ankle. Marked opacification - most likely osteomyelitis of the surrounding bony structures and phlegmon of soft tissues. b: sagittal: An irregular abscess in the center of the calcaneus (*) accompanied by opacification - most likely osteomyelitis of the surrounding bony structures and reactive edema of soft tissues. Fracture of the talus.
Conclusion

The imaging of the Charcot’s joint and its complications in the diabetic foot - namely the rocker bottom foot - is an important and challenging issue of musculoskeletal radiology, with the need of detecting already the subtle incipient changes - the tiny subcortical fractures and initial subluxations, as well as complex assessment of the plantar arch collapse and rocker bottom foot deformity together with information on the extent and severity of the neuropathic inflammatory changes and identification of septic complications. The septic issue, however, still remains a diagnostic problem at times. The employment of cross sectional methods - CT and MRI - is crucial, with specific indications for radiography still remaining.

References
