Genij Ortopedii. 2022. Vol. 28, no. 3. P. 378-385.

Original article

https://doi.org/10.18019/1028-4427-2022-28-3-378-385

MSCT semiotics of diabetic osteoarthropathy complicated by chronic osteomyelitis

G.V. Diachkova✉, A.S. Sudnitsyn, N.M. Klushin, К.A. Diachkov, T.A. Larionova, E.V. Khieva

Ilizarov National Medical Research Centre for Traumatology and Orthopedics, Kurgan, Russian Federation

Corresponding author: Galina V. Diachkovar, dgv2003@list.ru

Abstract

Background Conventional radiography, magnetic resonance imaging, nuclear medicine scintigraphy are the imaging techniques currently in use for the evaluation of diabetic neuroosteoarthropathy (DN) with computed tomography being not commonly employed even for cases complicated by chronic osteomyelitis. **The objective** was to explore MSCT-semiotics of anatomical and radiomorphological changes in foot bones in patients with DN complicated by chronic osteomyelitis (CO) to determine most common manifestations of CO in diabetic foot. **Material and methods** Single-centre retrospective study. A series of cases. Preoperative radiological findings, MSCT (multislice computed tomography) were examined in 14 patients with DN complicated by chronic osteomyelitis. **Results** The patients showed impaired structure of the cancellous bone of various severity depending on the nature and localization of foot bone destruction. Overall bone density was higher in cancellous bone of the distal tibia, talus, calcaneus with the local density ranging within significant limits and was maximum at some points of the subchondral tibia and talus and minimum in the intertrabecular areas of the calcaneus and the distal tibia. MSCT scans showed medial calcinosis of the arteries in 5 (35.7 %) from 14 patients. **Conclusion** MSCT as one of the most objective method for the qualitative and quantitative assessment of the bone is practical for identifying anatomical and topographic relationships of the foot bones and the ankle joint to facilitate reconstructions in three planes and VRT, which is important for assessing the foot in patients with DN complicated by chronic osteomyelitis. The technique allows measurement of the foot bone density in Hounsfield units determining the severity of osteoporosis, the extent of architectonics impairment to facilitate preoperative planning.

Keywords: diabetic neuroosteoarthropathy, chronic osteomyelitis, MSCT

For citation: Diachkova G.V., Sudnitsyn A.S., Kliushin N.M., Diachkov K.A., Larionova T.A., Khieva E.V. MSCT semiotics of diabetic osteoarthropathy complicated by chronic osteomyelitis. *Genij Ortopedii*, 2022, vol. 28, no 3, pp. 378-385. https://doi.org/10.18019/1028-4427-2022-28-3-378-385

INTRODUCTION

Diabetes, according to many experts, is a pandemic and the total number of people living with diabetes is projected to rise to 600 million by 2045 [1-5]. Diabetic foot is one of the most common, severe and expensive complications of diabetes [2, 3]. The prevalence of diabetes-related foot complications ranged from 3.3 % in Australia to 15 % in South America in 2018 [4, 5]. Charcot diabetic neuroosteoarthropathy (DNOAP) complicated by CO is characterized by six or five signs, referred to in the literature as 5(6) "D": density (change in density), distention (expansion of the joint space), debris (free small fragments), disorganization (disorganization), dislocation (dislocations / subluxations) that can lead to severe deformities and defects in the foot bones accompanied by soft tissue inflammation. The lack of adequate treatment can lead to amputation of the segment and death in some cases (15–25 %) [2, 6]. The algorithm for diagnosing DNOAP in the acute period has been developed and widely used to include radiography, MRI and various scintigraphy techniques [8–10].

C. Lauri and A. Leon suggested in 2020 that despite the higher sensitivity compared to radiography and MRI computed tomography (CT) had a limited role in visualization of changes in diabetic foot in the acute stage [6] to evaluate periosteal reaction, small sequesters, gas in soft tissues and calcifications at the site of chronic osteomyelitis. The main disadvantages of CT include low contrast resolution of soft tissues and inability to detect bone marrow edema at an early stage of inflammation [6]. Preoperative CT imaging can provide clinical benefits in the diagnosis of DNOAP complicated by an osteomyelitic process [6, 11–13]. There is an opportunity to explore radiological and anatomical relationships of the foot bones in three projections, changes in the architectonics of the bones and produce quantitative assessment of the density (HU) identifying the extent of osteoporosis. MSCT allows measurement of the soft tissue density to differentiate foci of pus, fluid and gas.

A clear visualization of the cortical bone and determination of the thickness and density facilitate preoperative planning of pin and nail placement, and three-dimensional reconstruction is practical for identifying localization of the pathological process with modern CT techniques, in particular [8, 14–17]. The use of preoperative MSCT is a must for patients with DNOAP since other imaging modalities fail to provide evaluation of bone status, characterization and bone quality assessment at the site of surgical intervention for better outcome and prophylaxis.

The **objective** was to explore MSCT-semiotics of anatomical and radiomorphological changes in foot bones in patients with DNOAP complicated by chronic osteomyelitis (CO) to determine most common manifestations of CO in diabetic foot.

MATERIAL AND METHODS

Single center retrospective study. Series of cases. Preoperative radiographs, MSCT findings were reviewed in 14 patients with DNOAP complicated by chronic osteomyelitis who were treated at the Clinic of Osteology Infection between 2017 and 2021. Inclusion criteria were patients with DNOAP complicated by chronic osteomyelitis supplied with complete imaging records. Exclusion criteria were absence of complete imaging records. The mean age of the patients was 56 ± 8.11 years. All patients were obese with BMI significantly exceeding normal values (range, 29.92–39.46; median 33.33). The duration of diabetes mellitus ranged from 9.5 to 20.75 years (median 17). The target glycated hemoglobin (HbA1c) ranged from 6.3 to 8.2 % (median 6.9) at the time of admission to the Clinic. The patients presented with foot deformity and functioning, long-term non-healing purulent wounds or fistulas. Radiological bone assessment was based on the classification system developed by Sanders and Eihengholz [19]. Location of the destruction focus was identified using the classification system. Most patients (n = 8; 57.1 %) had the destruction focus localized at the ankle joint graded Sanders type 4 injury. The destruction focus was detected at the site of the Chopard joint in 5 (35.7 %) patients and graded as Sanders type 3. One patient had injury localized in the forefoot and classified as Sanders type 2. Consolidation was identified in 4 (28.6 %) patients and coalescence diagnosed in 10 (71.4 %) patients using Eihengholz classification system. Surgical treatment of the patients included debridement of the purulent focus with sequesternecrectomy, reduction and adaptation of bone fragments followed by Ilizarov fixation of the tibia and the foot for fusion.

Radiography Anterolateral, lateral and axial radiological views of the foot and tibia were obtained with the digital X-ray ARC-OKO machine, registration certificate No. FSR 2008/02589 dated September 29, 2016 and a digital Shimadzu SONIALVISION G4 imaging platform, Japan, registration certificate No. FSZ 2008/01359 dated May 16, 2013. MSCT scans were obtained with GE Lihgt Speed VCT CT scanner using a special BONE reconstruction algorithm. Axial sections were processed with multiplanar reconstruction (MPR) in the coronal and sagittal planes. VRT reconstructions were used. Total and local density (Hounsfield units, HU) of the foot bones was measured preoperatively with histogramming. The architectonics of the calcaneus, talus, navicular, cuboid bones and distal tibia were also explored (Fig. 1).

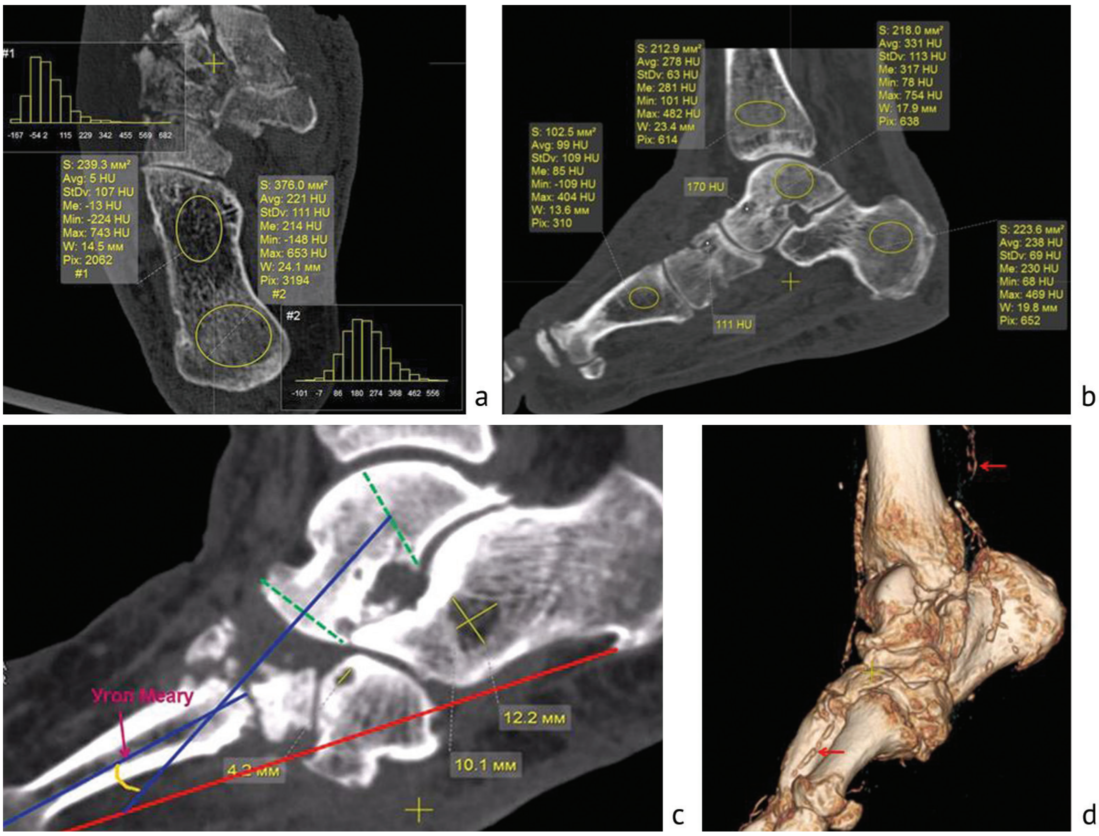

Fig. 1 MSCT of the feet of patients with DNOAP. Axial section (a), MPR in the sagittal plane, measuring the density of the calcaneus, talus, tibia, metatarsals (b); MPR in the sagittal plane, measuring the lateral talo-1-metatarsal angle (Meary angle), foot reference line (red line) (c); VRT reconstruction, Menckeberg mediacalcinosis, arrows (d)

Statistical data analysis was produced using Microsoft Excel spreadsheets and the Attestat program (version 9.3.1, author I.P. Gaydyshev). Quantitative data were presented in cases with a normal distribution as M ± σ, where M was the mean, σ was the quadratic mean and Me, the median. Significance of differences was determined with the Mann-Whitney test and the significance level was adopted at $p < 0.05$.

The study was performed in accordance with ethical principles for medical research involving human subjects stated in the Declaration of Helsinki developed by the World Medical Association as revised in 2000, Order of the Ministry of Health of the RF dtd 19th June 2003 No. 266 on Clinical Practice Guidelines in the Russian Federation. Written informed consent was obtained from all patients for publication of the findings without identifying details.

RESULTS

The architectonics and density of various portions of the calcaneus (n = 13), talus (n = 11), first metatarsal (n = 12) and tibia (n = 13) bones were examined in the patients. The density of the cortical bone of the tibia remained within normal limits (1455.7 ± 110.3 HU) gradually decreasing towards the epiphysis in patients without catastrophic ankle destruction (n = 8). The cancellous bone density measured 280.00 ± 40.30 HU in the distal tibia. The density varied considerably at individual points of the subchondral bone measuring 74 to 1400 HU with the values in the negative spectrum of the Hounsfield scale in the intertrabecular spaces (Table 1).

The distal tibia had a coarse trabecular structure with areas of low and high density; groups of bone trabeculae were longitudinally located in the subchondral bone and were separated by resorption areas (Fig. 2).

The calcaneal shape was significantly changed in 8 patients with the density of the calcaneal tuberosity and the body exceeding normal values in most cases but the local density varied significantly from high values to values in the negative spectrum of the Hounsfield scale (Table 2).

The calcaneal architectonics was impaired in all patients. Signs of arcade structuring were preserved in the form of the groups of bone trabeculae arranged along the force lines in 6 patients with the trabeculae being not clearly differentiated with a coarse trabecular structure. Interarcadial zone was pronounced with the bone shape preserved and had a higher density on sagittal sections and larger area with a significantly decreased density (-126 HU) in three patients (Fig. 3).

Table 1

Tibial density at different areas (n = 13)

Area of interest	Density (HU)			
	Total density	Me	min	max
Distal tibia	280.00 ± 40.30	280	-142	889
Subchonral bone	484.63 ± 99.61	487	-36	1389

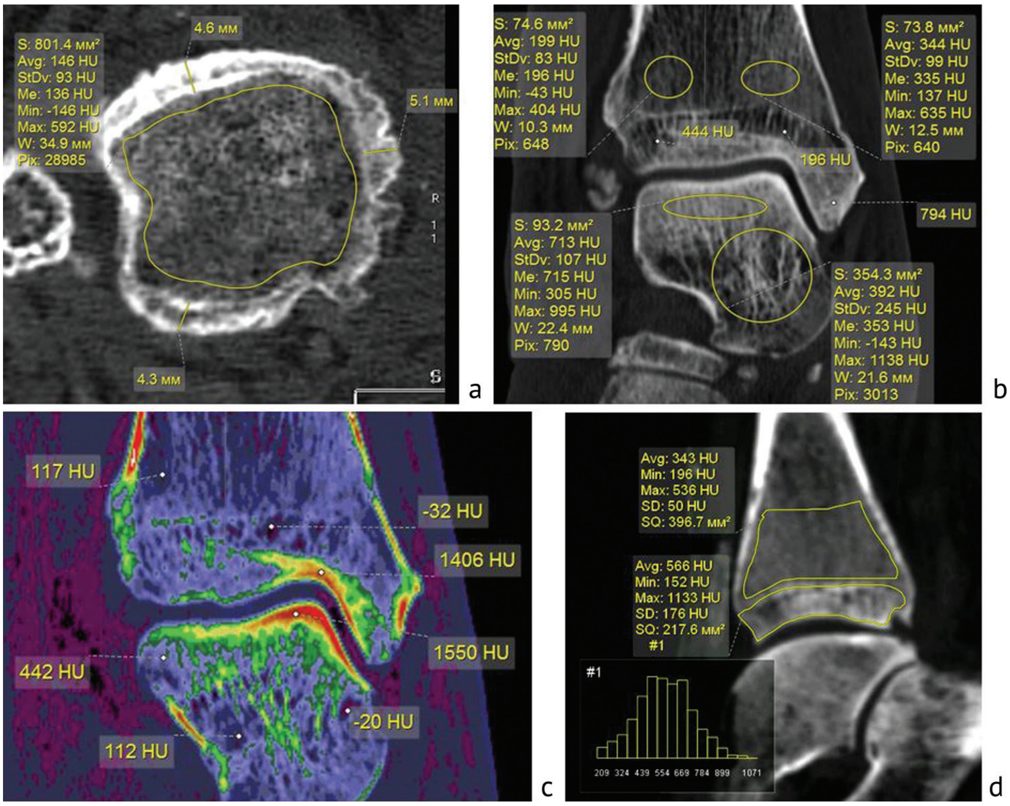

Fig. 2 MSCT of the feet of patients with DNOAP. Axial section, measuring the density in the distal tibia with histogramming (a); MPR in the frontal plane, measuring local density of the tibia and talus (b, c - color); MPR in the sagittal plane, measuring the density of the subchondral bone of the tibia and distal metaepiphysis (d)

Table 2

Calcaneal density measured in different areas (n = 13)

Area of interest	Density (HU)			
	Total density	Me	min	max
Total density of the calcaneus	277.58±39.17	276	-111	1302
Calcaneal tuberosity	194.37±49.05	186	-152	682
Calcaneal body	205.47±38.36	204	-126	1090

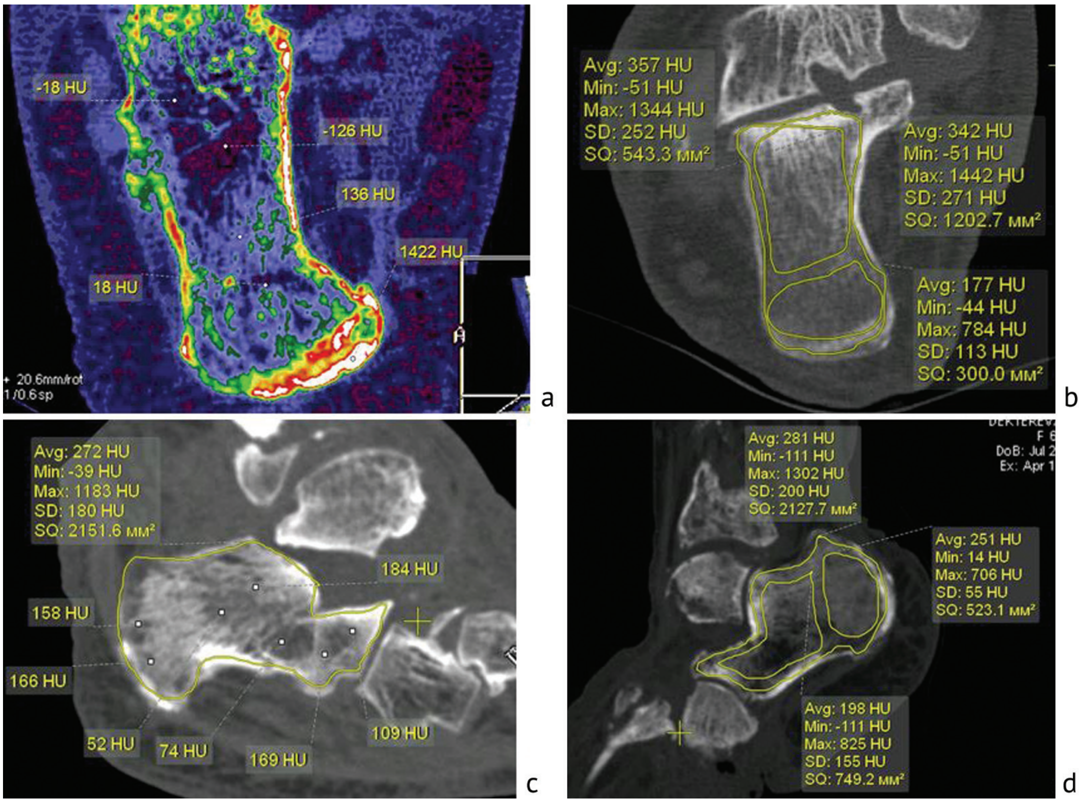

Fig. 3 MSCT of the ankle joint in patients with DNOAP. Axial sections, measuring the density of the calcaneus (a – color, b); MPR in the sagittal plane, measuring the total and local density of the calcaneus (c, d)

The total density of the talus exceeded normal values in six patients and was reduced in five cases, the talus was completely destroyed in three patients (Table 3).

The shape of the talus maintained in six patients with marginal defects and rarefaction zones of various shapes and sizes. The bone structure was impaired in all patients from grainy trabeculae to matte glass. Some patients retained smaller areas of normal fine trabecular structure. The density measured 900 to 1550 HU in the medial portions of the subchondral bone on frontal view (Fig. 4).

The local density of the cortical bone of the metatarsals in patients with localized destruction in the ankle joint without complete destruction of the talus was within the normal range and amounted to 1373.4 ± 194.8 HU. The density of the base and the head of the I metatarsal bone is presented in Table 4.

The shape of the head of the I metatarsal bone maintained in 12 patients, was defective in one case and almost completely destroyed in one case. The base of the bone was normally shaped in four patients and deformed in the rest cases with defects and resorption (Fig. 5).

Symptoms of Menckeberg's arterial mediacalcinosis were detected with MSCT in 5 (35.7 %) patients out of 14. The density of vascular walls measured 350 HU. Vessels were well visualized on VRT (Fig. 6).

Table 3

Talus density in different areas (n = 11)

Area of interest	Density (HU)			
	Total density (M)	Me	min	max
Total	485.00 ± 56.18	480	49	1447
Body	542.78 ± 75.22	564	-21	1367
Head	522.84 ± 67.49	532	-48	1372

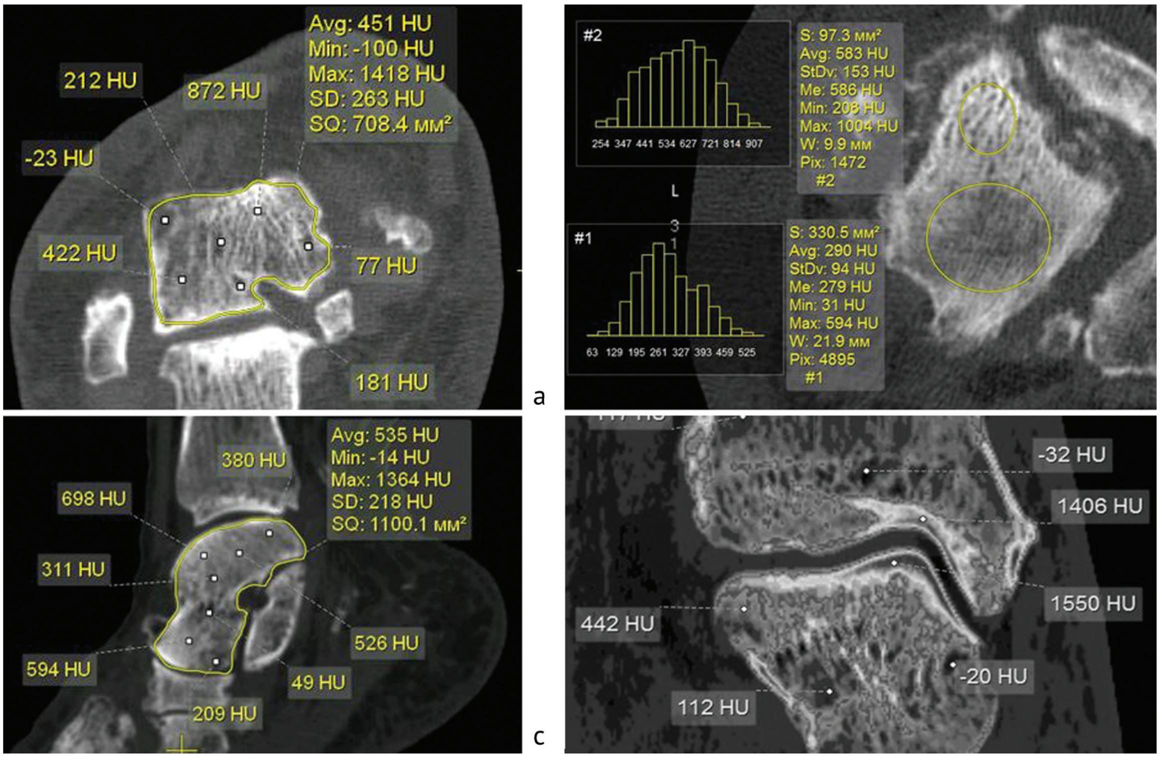

Fig. 4 MSCT of the ankle joint in patients with DNOAP. Axial sections, measuring the total and local density of the talus with histogramming (a, b); MPR in the sagittal plane, measuring the general and local density of the talus (c); MPR in the frontal plane, measuring the local density of the talus (d)

Table 4

Density of the I metatarsal bone in various areas (n = 12)

Area of interest	Density (HU)			
	Total density	Me	min	max
Base	153.14 ± 48.52	156	-49	623
Head	238.16 ± 24.65	240	-71	755
Cortical bone	–	1387.5	1373.4 ± 194.8	

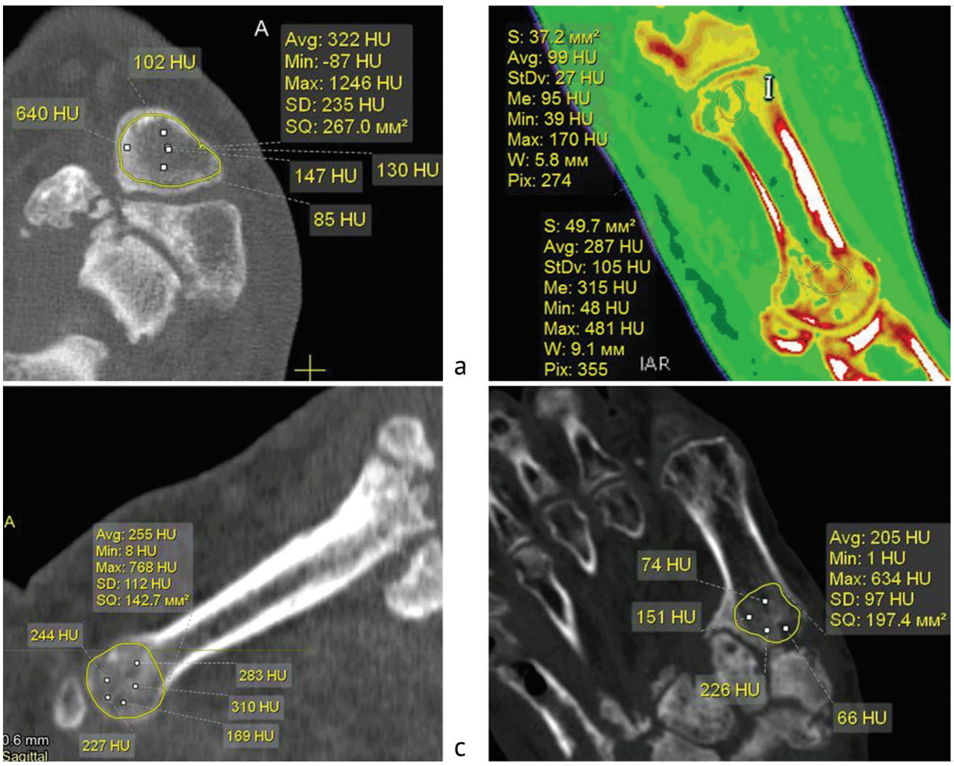

Fig. 5 MSCT of the foot and ankle joint in patients with DNOAP. Axial section, measuring the density of the I metatarsal bone (a); MPR in the sagittal plane, measuring the total and local density of the base and head of the I metatarsal bone (b – color, c). Axial section measuring the total and local density of the base of the I metatarsal bone (d)

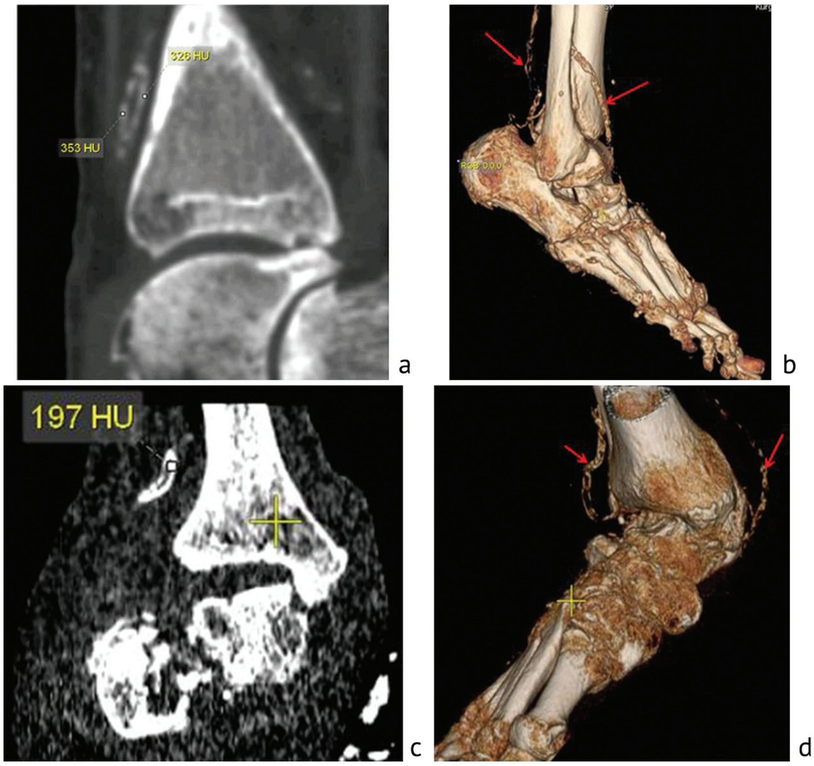

Fig. 6 MSCT of ankle joints and feet in patients with DNOAP. MPR sagittal plane of a 65-year-old patient D. diagnosed with DNOAP, mediacalcinosis, measuring the density of the artery wall (a); VRT, arterial mediacalcinosis (arrows) (b); MPR sagittal plane of a 58-year-old patient L. diagnosed with DNOAP, mediacalcinosis, measuring density of a vascular wall (c); VRT, arterial mediacalcinosis (arrows) (d)

The findings showed that impaired structure of the cancellous bone was observed in all patients with varying degrees of severity, depending on the nature and localization of the bone destruction in the foot. The total density of the cancellous tissue of the distal tibia, talus, and calcaneus was higher than normal, local density varied significantly and was maximum at some points of the subchondral bone of the tibia and talus, being minimum in the intertrabecular zones of the calcaneus and distal tibia. Arterial mediacalcinosis was detected with MSCT in 5 (35.7 %) patients out of 14.

DISCUSSION

The results of the work showed that the degree of changes in the anatomy of the foot bones and the distal tibia were individual for each patient due to localization of the destruction focus (Sanders types 2, 3, 4), duration of the disease, formation of a rocker bottom foot, the degree of collapse in the ankle joint or the midfoot and other changes in the foot anatomy as described by M.V. Parshikova et al., 2020 [19]. Radiological and morphological changes revealed in the patients had differences and primarily were manifested by common signs with different severity shown in the tables above. The literature analysis showed no data on the density of various foot bones in patients with DNOAP measured with MSCT, and some reports suggested more accurate identification of destruction foci, structural impairment, identification of gas, sequesters and preoperative planning [6, 11, 20]. One of the publications reporting the use of CT indicated that "densitometric assessment of soft tissues facilitated identification of low-density structures (+20 – +26 HU) in 82.3 % of cases that were seen as soft tissue abscesses in 71.4 %." The authors suggested that "CT-assessment of the bones facilitated identification of a greater extent of bone destruction in 64.7 % and detection of bone sequesters in 58.8 % as compared with radiographic data (31.2 %)". The authors believe that CT scanning can be effective for diagnosis of osteomyelitis complicating the course of DFS only in a combined assessment of the bones and soft tissues [19]. Dual-energy X-ray absorptiometry (DEXA) is most common technique used to measure BMD in the axial and peripheral skeleton (spine, femur). The authors reported decreased BMD in patients with DM and Charcot foot [21, 22]. Some studies reported no decrease in BMD in the proximal femur, spine, and calcaneus in adult diabetic patients [23, 24]. In our opinion, measurements of BMD in the axial and peripheral skeleton (femur) in patients with DNOAP is not very informative for a local assessment of the foot bones, for preoperative planning, in particular. Our numerous studies and literature data have shown that MSCT is a highly specific and sensitive method for diagnosing chronic osteomyelitis and can be used in preoperative examination of patients with DNOAP complicated with osteomyelitis [13, 20, 25–29].

CONCLUSION

MSCT as one of the most objective methods for qualitative and quantitative assessment of the bone is practical for obtaining data on the anatomical and topographic relationships of the foot bones and the ankle joint with the data processed in three planes and use of VRT that is extremely important for exploring the foot in patients with DNOAP complicated by chronic osteomyelitis. The method allows measurements of the density of all bones of the foot in Hounsfield units identifying severity of osteoporosis, the extent of impaired architectonics for preoperative planning.

REFERENCES

1. World Health Organization (WHO). *Globalnyi doklad po diabetu* [Global report on diabetes]. Geneva, 2018, 84 p. License: CC BY-NC-SA3.0 IGO. (in Russian)
2. Galstian G.R., Vikulova O.K., Isakov M.A., Zhelezniakova A.V., Serkov A.A., Egorova D.N., Artemova E.V., Shestakova M.V., Dedov I.I. Epidemiologiia sindroma diabeticheskoi stopy i amputatsii nizhnikh konechnostei v Rossiiskoi Federatsii po dannym Federalnogo Registra bolnykh sakharnym diabetom (2013-2016 gg.) [Epidemiology of the diabetic foot syndrome and amputations of the lower limbs in the Russian Federation according to the Federal Register of Patients with Diabetes Mellitus (2013-2016)]. *Sakharnyi Diabet*, 2018, vol. 21, no. 3, pp. 170-177. DOI: 10.14341/DM9688. (in Russian)
3. IDF *Diabetes Atlas*. 9th Ed. 2019. Available at: https://diabetesatlas.org/atlas/ninth-edition/
4. Zhang P., Lu J., Jing Y., Tang S., Zhu D., Bi Y. Global epidemiology of diabetic foot ulceration: a systematic review and meta-analysis. *Ann. Med*., 2017, vol. 49, no. 2, pp. 106-116. DOI: 10.1080/07853890.2016.1231932.
5. Carro G.V., Saurral R., Sagüez F.S., Witman E.L. Pie diabético en pacientes internados en hospitales de Latinoamérica [Diabetic foot among hospitalized patients in Latin America]. *Medicina* (B Aires), 2018, vol. 78, no. 4, pp. 243-251. (in Spanish)
6. Lauri C., Leone A., Cavallini M., Signore A., Giurato L., Uccioli L. Diabetic Foot Infections: The Diagnostic Challenges. *J. Clin. Med*., 2020, vol. 9, no. 6, pp. 1779. DOI: 10.3390/jcm9061779.
7. Lauri C., Glaudemans A.W.J.M., Campagna G., Keidar Z., Muchnik Kurash M., Georga S., Arsos G., Noriega-Álvarez E., Argento G., Kwee T.C., Slart R.H.J.A., Signore A. Comparison of White Blood Cell Scintigraphy, FDG PET/CT and MRI in Suspected Diabetic Foot Infection: Results of a Large Retrospective Multicenter Study. *J. Clin. Med*., 2020, vol. 9, no. 6, pp. 1645. DOI: 10.3390/jcm9061645. Zamyshevskaia M.A., Zavadovskaia V.D., Udodov V.D., Zorkaltsev M.A., Grigorev E.G. Rol magnitno-rezonansnoi tomografii pri issledovanii bolnykh s sindromom diabeticheskoi stopy [The role of magnetic resonance imaging in the study of patients with diabetic foot syndrome]. *Vestnik rentgenologii i radiologii*, 2014, no. 4, pp. 31-37. (in Russian) Available at: https://doi.org/10.20862/0042-4676-2014-0-4-31-37 (accessed 12.01.2021).
8. Expert Panel on Musculoskeletal Imaging; Walker E.A., Beaman F.D., Wessell D.E., Cassidy R.C., Czuczman G.J., Demertzis J.L., Lenchik L., Motamedi K., Pierce J.L., Sharma A., Ying-Kou Yung E., Kransdorf M.J. ACR Appropriateness Criteria® Suspected Osteomyelitis of the Foot in Patients with Diabetes Mellitus. *J. Am. Coll. Radiol*., 2019, vol. 16, no. 11S, pp. S440-S450. DOI: 10.1016/j.jacr.2019.05.027.
9. Zavadovskaia V.D., Zorkaltsev M.A., Udodov V.D., Zamyshevskaia M.A., Kilina O.Iu., Kurazhov A.P., Popov K.M. Vozmozhnosti programmno-sovmeshchennoi odnofotonnoi emissionnoi kompiuternoi tomografii, magnitno-rezonansnoi tomografii v diagnostike oslozhnennogo techeniia sindroma diabeticheskoi stopy [Possibilities of software-coupled single-photon emission computed tomography, magnetic resonance imaging in the diagnosis of complicated course of diabetic foot syndrome]. *Vestnik Rentgenologii i Radiologii*, 2015, no. 6, pp. 24-29. (in Russian)
10. Llewellyn A., Kraft J., Holton C., Harden M., Simmonds M. Imaging for detection of osteomyelitis in people with diabetic foot ulcers: A systematic review and meta-analysis. *Eur. J. Radiol*., 2020, vol. 131, 109215. DOI: 10.1016/j.ejrad.2020.109215.
11. Fayad L.M., Carrino J.A., Fishman E.K. Musculoskeletal infection: role of CT in the emergency department. *Radiographics*, 2007, vol. 27, no. 6, pp. 1723-1736. DOI: 10.1148/rg.276075033.
12. Rubitschung K., Sherwood A., Crisologo A.P., Bhavan K., Haley R.W., Wukich D.K., Castellino L., Hwang H., La Fontaine J., Chhabra A., Lavery L., Öz O.K. Pathophysiology and Molecular Imaging of Diabetic Foot Infections. *Int. J. Mol. Sci*., 2021, vol. 22, no. 21, pp. 11552. DOI: 10.3390/ijms222111552.
13. Galchina Iu.S., Karmazanovskii G.G., Paskhalova Iu.S. Osnovnye metody diagnostiki sindroma diabeticheskoi stopy [The main methods for diagnosing diabetic foot syndrome]. *Meditsinskaia Vizualizatsiia*, 2016, no. 6, pp. 100-116. (in Russian)
14. Martinez M., Peponis T., Hage A., Yeh D.D., Kaafarani H.M.A., Fagenholz P.J., King D.R., de Moya M.A., Velmahos G.C. The role of computed tomography in the diagnosis of necrotizing soft tissue infections. *World J. Surg*., 2018, vol. 42, no. 1, pp. 82-87. DOI: 10.1007/s00268-017-4145-x.
15. Aleksandrov S.M., Diachkova G.V., Diachkov K.A., Stepanov R.V., Larionova T.A. MSKT- semiotika khronicheskogo osteomielita kostei, obrazuiushchikh golenostopnyi sustav [MSCT- semiotics of chronic osteomyelitis of the bones forming the ankle joint]. *Vestnik Rossiiskogo Nauchnogo Tsentra Rentgenoradiologii*, 2014, no. 14-2, pp. 1-12. (in Russian)
16. Diachkova G.V., Diachkov K.A., Kliushin N.M., Larionova T.A., Shastov A.L. A multifaceted osteomyelitis: radiological diagnosis. *Genij Ortopedii*, 2020, vol. 26, no. 3, pp. 385-391. DOI: 10.18019/1028-4427-2020-26-3-385-391.
17. Ortolani M., Leardini A., Pavani C., Scicolone S., Girolami M., Bevoni R., Lullini G., Durante S., Berti L., Belvedere C. Angular and linear measurements of adult flexible flatfoot via weight-bearing CT scans and 3D bone reconstruction tools. *Sci. Rep*., 2021, vol. 11, no. 1, 16139. DOI: 10.1038/s41598-021-95708-x.
18. Chantelau E.A., Grützner G. Is the Eichenholtz classification still valid for the diabetic Charcot foot? *Swiss Med. Wkly*, 2014, vol. 144, pp. w13948. DOI: 10.4414/smw.2014.13948.
19. Parshikov M.V., Bardiugov P.S., Yarygin N.V. Orthopaedic aspects of diabetic foot syndrome classifications. *Genij Ortopedii*, 2020, vol. 26, no. 2, pp. 173-178. DOI: 10.18019/1028-4427-2020-26-2-173-178.
20. Liu G.L.,Yang B.K., Dong H.R. [Diagnosis and treatment of Charcot's osteoarthropathy]. *Zhongguo Gu Shang*, 2019, vol. 32, no. 12, pp. 1168-1172. (in Chinese) DOI: 10.3969/j.issn.1003-0034.2019.12.021.

21. Cho J.H., Min T.H., Chun D.I., Won S.H., Park S.Y., Kim K., Yi Y. Bone Mineral Density in Diabetes Mellitus Foot Patients for Prediction of Diabetic Neuropathic Osteoarthropathic Fracture. *J. Bone Metab*., 2020, vol. 27, no. 3, pp. 207-215. DOI: 10.11005/jbm.2020.27.3.207.
22. El Oraby H.A., Abdelsalam M.M., Eid Y.M., El Hilaly R., Marzouk H.A. Bone mineral density in type 2 diabetes patients with Charcot arthropathy. *Curr. Diabetes Rev*., 2019, vol. 15, no. 5, pp. 395-401. DOI: 10.2174/1573399814666180711115845.
23. Barwick A.L., de Jonge X.A., Tessier J.W., Ho A., Chuter V.H. The effect of diabetic neuropathy on foot bones: a systematic review and meta-analysis. *Diabet. Med*., 2014, vol. 31, no. 2, pp. 136-417. DOI: 10.1111/dme.12347.
24. Mohseni M., Hosseinzadeh P., Civitelli R., Eisen S. Effect of peripheral neuropathy on bone mineral density in adults with diabetes: A systematic review of the literature and meta-analysis. *Bone*, 2021, vol. 147, 115932. DOI: 10.1016/j.bone.2021.115932.
25. Trufanov G.E., Pchelin I.G., Pashnikova I.S. *Luchevaia diagnostika zabolevanii golenostopnogo sustava i stopy* [Radiodiagnosis of the ankle and foot diseases]. 3rd Ed. SPb., ELBI-SPB, 2020, 320 p. (in Russian)
26. Diachkova G.V., Kliushin N.M., Shastov A.L., Diachkov K.A., Netsvetov P.V., Larionova T.A. Osteomyelitic cavity as a form of chronic osteomyelitis termed by radiological morphology. *Genij Ortopedii*, 2019, vol. 25, no. 2, pp. 199-206. DOI: 10.18019/1028-4427-2019-25-2-199-206.
27. Rubin G.D. Computed tomography: revolutionizing the practice of medicine for 40 years. *Radiology*, 2014, vol. 273, no. 2 Suppl., pp. S45-S74. DOI: 10.1148/radiol.14141356.
28. Pineda C., Espinosa R., Pena A. Radiographic imaging in osteomyelitis: the role of plain radiography, computed tomography, ultrasonography, magnetic resonance imaging, and scintigraphy. *Semin. Plast. Surg*., 2009, vol. 23, no. 2, pp. 80-89. DOI: 10.1055/s-0029-1214160.

The article was submitted 18.01.2022; approved after reviewing 17.02.2022; accepted for publication 28.03.2022.

Information about the authors:

1. Galina V. Diachkova – Doctor of Medical Sciences, Professor, dgv2003@list.ru;
2. Anatolii S. Sudnitsyn – Candidate of Medical Sciences, anatol_anatol@mail.ru, ORCID: 0000-0002-2602-2457;
3. Nikolai M. Kliushin – Doctor of Medical Sciences, klyushin_nikolay@mail.ru;
4. Konstantin A. Diachkov – Doctor of Medical Sciences, dka_doc@mail.ru;
5. Tatiana A. Larionova – Candidate of Medical Sciences, lar_rad@mail.ru:
6. Ekaterina V. Khieva – khieva@mail.ru.

Funding *The work was produced as part of the state project "Personalization of methods for diagnosing and treating patients with osteoarticular pathology complicated by purulent infection to ensure stable arrest of the purulent process and restoration of orthopaedic status."*

Declaration of Conflicting Interests *The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.*