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Microabscesses as a possible cause of recurrence in chronic osteomyelitis

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Abstract

Introduction It is known that the density of the cortical plate of long bones in patients with chronic osteomyelitis changes throughout its extension. However, the nature of structural disorders in the cortical layer outside the inflammation zone has not been studied well. **Purpose** To study the structural features of the cortical plate of the femur and tibia outside the focus of inflammation to identify microcavities and microabscesses. **Material and methods** The study is retrospective conducted at one center. Evidence level IV. In 92 patients with chronic osteomyelitis of long bones of the lower extremities, using polypositional radiography and multislice computed tomography (MSCT), the features of radiological morphology of the femur and tibia were studied in order to reveal structural features of the cortical plate and identify microcavities. Results The cause of osteomyelitis in 5 cases was a consequence of hematogenous osteomyelitis, and in 87 cases it developed due to trauma or surgery. The most common location of chronic osteomyelitis was the distal femur and tibia. Anatomical changes in the femur and tibia in all patients had individual differences. Radiological morphological manifestations such as local and general osteoporosis, foci of osteosclerosis, architectonic disorders occurred in all patients. However, the severity of changes in the bone structure was extremely diverse, including the changes in bone density. **Conclusion** The data obtained indicate that radiological morphological changes in the cortical plate outside the zone of destruction are manifested by formation of microcavities and microabscesses in 15.6 % of patients, what plays an important role in possible recurrence of osteomyelitis.

Keywords: chronic osteomyelitis, long bone, MSCT, cortical plate, microabscess

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INTRODUCTION

The current methods of radiological imaging are able to accurately diagnose chronic inflammation process in long bones. However, modern effective methods do not always achieve the expected result, since the location of osteomyelitis, prevalence of destruction, and duration of the disease vary [1–5]. In addition, the specificity and sensitivity of diagnostic methods for various manifestations, stage of the disease, volume or area of the focus of inflammation are far from being equivalent [6–9]. The use of magnetic resonance imaging (MRI), PET/CT, PET/CT with 18 F-fluorodeoxyglucose enables to identify foci of inflammation, but small microcavities or microabscesses can be diagnosed with a high probability only with MSCT and data processing using workstations. Detection of microcavities and microabscesses is extremely important for the prevention of osteomyelitis recurrence as far as an undetected inflammatory focus of 0.2–0.3 mm^2 at some distance from the main one may be outside the resection area and cause later an increase in the area of inflammation and the development of a recurrence. Govaert et al. (2018) suggested that it is more logical to apply an imaging method that can not only confirm the diagnosis of osteomyelitis, but also help in determining the surgical tactics [10]. Such methods for diagnosing chronic osteomyelitis include MSCT [11–14]. The use of MSCT to study bone microarchitectonics was shown by Chen et al. (2018) and stated that MSCT data correlate well with micro-CT parameters [15]. This is extremely important for the detection of microabscesses, or small foci of exudative inflammation, corresponding in density to pus. The density of abscess content, according to various authors, ranges from 20 to 45 HU [16–18]. According to Grigorovsky et al. (2018), approximately in every third case of latent sclerosing hematogenous osteomyelitis course, small foci of purulent inflammation, being micro-abscesses of 1–3 mm in diameter, were found among the resorption cavities in the cortex and bone regenerates, indicating purulent inflammation [19]. Similar changes are detected in patients with chronic osteomyelitis. It is of particular importance for determining micro-abscesses at some distance from the focus of necrosis that has to be removed during the operation, but a small cavity may be left in the area of a conditionally "healthy" bone and can serve as a source of recurrence. Identification of micro-abscesses during preoperative examination and in patients with recurrence was the basis for this work.

Purpose To study the features of the cortical plate in the femur and tibia outside the inflammation focus to reveal microcavities and microabscesses.

Study design Radiography and MSCT were used to examine 92 patients with chronic osteomyelitis of the femur and tibia treated at the Ilizarov NMRC for TO in 2018–2020. It is a retrospective, single-center study of level of evidence IV. The study included patients aged 18 to 60 years with chronic osteomyelitis in long bones of the lower extremities with available X-rays and MSCT archives. Exclusion criteria were age of patients over 60 years, total bone involvement, unavailable complete X-ray and MSCT sets. The study was performed in accordance with the ethical standards of the Declaration of Helsinki of the World Medical Association as amended by the Ministry of Health of the Russian Federation, approved by the ethics committee of the Ilizarov NMRC for TO of the Ministry of Health of Russia. All patients signed an informed consent to participate in the study without identification.

MATERIAL AND METHODS

Radiography and multislice computed tomography were performed in 92 patients aged 18 to 60 years (45.7 ± 13.9). Males in the analyzed group accounted for 83.3 %. Osteomyelitis in 87 patients was caused by trauma or surgery, the consequences of hematogenous osteomyelitis were observed in five cases (Table 1).

Table 1

Location and etiology of osteomyelitis in the patients

Segment	Hematogenous osteomyelitis	Post-traumatic or postsurgical osteomyelitis
Femur	4	26
Lower leg bones	1	61
Total	5	87

All patients were treated for chronic osteomyelitis in various clinics of the Russian Federation from 5 to 25 years, and were referred to the Clinic for Purulent Osteology of the Federal State Budgetary Institution Ilizarov National Research Center for Traumatology and Orthopedics.

Polypositional radiography and MSCT were performed in 92 patients. The studies were performed on Toshiba Aquilion-64 and GE Light Speed VCT CT scanners using a special BONE reconstruction algorithm. Axial sections were processed in the multiplanar reconstruction (MPR) mode in the coronal and sagittal planes. To study the cortical plate outside the area of inflammation before treatment, the total and local density (Hounsfield units, HU) was measured. To identify microcavities (up to 2.0–7.5 mm^2 in area), the structure of the cortical plate along the entire length of the bone outside the inflammation zone was analyzed. Once a microcavity was detected, its area was measured. Inside the cavity, density measurement was performed by points with an area of up to 01–0.2 mm^2 (7–10 points) inside the microcavities in order to identify areas with a density of 10 to 45 HU (liquid, purulent content). To identify areas with the density mentioned in larger cavities, density measurement was performed at 25–30 points. For a more complete idea of the density in the selected area, histograms were built (Fig. 1).

Statistical data analysis was carried out with the Microsoft Excel-2010 data analysis package and the Attestat-2001 program. Data on bone density in the case of a normal distribution are presented as M ± σ, where M is the mean value, σ is the standard deviation. To compare quantitative indicators between groups, Student's t-test (with a normal distribution in both groups) or the Mann-Whitney test were used. Differences were considered significant at $p < 0.05$.

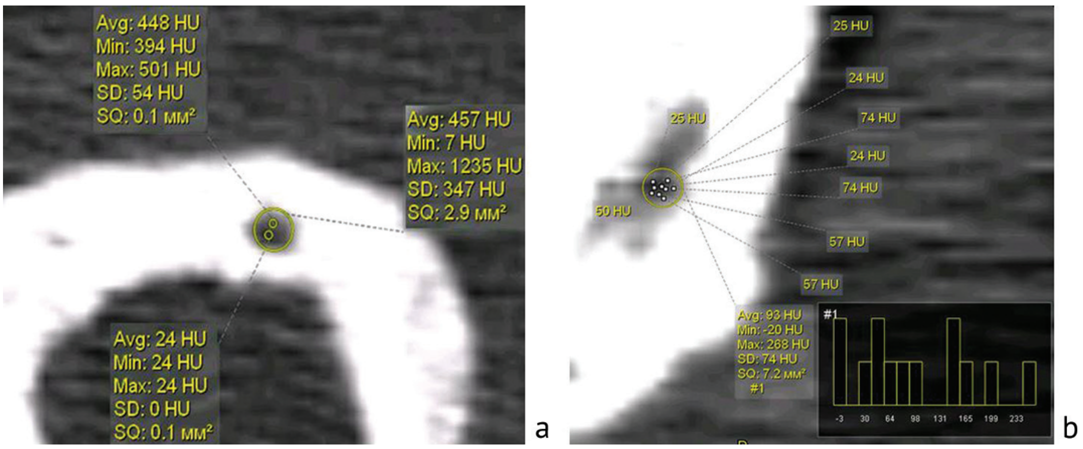

Fig. 1 MSCT of the tibia of a 56-year old patient M. Axial projection. Microcavity with an area of 2.9 mm^2. Inside the cavity there are points, the area of which is 0.1 mm^2, with a density in one case of 24 HU, in the other up to 448 HU (a). Microcavity with an area 7.2 mm^2. The measurements were taken at 9 points. Histogram (b)

RESULTS

A total of 3,458 measurements of the area of microcavities and the density of various areas inside them were performed that were recorded on axial sections; however, the total number of measurements in the area of microcavities to search for points with a density approaching that of pus was more than 5,000.

Thus, for examining a microcavity in patient M., 13 points with an area of 0.1 mm^2 were studied, the density of some was 29–49 HU, in other 11 it ranged from 55 to 700 or more HU. There were points with a density of 29 to 49 HU, what, according to some authors, corresponds to the density of pus [16, 17, 18] (Fig. 2).

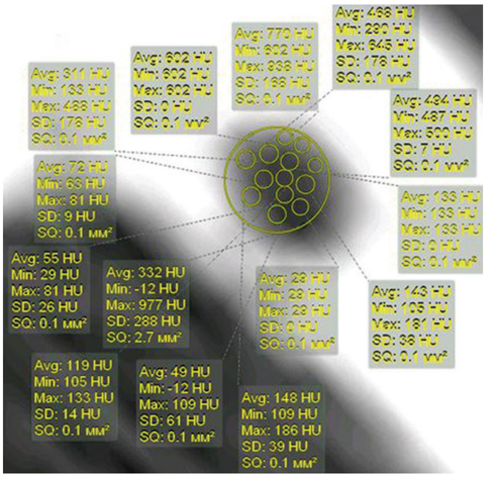

Fig. 2 MSCT of the lower leg of patient M., 56 years old. Chronic osteomyelitis of the tibia. Axial projection. Microcavity with an area of 2.7 mm^2 is marked. In the cavity, there are points which density ranges from 29 to 49 HU; in the other 11 points, the range is from 72 to 700 HU

The minimum area of a point in the cavity which density was measured was 0.1 mm^2; in some cases, points with an area of up to 0.4 mm^2 were chosen. The density of the content at the points of a small area ranged from -16 HU to +33 HU. Values of 30–33 HU could be regarded as related to liquid content, including of purulent nature. Around the microcavity, the density ranged from 114 to 167 HU (Fig. 3).

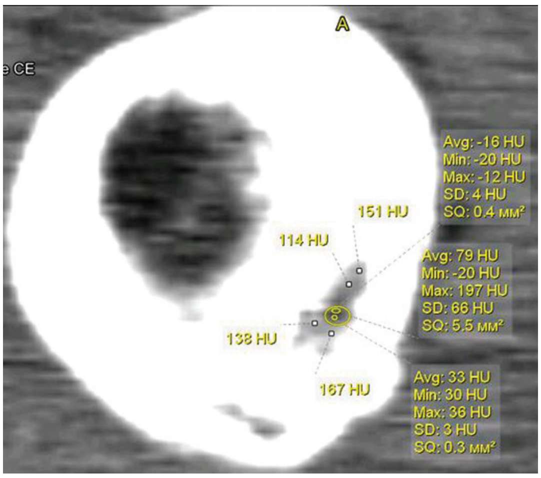

Fig. 3 MSCT of the femur of patient X., 38 years old. Axial projection. Microcavity with an area of 5.5 mm^2. Points are marked inside the cavity, the area of which was 0.3–0.4 mm^2, and the density ranged from 16 HU to 33 HU

There were cases with the density at different points of the cavity equal from +20 to +41 HU, what corresponded to liquid content (Fig. 4).

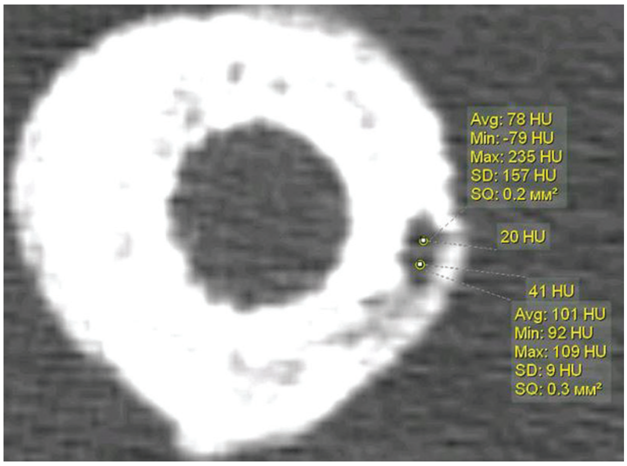

Fig. 4 MSCT of the femur of patient R., 52 years old. Axial projection. Microcavity. Local density at two points with areas of 0.2 mm^2 and 0.3 mm^2 significantly differed from the mean and standard deviation, being 20 and 40 HU

Table 2 presents data on the number of microcavities outside the focus of inflammation or outside the area of surgical intervention, and the number of microcavities with areas of purulent content (Table 2).

Table 2

Number of microcavities outside the focus of inflammation or outside the area of surgical intervention and their area, the number of microcavities with areas of purulent content (n = 92)

Parameter		Femur	Tibia
Number of microcavities outside the infection nidus and outside the zone of surgical intervention		18	4
Microcavity area	2 mm^2	3	2
	2.5 mm^2	7	1
	3 mm^2	4	1
	3.5 mm^2	4	-
Number of microcavities having the density corresponding to the areas with purulent content		12	3

Analysis of the data obtained showed that a total of 22 cavities were found outside the destruction zone or the former surgical intervention. The area of isolated cavities ranged from 2 to 7.5 mm^2. The density in different parts of such cavities was different, with a maximum value of 305 HU in one of the measured points, and did not exceed 50 HU in the rest. The number of microcavities with a density corresponding to areas with purulent contents was 15, and they were mainly located in the femur. Among the patients with osteomyelitis of the tibia, there dominated patients in whom changes in the structure of the cortical plate in the localization of the focus of destruction in any zone extended to almost the entire bone, and due to multilayered nature, significant changes in the architectonics of the microcavity were detected extremely rarely.

This study of the density of microcavities showed that this indicator fluctuated significantly in different parts; however, since the task of the study was to identify purulent content, statistical processing of the data was carried out that corresponded mostly to liquid content, including those of a purulent nature. The results are shown in Table 3.

Table 3

Density of microcavity content corresponding to liquid content (n = 15)

Density, HU	Number of cavities	
	Femur	Tibia
24.3 ± 8.4	5	2
35.6 ± 9.2	7	1

DISCUSSION

The challenges of treatment in chronic osteomyelitis, various forms of its manifestation, and anatomical and biochemical changes in the bone continue to attract the attention of specialists in various fields to this problem [20–22]. Literature data and many years of our experience with the use of MSCT in examining patients with chronic osteomyelitis give us reason to assert that the capabilities of this technique for detecting small sequesters, microcavities, the nature and prevalence of changes in the cortical plate, adjacent areas of the bone allow us to accurately determine small areas of the bone (up to 0.2–2 mm^2), within a larger cavity (7–10 mm^2), and determine the point density (HU) inside this area [23, 24]. This is extremely necessary to detect microabscesses in order to prevent chronic osteomyelitis recurrence [19].

According to many authors, the capabilities of micro-ST and electron microscopy for detecting microcavities and microabscesses, due to its methodological features, are much greater than of MSCT [1]. However, MSCT can be used for examination of any long bone in patients with chronic osteomyelitis before surgery in order to determine not only the location of the inflammation nidus, like PET / CT with 18 F-fluorodeoxyglucose or labeled leukocytes, but also structural features and small details in the focus of destruction and along the bone to be used for a more careful planning of surgical interventions [14, 15, 24, 25]. Govaert et al. (2018) suggested that it is more correct to use an imaging method that is able to confirm not only the diagnosis of osteomyelitis but also help in determining the surgical tactics [10, 26].

In this regard, it is hardly possible to agree with the conclusions of Llewellyn et al. (2019) that the greater availability of MRI systems and the fact that MRI does not expose patients to harmful ionizing radiation may mean that MRI is preferable for diagnosing osteomyelitis in most cases [3]. The possibilities of MRI for the quantitative assessment of the state of the bone are well known. Our data showed that microcavities and microabscesses are more common in patients with chronic osteomyelitis of the femur. A total of 22 microcavities (15.6 %) were found in 92 patients, 18 of them in the femur, despite the fact that the number of patients with chronic osteomyelitis of the tibia prevailed. Therefore, it was possible in a relatively unchanged and a thicker cortical plate of the femur outside the focus of inflammation to detect microcavities and microabscesses, and under the conditions of its multilayer nature to identify assimilation of periostitis, extensive resorption zones. Cavities in the tibia were detected less frequently due to a pronounced change in architectonics. Moreover, the cortical plate of the femur was approximately the same thickness along the diaphysis and thicker than the tibial plate, which had a thickness of no more than 1.7–2.1 mm in the metaphyseal region.

CONCLUSION

The data obtained indicate that radiological morphological changes in the cortical plate outside the zone of destruction are manifested by the formation of microcavities and microabscesses in 15.6 % of patients, what plays an important role in the possible recurrence of osteomyelitis.

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