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Morphofunctional Aspects of Bone Tissue at Osteoporosis

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ABSTRACT

Objective: morphofunctional aspects of bone tissue at osteoporosis.
Methods: The clinical material of 117 patients with isolated and multiple fractures of typical localizations on background of systemic osteoporosis as well with degenerative diseases of the musculoskeletal system, which were presented by deforming arthrosis of hip joints of 3rd degree. The specimens of bone tissue were browsed and photographed in light microscope «TOPIC-T» CETI. The specimens were fixed in standard glutaraldehyde fixative and then they were browsed in raster electron microscope «FE1 Quanta 200 3D» и «FE1 Quanta 600 FEG»(Netherlands). The processing and formation of AFM- images were conducted using software «NOVA»(NT-MDT, Russia) and «Image Analysis» (NT-MDT, Russia).
Results: The decreasing of total area of bone tissue was morphological manifestation of osteoporosis. Normal bone plates in cancellous bone became thin and perforated, trabecular lattice system also became thinner and partially interrupted. Trabeculae became thin, distance between them increased, what led to spreading of bone marrow space. The structure of Havers canals was violated. The thinning of tissue in cancellous substance was due to transformation of endosteal layer of cortical bone. The fibres of intercellular substance of bone tissue were placed randomly, large intervals were between bunches.
Conclusions: At exploration of morphofunctional features of bone tissue at osteoporosis it was founded that the decreasing of total area of solid substance in bone tissue took place. In cancellous substance bone plates became perforated and thin, collapsed, forming large cavities. Trabecular lattice system became thin and partially interrupted. Trabeculae became thin, distance between them increased.
Key words: osteoporosis, bone tissue, bone fracture, old age
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INTRODUCTION

The increasing aging of population is one of demographic characteristics of our reality. [1-3]. Currently, osteoporosis is the problem of modern human due to its high prevalence, it is the main reason of invalidisation, decreasing of life quality and premature death of the elderly [4-6]. According to data of the International Osteoporosis Foundation, more than 14 mln. people (10% of population) suffer from osteoporosis, another 20 mln. have osteopenia, concequently 34 mln people have high risk of fractures [7, 8]. Although, osteoporosis is less common in men than in women, the mortality rate is higher. For example, the lethality during 1 year after hip fracture was 37.5%, what was higher on 51% in comparison with indexes in women [9]. The decreasing of density of bone tissue, violation of microarchitectonics, increasing of fragility of bones are take place in result of violation of bone metabolism balance with prevalence of resorption above formation. [10, 11].

The purpose of our exploration was research of morphofunctional features of bone tissue at osteoporosis.

MATERIALS AND METHODS

The clinical research was undergone in City Clinical Hospital No. 2, Belgorod and morphological and biochemical part of research was undergone in laboratory of pathology department of Federal State Autonomous Educational Institution of Higher Education" Belgorod State University".
In scope of performed work, 117 patients with isolative and multiple fractures of typical localizations on background of system osteoporosis (proximal part of the femur (transtrochanteric area, subtrochanteric area, the neck), femoral diaphysis, distal metaepiphyses of forearm, proximal part of humerus (surgical and anatomical neck), humeral diaphysis and patients with deforming arthrosis of hip joint of 3rd degree were researched. System osteoporosis was confirmed according to data of radiography, as well as densitometry. Next groups were formed by age criteria. (Table. 1).

Table 1: Formation of groups by age criteria

Age	Number human	Surgical treatment
medium	46 (39,3%)	35 (20 women, 15 men)
Aged	46 (39,3%)	30 (24 women,6 men)
Oldage	21 (17,9%)	10 (8 women, 2 men)
centenarians	4 (3,4%)	2women
Total	117	77

Fractures of bones and progression of degenerative violations in hip joint were detected by standard roentgenograms in direct, lateral and axial projections (axial projection of hip joint was used additionally for diagnosis of pathology of hip joint).

Patients with fractures were undergone to conservative treatment (plaster immobilization), and surgery according to indication (reduction of bone fragments with following osteosynthes). Patients with femur neck fractures were un-

dergone to total hip arthroplasty. The same surgery was conducted to all patients with deforming arthrosis.

The capture of bone specimens from resected femur head was conducted during total hip arthroplasty. Except this, the capture of material was conducted in patients with fractures of different age groups (patients of middle and senile age with osteoporosis).

The specimens taken from bone tissue were fixed in 10% neutral formalin for histological examination with light microscopy. The specimens were filled in paraffin after decalcification, than slices were prepared on microtome with following staining of hematoxylin and eosin. The specimens were browsed and photographed in light microscope «TOPIC-T» CETI.

For scanning electron microscopy the specimens were fixed in standard glutaraldehyde fixative and then they were browsed in raster microscope «FE1 Quanta 200 3D» and «FE1 Quanta 600 FEG» (Netherlands).

Photography and morphometric analysis for research of specimens with help of AFM was conducted after objective browsing. The research was conducted in regimes of constant and interruptive contacts on device «Ntegra-Aura» (NT-MDT Company) with usage of commercial Si and SiN cantilevers (NSG01, NT-MDT, Russia) in circumstances of atmosphere and low vacuum. Mica (muscovite) or highly oriented pyrolytic graphite (pyrographite) were used as substrates for research of surface of spall. The processing and formation of AFM- images were conducted using software «NOVA» (NT-MDT, Russia) and «Image Analysis» (NT-MDT, Russia).

Statistic processing of materials of materials of research was conducted on IBM PC (IntelPentium-III), WindowsMillenuim with use of software Statisticafor Windows Version 6.0 (StatSoftInc., USA).

RESULTS AND DISCUSSION

The decreasing of total area of solid substance in bone tissue of hip joint was observed at osteoporosis. Bone plates in cancellous bone became thin and perforated, trabecular lattice system also became thinner and partially interrupted, forming large cavities. (Fig.1,3,4). In some areas they were significantly thin with broken edges. (Fig. 4). Lattice system also became thinner and partially interrupted. Trabeculae became thin, distance between them increased. The thinning was in cancellous bone, but some quantity of osteons preserved under periosteum.

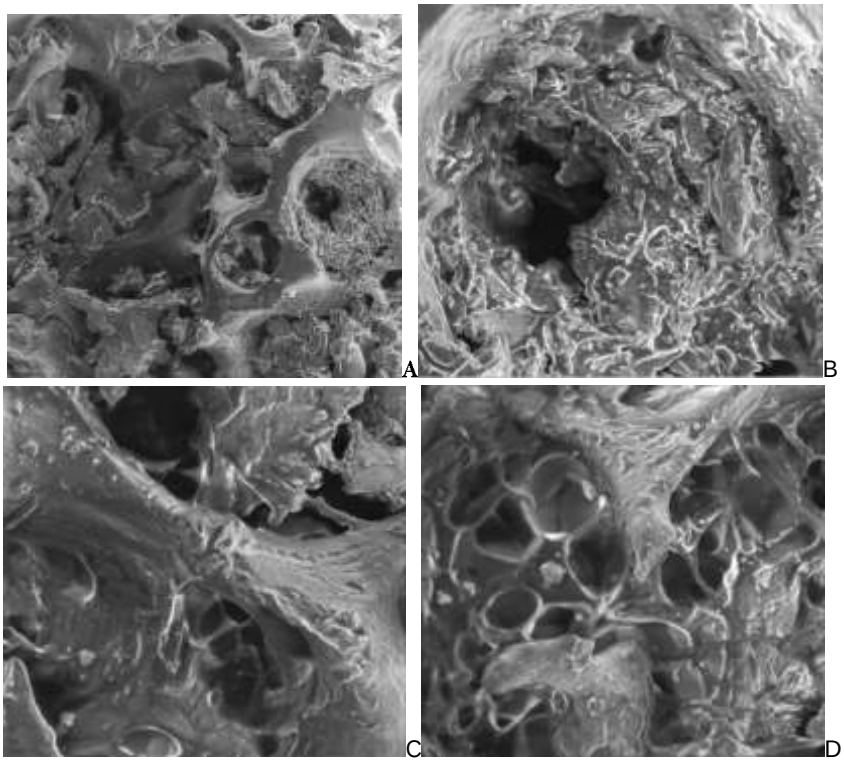


Figure 1: Fragment of the femoral head obtained as a result of the operation of total hip arthroplasty of a 60-year-old woman with a diagnosis of Closed transcervical fracture of the femur against the background of systemic osteoporosis. In the tissue - large cavities of irregular shape, with uneven edges. In part of them (Fig. A) - blood clots. The structure of osteon is broken. The walls of the Haversian channels are changed (A, B). The clearance is narrowed. Layers of small star-shaped voids are located parallel to the surface of the plates, continuing into numerous thin tubules (B, D), in which there are bone cells that give processes to the tubules. They are of various magnitudes, and their form is changed.
SAM. Fig. B (500), C (x500), D (X1000) fragments of Fig. A (x150).

Microfractures of bone beams were accompanied with small hemorrhages, from which clots had formed. (Fig. 1,2,3). Osteogenic cell tissue was detected. (Fig. 2). Micro-callus of coarse fiber structure was formed from it. Havers canal with

surrounding concentric bone plates is the structural unit of compact substance of bone. The anatomy of osteon was violated. (Fig.1,3). Walls of Havers canal were violated. The clearance was narrowed. The layer of small star-shaped voids was located in parallel of surface of these plates. These voids continuing in numerous thin canals (" bone bodies"), where bone cells, giving processes into canals, were located (Fig. 1).

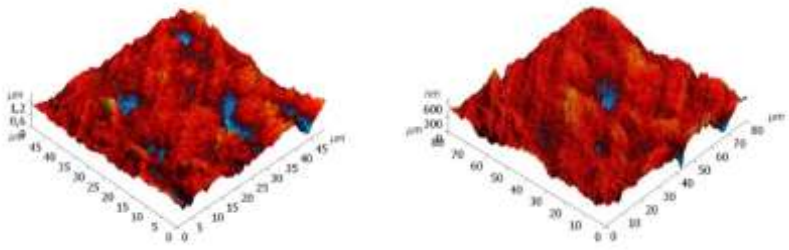


Figure 2: Fragment of the femoral head obtained as a result of surgery during hip joint replacement with osteoporosis in a 69-year-old man. In the tissue - cavities of irregular shape, with uneven edges. In some of them - blood clots. The fabric has a coarse fiber structure with a violation of the location of the fibers. Atomic force microscopy. Three-dimensional image.

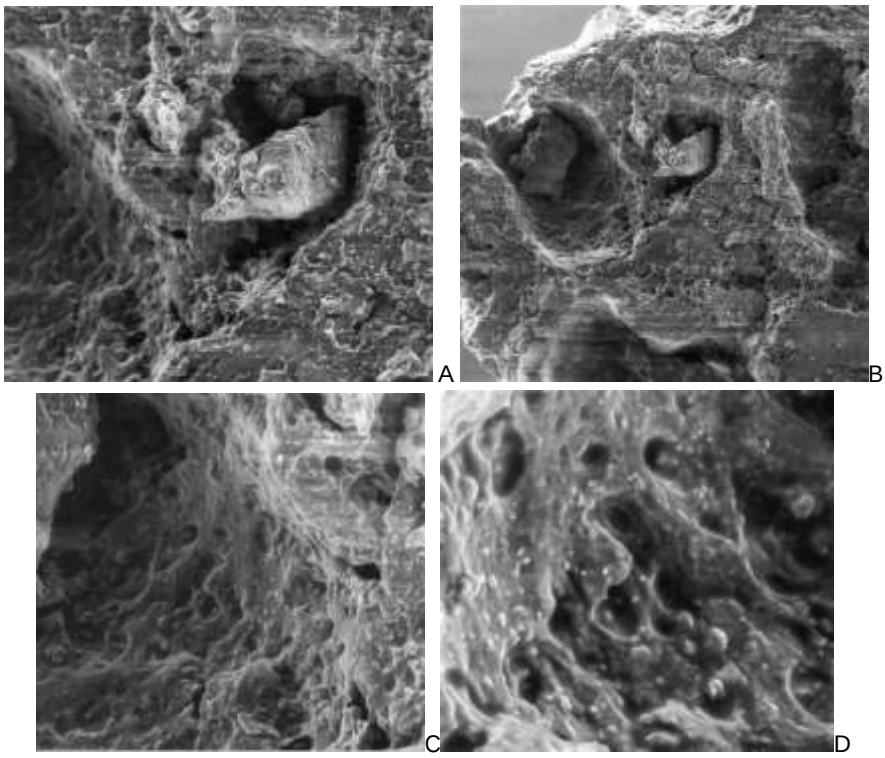
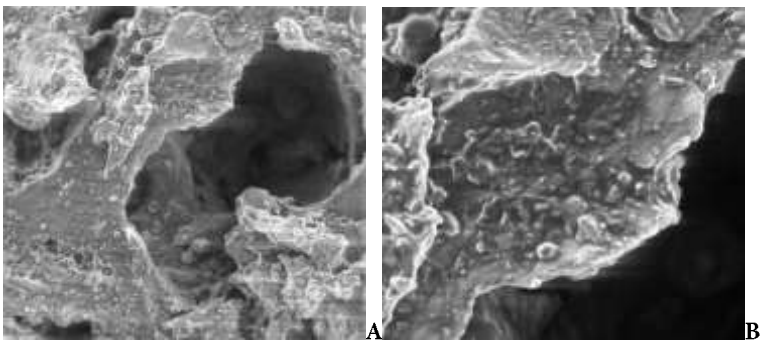


Figure 3: Fragment of the femoral head obtained as a result of an operation during hip joint replacement with osteoporosis in a 65-year-old woman. The structure of the osteon is broken. In the tissue - large cavities of irregular shape, with uneven edges. In part of them (Fig. A) - blood clots.
SAM. Fig. B (200), C (x400), D (x800) fragments of Fig. A (x100).



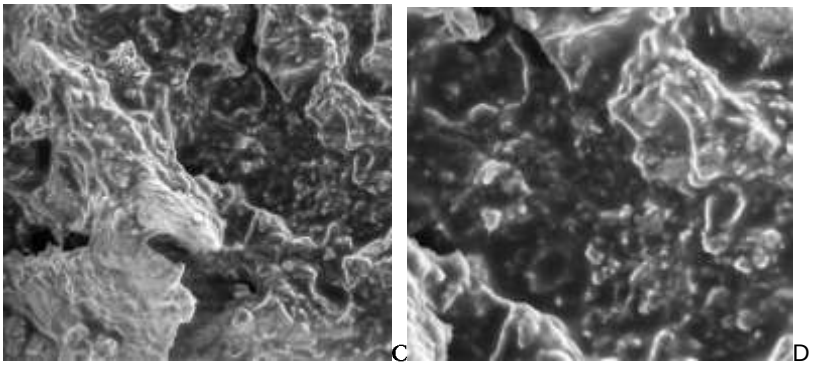


Figure 4: Fragment of the femoral head obtained as a result of an operation during hip replacement with osteoporosis in a 68-year-old man. The structure of the osteon is broken. In the tissue - large cavities of irregular shape, with uneven edges, thinned and partially broken off. In part of them (Fig. A) – thrombus. SAM. Fig. B (x200), C (x600), D (x500) fragments of Fig. A (x100).

The iliac bones during conduction of bone plasty at impression fractures of condyles of tibia were second group. Collagen fibers, which were surrounded by hydroxyapatite crystals and formed in plates, presented its base. They were located concentrically around Havers canals, where thin-walled arteries and veins passed. Their another part was between these systems, clasping their whole groups or passing in parallel with bine surface. Canals with plates formed right osteons of concentric form. The layer of small star-shaped voids was located in parallel of surface of these plates. These voids continuing in numerous thin canals, where where bone cells, giving processes into canals, were located. The cancellous substance had no Havers canals. Intercellular substance of bone tissue consisted from base substance and fibers, formed into bunches, which had ordered and promiscuous orientation.

The decreasing of total area of bone tissue was morphological manifestation of osteoporosis. Normal bone plates in cancellous bone became thin and perforated, trabecular lattice system also became thinner and partially interrupted. Trabeculae became thin, distance between them increased, what led to spreading of bone marrow space. The structure of Havers canals was violated. The thinning of tissue in cancellous substance was due to transformation of endosteal layer of cortical bone. The fibers of intercellular substance of bone tissue were placed randomly, large intervals were between bunches (pic. 5,6). Some quantity of osteons preserved under periosteum, the formation of new bone in cancellous bone was violated due to absence of germ surfaces.

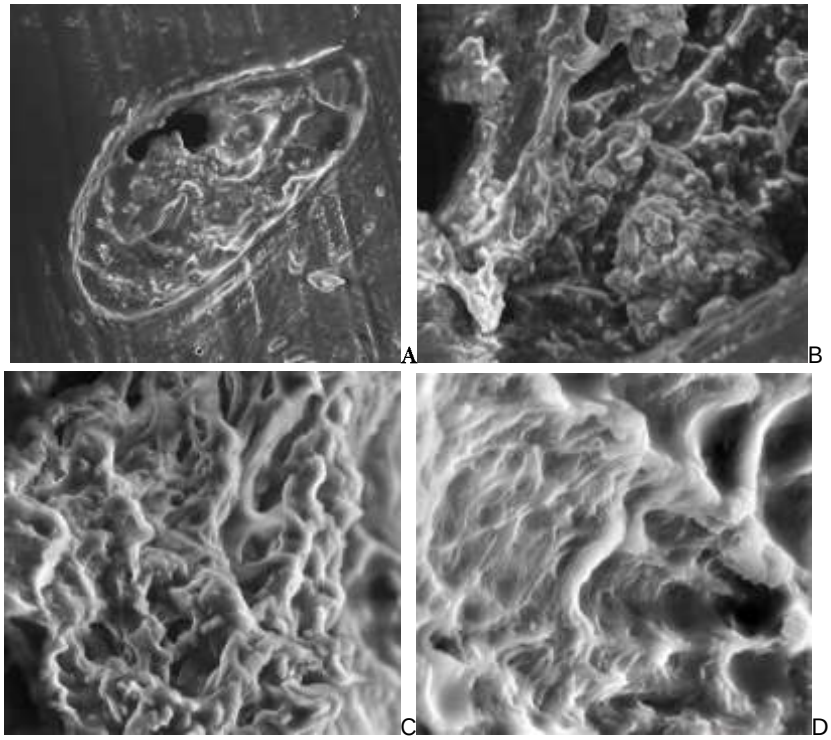


Figure 5: Fragment of the bone tissue from the iliac crest during bone grafting during fractures with a defect in bone mass during the impression fracture of the tibial condyles against osteoporosis in a 70-year-old man. The structure of Haversian

channels is broken, the lumen is narrowed, the structure of the walls (Fig. C, D) is changed. SAM. Fig. B (x1000), C (x2000), D (x4000) fragments of Fig. A (x500).

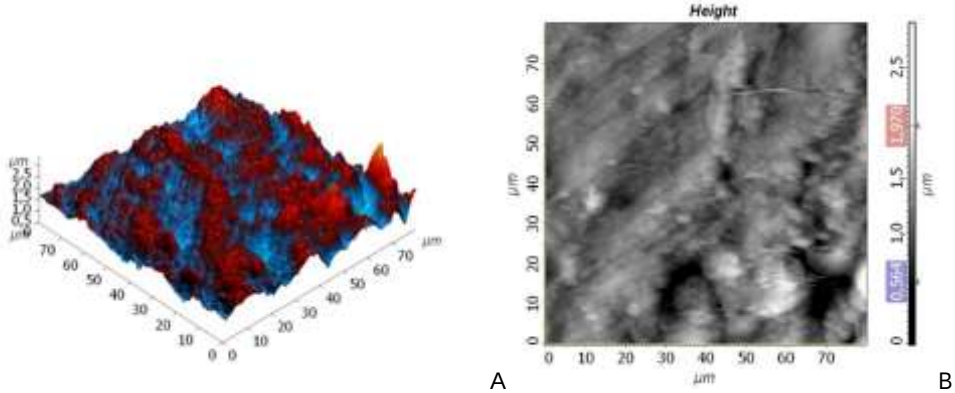


Figure 6: Fragment of the bone tissue from the iliac crest during bone grafting during fractures with a defect in bone mass during the impression fracture of the tibial condyles against osteoporosis in a 70-year-old man. The structure of bone tissue is broken. The coarse fibrous intercellular tissue does not have a clear, parallel orientation of the fibers. Large cavities are observed. Atomic force microscopy.
Fig. A - three-dimensional image, B - two-dimensional.

CONCLUSION

Thus, at exploration of morphofunctional features of bone tissue at osteoporosis it was founded that the decreasing of total area of solid substance in bone tissue took place. In cancellous substance bone plates became perforated and thin, collapsed, forming large cavities. Trabecular lattice system became thin and partially interrupted. Trabeculae became thin, distance between them increased.

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