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FORENSIC MORPHOLOGICAL SIGNS CHARACTERIZING STABILITY OF THE FEMUR, TIBIA AND FIBULA DURING EFFECT OF EXTERNAL DESTRUCTIVE LOAD

MORFOLOGICZNE OBJAWY WYKORZYSTYWANE W KRYMINALISTYCE CHARAKTERYZUJĄCE STABILNOŚĆ KOŚCI UDOWEJ, KOŚCI STRZAŁKOWEJ ORAZ KOŚCI PISZCZELOWEJ W TRAKCIE DZIAŁANIA ZEWNĘTRZNEJ SIŁY NISZCZĄCEJ

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ABSTRACT

Introduction: Fractures of the lower limb bones very often become the subject of forensic expertise when experts have to determine the mechanisms of fracture formation, make retrospective restoration of conditions of their occurrence, solve the issues concerning the possibility of their formation under certain conditions.

The aim of study is directed to investigation of morphological signs facilitating solidity of the osseous tissue of the lower limb long tubular bones, and therefore, promoting biochemical processes of their destruction in case of external traumatic impact.

Materials and methods: Expert investigations included 128 injuries of the long tubular bones of the lower limb: femoral bone – 40 cases, tibia – 46, fibula – 42. Fractures of every bone were assessed by the three thirds: proximal, middle and distal. All the 29 macroscopic and 8 microscopic morphological signs of the osseous tissue were examined. Control studies were carried out on 576 specimens of the femoral bone, tibia and fibula (192 specimens of each), removed from dead males and females aged from 24 to 70.

Results: The most valuable morphological signs forming "modulus of stability" are: length of plastic deformity zones from the site of stretching and compression, deviation angle of sphenoid cracks together with the character of traumatic injury impact. An important value in this respect belongs to the square of the medullar canal, length of the biggest sphenoid crack, number of longitudinal cracks and shape of the medullar canal from the site of compression, total mineral content and the height of the biggest crest in the rupture zone.

Conclusions: "Modulus of stability" of the osseous tissue of the long tubular bones of the lower limb most accurately reflects interaction of traumatic mechanical impact with the bone structures during their injuries that should be considered in forensic practice in the process of making expertise.

KEY WORDS: stability, morphological signs, osseous tissue, tubular bones, lower limb

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INTRODUCTION

Fractures of the lower limb bones occur twice as many as fractures of the upper limb bones. They often become the subject of forensic expertise when experts have to determine the mechanisms of fracture formation, make retrospective restoration of conditions of their occurrence, solve the issues concerning the possibility of their formation under certain conditions, etc.

At the present stage of development of forensic science and practice determination of the mechanisms of fracture formation includes a comprehensive approach concerning this issue with investigation of physical properties of the osseous tissue, analysis of the regularities of deformities and destruction considering structural and geometric peculiarities of bones [1-3].

Nowadays forensic medicine experiences the lack of a clear algorithm concerning the effect of structural-functional peculiarities of certain portions of the lower limb long bones and regularities of mechanogenesis and morphogenesis of their fractures. At the same time, modern forensic practice requires a detailed study of the main structural components of the long tubular bones influencing on their stability in case of their destruction [4,5].

THE AIM

The study aims at investigation of morphological signs facilitating solidity of the osseous tissue of the lower limb long tubular bones, and therefore, promoting biochemical processes of their destruction in case of external traumatic impact.

MATERIALS AND METHODS

Our expert investigations included injuries of the long tubular bones of the lower limb: femoral bone – 40 cases, tibia – 46, fibula – 42. Fractures of every bone were assessed by the three thirds: proximal, middle and distal.

Metric *macroscopic* measurements were made by means of a caliper – directly on the bone and by means of applied

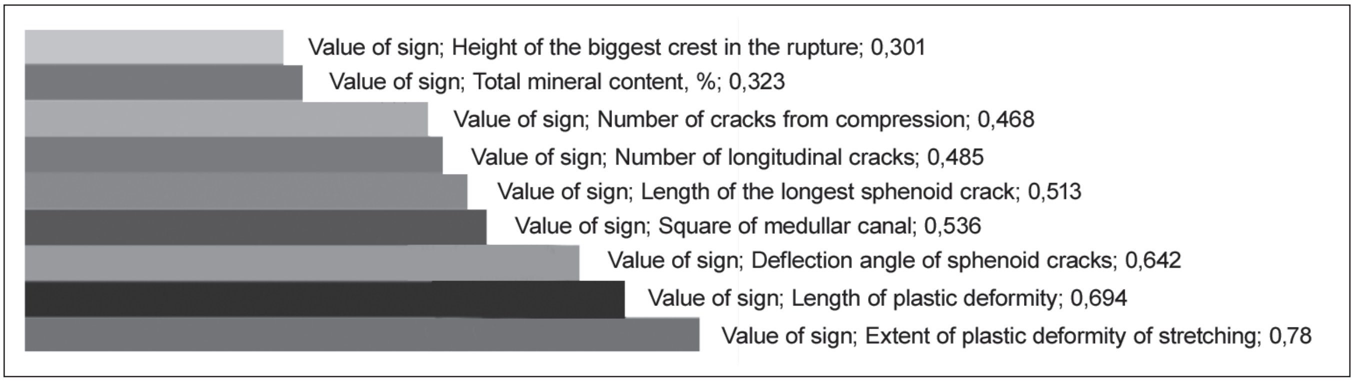

Fig. 1. A number of forensic morphological signs of "modulus of stability" of the lower limb long tubular bones and their value.

computer programs including the functions of taking linear sizes and distance between separate elements – on a digital image of a destructed bone.

Totally 29 parameters were obtained characterizing structural-functional peculiarities of the examined bone in the place of destruction, area and square of its fracture: bone circumference; longitudinal bone diameter; transverse bone diameter; longitudinal diameter of the medullar canal; transverse diameter of the medullar canal; medullar parameter in the longitudinal direction (correlation of longitudinal diameters of the medullar canal and bone); medullar parameter in the transverse direction (correlation of transverse diameters of the medullar canal and bone); the compact substance thickness in the anterior bone sectors; the compact substance thickness in the posterior bone sectors; the compact substance thickness in the median bone sectors; the compact substance thickness in the lateral bone sectors; discontinuity coefficient concerning the bone diameter; discontinuity coefficient concerning the compact substance thickness; extent of a plastic deformity area from the side of rupture; the number of teeth in the area of rupture; the number of treelike fissures from the side of sprain; the number of longitudinal fissures from the side of sprain; the number of fissures from the medullar canal from the side of sprain; rupture area coefficient concerning the bone diameter; rupture area coefficient concerning the compact substance thickness; extent of a plastic deformity area from the side of compression; the height of the biggest crest in the rupture area; the number of V-shaped fissures passing from the final portions of the cone-shaped depressions in the rupture area; the number of V-shaped fissures passing from the lateral portions of the cone-shaped depressions in the rupture area; the length of the longest V-shaped fissure; deviation angle of V-shaped fissures; the number of fissures from the medullar canal from the side of compression; the number of X-, V-shape fissures from the side of compression; the number of longitudinal fissures from the side of compression.

Examination of morphological signs of the osseous tissue on the *micro-level* was conducted on 576 specimens of the femoral bone, tibia and fibula (192 specimens of each), removed from dead males and females aged from 24 to 70 (the control group). 156 (81,2 %) specimens of every bone were taken from men and 36 (18,8 %) – from women. The biggest number of the examined specimens were taken from the individuals 36-60 years of age –144 (75,0 %) from every bone; 24 (12,5 %) from the femoral bone, tibia and fibula were taken from the individuals 22-35 years of age and 61-74 years.

General volume of every specimen V_1 was determined by means of centrifuge tubes with marks, their mass before and after their filling with fluid (ortoxylene), centrifugation, drying, processing of the organic substance in the muffle furnace, obtaining appropriate masses m i m^1.

The data received were processed by means of a number of physical formulas, therefore obtaining a number of volumetric-massive parameters: the volume of pores of the hard matrix and water, the volume of organic and mineral content, density of organic and mineral content of every specimen, total density and the content of mineral mass in them. The square of the medullar canal in the proximal, middle and distal portions of the femoral bone, tibia and fibula with accuracy to 0,01 cm was calculated as well.

In the process of the comparative analysis and generalization of the findings obtained with calculation of such statistical indices as arithmetic mean, mean arithmetic error, mean-square deviation, quartile and confidence interval with the use of frequency analysis, single-factor and multi-factor analyses of variance, the interrelations between the main characteristics of fractures and morphological structural signs of different portions of the lower limb long bones were determined.

RESULTS AND DISCUSSION

The part of the bone due to the effect of external impact is accompanied by deformity of the osseous tissue with formation of fractures, stratification, flexion and micro-crakcs. Splits and crests with dentate surface and a number of cracks in the bone are formed in the direction of force vector action.

The effect of physical forces causing bone fractures included four main groups: blunt injuries with flexion deformity, twisting, compression and effect along the axis of the limb.

Determined regularities of structural disorders of the lower limb long tubular bones in case of their injuries enabled to distribute structural-functional peculiarities of their structure and separate morphological signs of bone fractures.

All the 29 morphological parameters of fracture area and 8 volumetric-massive parameters of structural peculiarities of the examined bones were grouped into separate factors (modules).

Among others the factor is distinguished that is the most valuable and rather completely reflects interrelation of traumatic mechanical impact with bone structures and its injuries. The most complete and integral its characteristics will be grouping together interrelated forensic-morphological signs under the name "modulus of stability" of the bone (Fig. 1).

This factor sufficiently describes interrelation of traumatic mechanical force with bone structures and its injuries associated with "modulus of stability" of the bone. Length of plastic deformity zones from the site of stretching and compression is the most important sign in it. Deflection angle of sphenoid cracks consisting factor 3 occupies a leading position together with the character of traumatic force action. An important value in this respect belongs to the square of the medullar canal, length of the biggest sphenoid crack, number of longitudinal cracks and shape of the medullar canal from the site of compression, total mineral content and the height of the biggest crest in the rupture zone.

Thus, long bones of the lower limbs exclusively rationally meet structural requirements of the human body. Possessing a minimal weight due to their hollow tubular structure they ensure high stability to axial forces of compression [6].

Next parameters of the bones as circumference, thickness of the compact osseous substance, size of the medullary canal, mineral and organic content play an important role in the formation of firmness and stability to the influence of mechanical environmental factors [7-8].

Trauma is associated with the formation of a number of cracks of different types. Splits and crests with dentate surface are formed in the direction of force vector action. In general, the frequency of crack formation and their number depended on the circumstances and severity of the trauma itself. At the same time, different types of cracks demonstrated their maximal values according to their amount reflecting the mechanics of fracture.

In addition to mechanical effect of physical force on the bone, formation of cracks is considerably affected by physical-chemical features of the bone itself, its content and geometric shape [9-10].

The prospects of future studies consists of further comprehensive examination of interrelations between the main structural components of the osseous tissue and regularities of formation of morphological signs in case of fractures of various bones of the human skeleton. Detection of morphological signs of long tubular bones fractures enables to identify the character of the injury and find the mechanism of its occurrence in forensic-medical practice.

CONCLUSIONS

1. Proximal, median and distal thirds of the femur, tibia and fibula of the lower limb possess a considerable number of morphological peculiarities reflecting their stability.
2. "Modulus of stability" of the osseous tissue of the long tubular bones of the lower limb reflects interrelation of a traumatic mechanical impact with bone structure in case of injury that should be considered in forensic practice in the process of determining the mechanisms of their destruction.

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Conflict of interest:
The Author declare no conflict of interest.

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