Original Article

ISSN (O): 2635-0823; ISSN (P): 2635-0815

Complex Radiation Diagnostics of Non-Healed Fractures and Post-Traumatic False Joints of Long Tubular Bones

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Abstract

The dependence of severity, and accordingly, the number of complications and consequences, including false joints, on the mechanism of injury is known. Recently, there has been an increase in the number of injuries resulting from exposure to high kinetic energy (road traffic, firearms), leading to an increase in disability. In this regard, in order to reduce the severity of the social consequences of injuries, specialized assistance to victims, the introduction of new diagnostic and treatment technologies, both at the stage of primary care and at the stage of treatment of consequences, is becoming important. The purpose of the study. To improve the diagnosis of ungrown fractures and post-traumatic false joints of long tubular bones by using complex ultrasound diagnostics. The study of patients was carried out in a supine position or sitting at rest and was carried out both under conditions of plaster immobilization and without it. During plaster immobilization, the sensor was positioned through a ”window” in the plaster splint, while control from the healthy limb was carried out in the same position of the sensor as on the affected side.

Keywords: Osteoreparation Disorders, Orthopedic, Pseudoarthrosis, Ungrown Fractures, Ultrasound Examinations.

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Received: 05 December 2021 **Revised: 16 January 2022** **Accepted: 29 January 2022** **Published: 10 February 2022**

Introduction

Osteoreparation disorders in the form of false joints and bone defects in the structure of orthopedic pathology account for 16.7-57.6%.[1] Non-fusion and false joints of long tubular bones, bone tissue defects reach 39.3% of the complications of conservative or surgical methods of treatment.[2,3]

The dependence of severity, and accordingly, the number of complications and consequences, including false joints, on the mechanism of injury is known. Recently, there has been an increase in the number of injuries resulting from exposure to high kinetic energy (road traffic, firearms), leading to an increase in disability. In this regard, in order to reduce the severity of the social consequences of injuries, specialized assistance to victims, the introduction of new diagnostic and treatment technologies, both at the stage of primary care and at the stage of treatment of consequences, is becoming important.[4–6]

The manifestation of disorders of reparative osteogenesis in the form of delayed consolidation of fractures, the formation of pseudoarthrosis and bone defects requires long-term treatment using a complex set of surgical interventions, while not always achieving a satisfactory result. The study of disorders of reparative osteogenesis in bone injuries, osteotomies, bone grafting, the use of various types of osteosynthesis is one of the urgent problems of modern traumatology and orthopedics.

The purpose of the study: To improve the diagnosis of ungrown fractures and post-traumatic false joints of long tubular bones by using complex ultrasound diagnostics.

Material and Methods

The present work is based on the analysis of the results of a comprehensive clinical and laboratory, ultrasound and X-ray examination in 34 patients with posttraumatic false joints and non-accreted fractures of long tubular bones.

The study was conducted in two stages. At the first stage, in order to identify the structure, trends and features of injuries to long tubular bones of various age groups and features of care for them, a retrospective analysis of 15 medical histories of patients admitted to the Department of traumatology for the period from 2012 to 2016 with complications of fractures of tubular bones was carried out.

At the second stage of the study, a prospective analysis was carried out of 19 patients with complications of fractures of long tubular bones who were admitted to the RSNPMC of Traumatology and Orthopedics from 2017 to 2019. In this section of the research, a comparative analysis of the features of mechanogenesis, the clinic and the results of treatment of ungrown fractures and false joints in patients was carried out using generally accepted radiological control methods in comparison with the ultrasound diagnostic method proposed by us, monitoring the processes of fracture consolidation disorders. The analyzed group of patients included: men - 9 patients, women - 6 patients. The average age of the patients was (36 ± 3) years. In the main group of the study there were 19 patients (12 men and 7 women) admitted within 4 months to 3 years after the primary injury with various disorders of the course of consolidation of the fracture of long tubular bones. The study included only those patients who had no clinical or laboratory signs of inflammatory phenomena at the fracture site at the time of admission. In this group, isolated damage was observed in 5 patients. As in the retrospective analysis group, multiple injuries occurred in 2 patients: in 1 patient - a fused fracture of the bones of the right tibia in s/3, a fused fracture of the left humerus, in the 2nd patient - a fused fracture of the distal bones of the left tibia. The average age of patients was 39.4 years. X-ray examination was performed on all patients who participated in the study (34 patients) before the start of treatment and at its various stages using the Flexavision digital device, Japan.

Ultrasound examinations were performed in all patients with ungrown fractures and pseudoarthrosis of the bones of the forearm, humerus, femur, and shin bones. Ultrasound devices My Lab-40, Italy, Sonoscape S 22 were used in real time using broadband, high-frequency linear sensors of 8.0 - 12.0 MHz, thanks to which high resolution is provided on diagnostic images of connective tissue structures of the bone surface (cortical layer of bone). The study of patients was carried out in a supine position or sitting at rest and was carried out both under conditions of plaster immobilization and without it. During plaster immobilization, the sensor was positioned through a ”window” in the plaster splint, while control from the healthy limb was carried out in the same position of the sensor as on the affected side.

Results and Discussion

The retrospective analysis group included data from the medical histories of 15 patients with various types of disorders of consolidation of fractures of long tubular bones. In the study group, 2 patients had delayed fracture consolidation, 5 patients had non-fusion of the fracture, and 8 patients were diagnosed with pseudoarthrosis of long tubular bones. Follow-up periods ranged from 3 months to 1.5 years after fractures of long tubular bones.

When conducting a retrospective analysis of the results of diagnosis and treatment of patients with disorders of consolidation of fractures of long tubular bones, who underwent X-ray methods, as well as bone-plastic surgery, without taking into account the localization of the zone of non-fusion and the area of contact between fragments, that is, ultrasound methods were not used in this group of patients.

It can be noted that in retrospective analysis, as a result of diagnosis and treatment, a number of therapeutic and diagnostic errors were made, which could have been avoided with a timely examination of the injured by a traumatologist and ultrasound examinations in monitoring.

The deadlines from the moment of fracture in the main group were: up to 1 year - 13 radiographs; over 1 year - 7 radiographs.

The multiplicity of X-ray images depended mainly on the nature of non-accreted fractures and pseudoarthrosis. As a standard, radiography of the damaged limb was performed upon admission, after the reposition of fragments, 5-7 days after the reduction of soft tissue edema and before discharge, as well as radiography was performed at non-standard times: in the presence of secondary displacements and repeated repositions, during treatment with skeletal traction and osteosynthesis.

During the analysis of radiographs, we found that:

1. In all cases, the area of non-fusion is represented by two fragments with a predominance of an oblique or transverse fracture line;
2. The area of contact between fragments varies from 35% to 70%; 3. In the area of the non-fusion zone, the density of bone tissue increases by approximately 20% of the density of the intact bone, and then, as it moves away from this area, it approaches the normal value (observed in the intact bone).

The X-ray method determined the efficiency of reposition, the stability of osteosynthesis, and the degree of fracture consolidation.

In the study group (19), all patients underwent ultrasound scanning to identify the nature of the limb injury. In the vast majority of cases, the echography of superficially located structures, carried out in B-mode, allowed us to solve the tasks assigned to us.

A prerequisite for conducting an ultrasound examination of long tubular bones was scanning the structure of interest to us and comparing it with a similar structure of the contralateral side, which allowed us to detect minimal changes. First of all, it concerned the assessment of the periosteum, articular cracks, the thickness of hyaline cartilage, as well as bone calluses. Reliable, in terms of the diagnosis of pathological changes in soft tissue structures, is the difference in the thickness of the

studied structure exceeding 2 mm.

Ultrasound examination of bones was limited exclusively to the assessment of articular surfaces and the external contour, since due to the powerful reflection of ultrasonic waves from the bone surface, it is impossible to assess the structure of bone tissue during ultrasound scanning. Normally, with echography, the bone surface is visualized as a hyperechoic linear structure.

When scanning an intact limb, soft tissue structures and bone are determined in the following sequence: from the scanning surface of the sensor to the bone. The visual picture of the structures is as follows: the skin was defined as a hyperechoic linear structure, the subcutaneous fat layer was represented as a layer of homogeneous tissue, reduced echogenicity and varied in thickness, muscle tissue - as a feathery structure of reduced echogenicity, the periosteum was not determined when scanning an intact limb, the cortical layer of bone was represented by a hyperechoic linear structure that does not pass ultrasound through itself. In the angioregime, the blood flow is not determined (not changed) in the paraossal soft tissues.

Ultrasound of the osteoreparation zone was performed in triplex scanning mode. Technique: two-dimensional scanning mode (B-mode) to assess the cortical layer of bone, that is, to visualize a bone wound; ultrasound angiography - modes of color Doppler mapping (CC) and energy mapping (EC), which were used to determine the qualitative characteristics of blood flow with an assessment of the direction of blood flow in the vessels (to the sensor or from the sensor). These techniques also make it possible to visualize vessels in the forming osteoid tissue of the regenerate.

The use of pulse-wave Doppler technique made it possible to determine the quantitative characteristics of local blood flow in the injury zone in the emerging regenerate with an assessment of spectral hemodynamic parameters of blood flow (velocity indicators, peripheral resistance index.[7–9]

In the course of studying the course of the reparative process by ultrasound, two techniques were used. In the presence of a plaster cast or a splint, the study was carried out through a specially created acoustic window, the dimensions of which made it possible to install an ultrasonic sensor on the ”area of interest” and thereby ensure the unhindered passage of ultrasound.[10,11]

When diagnosing false joints in B-mode, changes from the soft tissues were represented by edema or hematoma - in more severe cases of damage (fracture of the femur). Soft tissue edema was determined by an increase in volume in comparison with the contralateral limb, the echogenicity of subcutaneous fat was unevenly increased, there was no violation of the integrity of the structures of muscle tissue fibers.[12]

With the help of ultrasound scanning, the interstitial gap was visualized, its linear dimensions were determined, and the dynamics of its filling with hyperechoic inclusions were evaluated. The results of ultrasonographic studies indicated a different nature of ultrasound imaging of reparative processes in patients with fractures and false joints of long bones.

Common to all injuries was the presence of a heterogeneous interstitial gap at the beginning of treatment, followed by the formation of linear echopositis structures in it. Prognostically favorable for bone restoration was the small depth of the visualized fracture gap, which in uncomplicated cases did not exceed 2-3 mm, whereas in cases of impaired consolidation between fragments it was up to 5 mm. The timing of the formation of a callus was slower in fractures with consolidation disorders compared to fractures of uncomplicated course, which was expressed in a slower appearance of hyperechoic inclusions and filling of their interstitial gap.

In the course of our research, we have revealed the ultrasonic stages of consolidation disorders in non-accreted fractures and post-traumatic false joints of long tubular bones, regardless of the injury segment.

The following stages of ultrasound monitoring of fracture healing disorders (dysreparative osteogenesis) are identified, which are inaccessible to conventional radiological and clinical research methods:

1. The stage of microcirculation disturbance, in which the B-mode determines the nature of bone damage, the degree of displacement of fragments and changes in soft tissues in the form of edema, hematoma; in the CDC mode, there are no signs of blood flow in the zone;
2. The stage of restoration of local blood circulation of reparative signs after surgery: - in B-mode, detection of periosteal reaction in the form of the presence of an additional linear hyperechoic structure located in parallel above the inter-fragment gap and hyperechoic segments (fragments). In the CDC mode, the location in the arterial vessels of the muscular type, the systolic blood flow rate did not exceed 10 cm / s, the peripheral resistance index RI = 0.56-0.75. In the veins, the blood flow rate is 3-7cm/s;
3. The stage of increased blood flow and the formation of connective tissue corns in the process of physical rehabilitation: in the B-mode, a zone of reduced echogenicity of the signal was determined paraossally under the periosteal and reaction, the interstitial gap is represented by a hypoechoic formation with multiple small to 1-2 mm hyperechoic signals in the structure (soft corn); in the CDK mode and during spectral dopplerometry, a local increase in blood flow with a blood flow velocity in the arteries Vs = 12-19-23 cm/s, in veins 5-9 cm/s, RI = 0.57-0.66.

According to the results of the research, we have presented the timing of the detection of early signs of the appearance of a callus according to the ultrasound method, the X-ray method.

Considering that it is difficult to determine the timing of the formation of a callus during palpation of a damaged limb, we took the clinical timing of the consolidation stage, at which the functional restoration of the limb occurs.

Conclusion

Thus, in the course of prospective dynamic observation, we determined that the ultrasound method is the leader in early determination of the timing of the formation of a callus, the X-ray method is in second place in identifying the timing, clinical signs are detected in more distant terms. Earlier terms of clinical recovery were determined in patients with ungrown fractures of the bones of the upper limb and in the age subgroup. Later periods of clinical recovery were noted in patients with fractures of the bones of the lower limb. Earlier clinical recovery in fractures of long tubular bones was noted in patients with fractures of the forearm bones.

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How to cite this article: Yusupalieva GA, Yuldashev TA, Akhralov SF, Manashova AR, Umarova UA. Complex Radiation Diagnostics of Non-Healed Fractures and Post-Traumatic False Joints of Long Tubular Bones. Adv Clin Med Res. 2022;3(1):5-8.

Source of Support: Nil, **Conflict of Interest:** None declared.