

Conference paper

## Surgical Treatment of Fractures of Long Tubular Bones of Elderly and Old-Aged People with the Usage of Shape Memory Implants

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### 1 Introduction

The increase of prosperity conditions the increase of life span among the population of the planet with the increase in the number of elderly and old-aged people. Such population of people carries high frequency and risk of bone fractures. Conservative methods condition long periods of immobilization of joints to “post-immobilization osteoporosis”, with that the inconveniences during the treatment process sometimes require outside help and thus lower the quality of life of the patient [13, 14]. Operational methods of treatment of bone fractures offer particular difficulties associated with age-related changes of bone structures, breaches in vessel blood flow, effecting the processes of bone fracture consolidation [13]. Traditional clamps do not always satisfy the requirements of osteosynthesis in this category of patients when it comes to quality and technique. Quite a significant element in treatment of fractures is the precision of reposition of bone pieces, their secure positioning in the achieved correction and with a particular amount of compression [11, 13]. For the purpose of maintaining the pace of consolidation, it is also necessary to increase the value of the regional blood flow of the extremity, we use inter-arterial injection of vessel cocktails of medicinal substances, which allows to decrease the time periods of the fusion of bone pieces. The application of established methods of osteosynthesis without taking the type and localization of tubular bone fracture into consideration leads to

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failures due to the fact that the tubular bone is functionally heterogeneous in structure and strength.

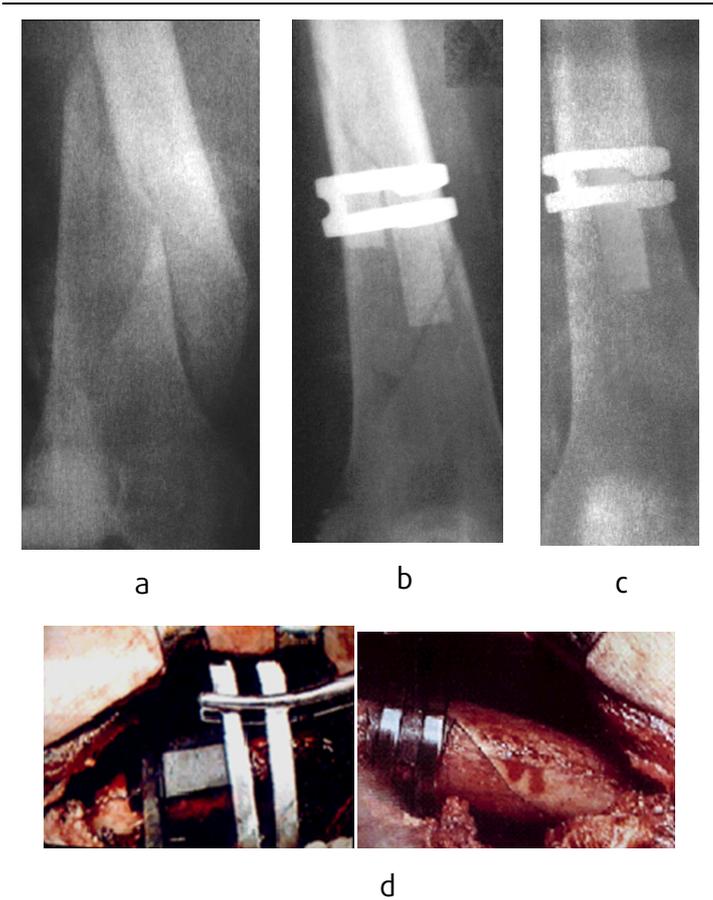


Fig. 1. Roentgenograms of patient R., age 68, with spiral fracture of distal metaphysis of the right hipbone: a – before the surgery; b – after the surgery; c – 6 months after the surgery; d – during the surgery

Clamps used by individuals of young age transferred into conditions of bone with degenerately changed structure leads to failure of fixation of broken-off bone pieces. In the duration of the last quarter of a century, the application of implants with the effect of shape memory has been successfully used in traumatology and orthopedics, and thus has opened the era of osteosynthesis in bone fractures. Along with the effect of shape memory, realizing the work of clamps into compressing, it is important to mention the elasticity of structure material. The development of porous implants in the last decade in different fields of surgery has found its reflection in operative therapy of bone fractures. The practicability of this material lies in perforating porousness, which allows to relief excessively local

pressures of the clamp on the bone, with simultaneous creation of firm fulcrums for the “working” construction elements.

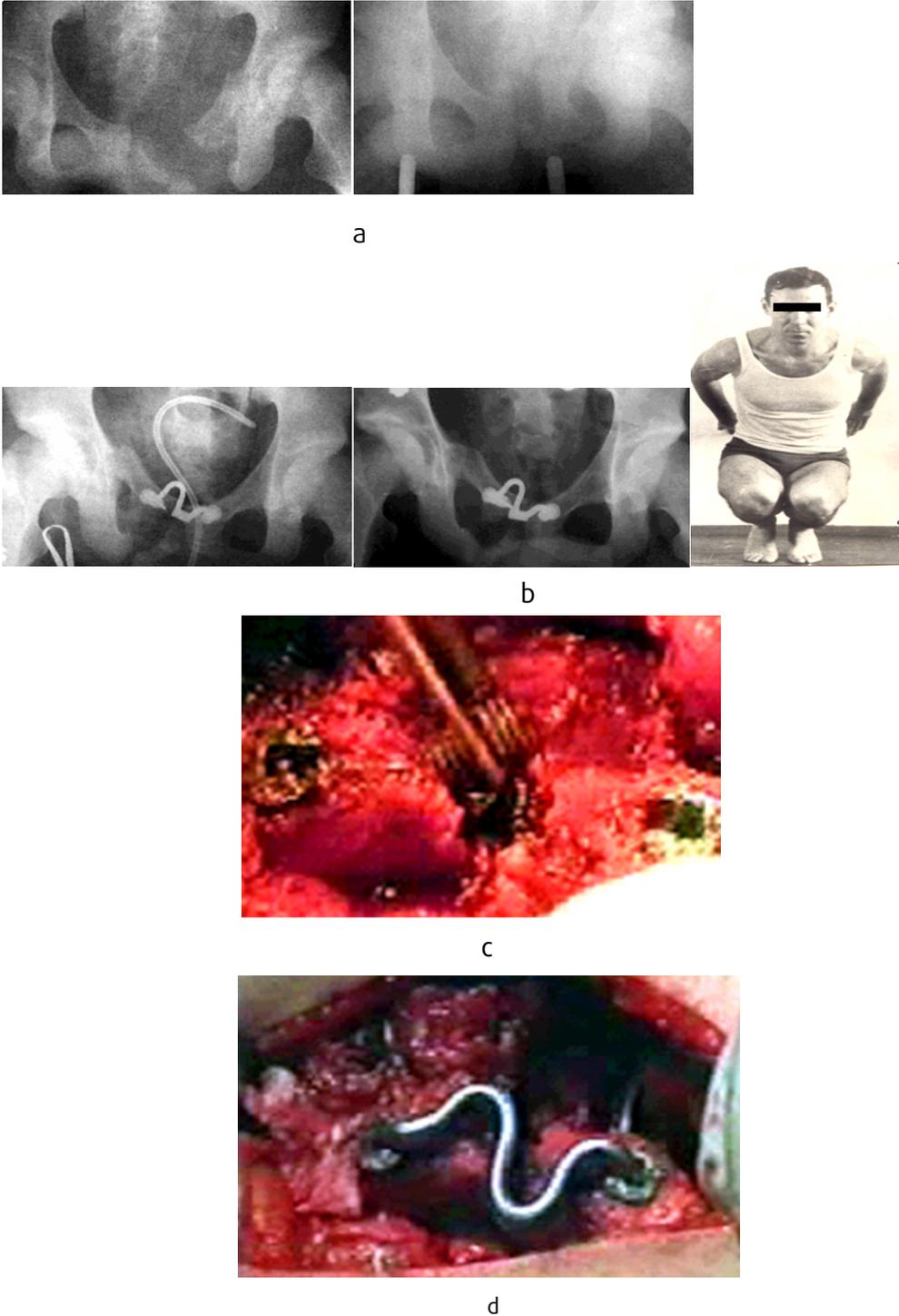


Fig. 2. Roentgenograms of patient O., age 35, with pelvis fracture with dislocation of the pelvic ring: the horizontal branch of pubic and ascending branch of ischium on the right: a - before the surgery; b - during treatment in hammock; c - after the surgery; d - 11 months after the surgery

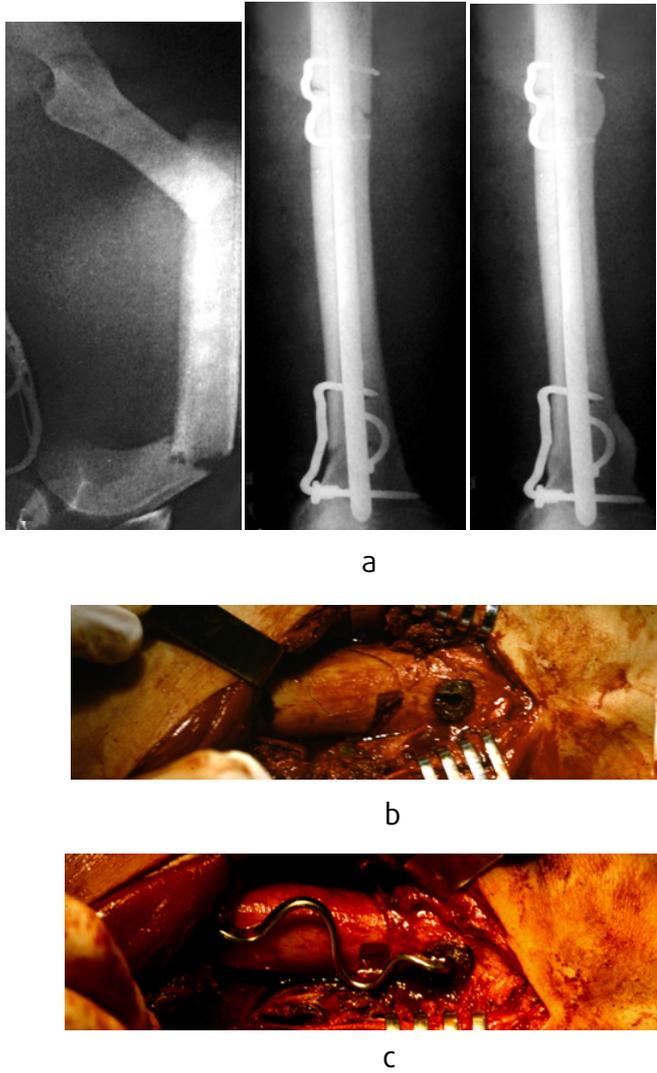


Fig. 3. a - before the surgery; b - after the surgery; c - during the surgery

Constructions from porous permeable material with shape memory in cases of accompanying disease (diabetes, etc.) have been used by us as a depo of medicinal substances, in particular, have been previously soaked with medicinal forms (insulin, etc.) [6]. The inherent qualities of capillarity and the significant volume of pores of the porous implant allows for saturation with liquid medicinal substances. Further on, during an extended period of time, liquid medicinal forms are fractionally excreted into surrounding tissues and the bloodstream. In practice, this has given patients the ability to abandon the use of insulin in the duration of 1.5 - 3 weeks, in the subsequent 3 - 4 weeks only small single supporting doses were needed, and also in the subsequent 2 - 2.5 months the same doses were needed doubly. In the course of the entire duration of fracture consolidation, the glucose level is successfully regulated, significantly, decreasing and lengthening the intervals of injection, through the creation of the depo of medicinal substances

in the porous material [6], which had a positive effect on the flow of the wound process and the process of bone fracture repair.

## 2 Experimental

For the implementation of the task set forth, TN-10 model material with shape memory effect was chosen. Another element allowing to release excessive pressures was manufactured (in the form of "couplings" and oval plates) from porous permeable material with shape memory, model TN-1P with permeable porosity of 60% [2, 5, 6]. Porous permeable "couplings" were used in combination with compressing brackets with thermomechanical memory, and porous semi-oval plates were placed under circular clamps with shape memory [8, 9, 10]. The circular device ought to be chosen accurately when it comes to the factors of both shape and size. In the production of circular constructions, we abandoned the perfectly circular clamp. At present time, on the bases of the conducted osteometric research of the cross-section of each section of the tubular bone, which has been recorded in the computer. Circular clamps with shape memory are made individually and with maximum adaptation to the level of section of the damaged bone, produced by the result of the computer program. 3 narrow porous semi-oval plates are respectively placed under the bone sections undergoing high pressures of the circular clamp, which, as they amortize, release excessively high pressures without disturbing the circulation of liquids in the process. We have altered the compressing clamps with thermomechanical memory, they are flattened in the sagittal plane, which increased the indicators of their strength characteristics. The porous permeable "couplings" previously set in place in each on the bone pieces of the fractured bone, into the openings of the canals into which the legs are imbedded, of the previously cooled compressing clamp with shape memory. The porous "coupling", having a large surface area, prevents deformation and destruction of bone tissue, which are produced by the compressing device. As a result, the "working elements" of the compressing clamp with thermomechanical memory gain a sound point of support, and consequently, the amount of compression remains at a sufficient level. The change of the compressing clamps allowed the application of the combination with intramedullary pin during osteosynthesis of tubular bones. At that, the legs of the compressing clamp go through both cortical plates of bone pieces, tightly jamming with a flat rectangular nail in the marrowy canal, which prevents rotational dislocations of the bone pieces [4, 5, 8, 9, 10].

This combination has found its real practical application in the process of osteosynthesis of tubular bones in five variations:

- fractures with cross-section fracture surface and fracture-dislocations. For this, one or two porous “couplings” are used, which are placed at inner-bone level in each of the broken-off bone pieces, in combination with the compressing clamp with shape memory, in such conditions, the stability of fixation is significantly increased;
- fractures with cross-section fracture line with potentially weak capacity of bone recovery processes. In this case, a porous plate with shape memory is used as the main fixating device, which was supplemented with a compressing clamp with porous “couplings”;
- fracture-dislocations of the acromial end of the collarbone. In this case, an “acromial” hook was used that allowed to fix the distal acromial end of the collarbone to the rostral outgrowth of the shoulder blade. And with the goal of elimination of the damage of the acromial end of the collarbone by the hook with shape memory which was fixed in the structurally porous character of the bone end of the collarbone by means of prior installation of porous “coupling” with the possibility of attaching of the oblique fracture by means of circular clamp with thermomechanical memory and of porous plate;
- oblique and comminuted fractures. A significant additional method to the fixation by circular devices with thermomechanical memory is in the following: three porous permeable semi-oval plates made of shape memory material are placed on repositioned bone pieces. And the working elements of the circular device have to be precisely placed on the porous plates that allow to lower excessive pressures produced by the clamp smoothly;
- comminuted T - and Y- shaped fractures. Their synthesis is accomplished with two lengthened porous “couplings”. “Couplings” are implanted through previously prepared canals in bone pieces located opposite of one another, and through the canal openings in the “couplings” a cooled compressing spiral rod with shape memory is placed, which brings the bone pieces closer to one another as it regains its shape, providing stable attachment.

### 3 Results and discussion

47 patients had surgeries in the clinic, including 2 - fractured bones, 4 - femoral neck fractures, 7 - oblique and comminuted fractures of metaphysis femoral, 7 - fractures of condyles of the tibia, 6 - fractures of the ankle joint, 1 - fracture of the collarbone, 3 - fractures of the “surgical” neck of humerus, 2 - fractures of condyles of the brachial bone, 2 - fractures of diaphysis of the brachial bone, 1 - fracture of diaphysis of the forearm bones, 7 - fractures of distal epimetaphysis of the spokebone, 3 - fractures of hand bones, and 2 - during recovery surgery of valgus

deformation of I toe. And 19 cases (40.4%) were men, 28 cases (59.6%) were women, ages 46-85. In the cases of 8 people with diabetes: 2 - with diabetes + bronchial asthma, 6 - insulin-dependent form of diabetes. 21 patients (44.7%) were subjected to operational treatment with cross-section type of tubular bone fracture, including the cases involving combined application of clamps with shape memory and porous permeable "couplings", which totaled 18 patients (85.7%), and 3 cases of independent compressing clamps (14.3%). Osteosynthesis with oblique bone damages of 16 patients (34.0%), including double-clip ring-shaped clamps in combination with porous plates, used in 14 cases (87.5%), and a double-clip circular device, used independently in 2 cases (12.5%). We used two-step osteosynthesis with the application of multipotent cell material in the process of further work with 10 patients (21.3%). In the case of independent application of devices with thermomechanical memory in the process of osteosynthesis of fractures in the cases of elderly and old-aged people with involute bone changes, and also in the cases of fracture synthesizing with spongy bone structure where it is difficult to provide stable placement of bone pieces. This circumstance makes it necessary to lengthen the time periods of external immobilization, which has negative effects on the consolidation of bone pieces.

We have studied the remote results of treatment within the time frame of 1.5-3 years in the cases of 26 patients who have been operated upon via the combined method with the usage of porous material with shape memory: in the cases of 22 patients (84.6%) the results were declared good, in the cases of 2 patients (7.7%) the results were declared satisfactory, and in the cases of 2 more patients (7.7%) the results were declared unsatisfactory, which were the cases of bone fractures that did not grow back together that required the usage of bone plate in the future. At the same time, 8 patients went through surgery with the usage of multipotent cells on a porous carrier, and all 8 results were declared good, and the fractures grew back together within shorter time periods (Fig. 1, 2, 3).

## 4 Summary

- Combined osteosynthesis via constructions with thermomechanical memory and porous permeable material provides secure attachment of bone pieces with spongy bone tissue structure, and also in the cases of fractures accompanied by changes in bone tissue of elderly people.
- Porous constructions with shape memory with large surface area are capable of relieving 2 - 3 times the amount of additional pressures applied upon bone tissue by dynamic constructions.

- Devices with thermomechanical memory used in combination with porous implants gain a firm point of support, providing stable correction in the location of the fracture in the process.
- Porous permeable material with shape memory is able to create a depo of liquid medical substances which a excreted into the surrounding tissues over a long period of time.
- The most promising direction is the direction with the application of young multipotent cells cultivated on a carrier of porous material within the body of the patient, in the cases of fractures accompanied by difficult cases of osteoporosis.

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