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MECHANICAL TESTS OF THE EXTERNAL FIXATOR OF THE HAND – ANALYSE OF THE THREE-DIMENSIONAL SPACING OF THE BONE IMPLANTS TO THE STABILITY OF BONE FRACTURE FIXING

S. Frankowski[1], P. Frankowski[2]

Summary: *The aim of the study was to present influence of the three-dimensional spacing of the bone implants to the stability of bone fracture fixing in biplane external stabilizer for small bones. The bone chips are fastened by two pairs of Kirschner's wires settled in the frames with can displace along two pins. The various kind of the bone fractures were tested. The analyze was made for the tension, torsion, bending and compression for the different bone fracture configuration.*

Introduction

An external fixation of the bone fragments does not require other immobilization in plaster cast. It leads to earlier rehabilitation and of the patient .It concerns not only small bone fragments but also long bones as well as the fractures of the pelvis. This method can be also used for lengthening or shortening bones. During treatment in most cases the functionality of the fixed limb is kept. The external fixation although laden with a certain defects in comparison with internal stabilisation (e.g. suppuration ,injury of nerves end vessels) is less invasive and in some cases could be applied ambulatory.

Object of the study

The presented fixator (Fig.1) is the original compression-distraction instrument for external stabilization of small bone fragments. During construction an easiness of assembly and a correction bone chips position was taken to consideration. The Kirschner's wires perform implant function of bone grafts.

The system consists of the four equal kinematics pairs. The basis make two pines M-5 (1) on which are situated bodies (2) for wires fixation (3). Fixation ad positioning the bodies of any place the pines is defined by two nuts (4) for every kinematics' pairs. There are screws with a plate fixed (5) in the bodies which locate and fasten the wires determines simultaneously mutual location of the pines. It influences rigidity of all system. Either of the

[1]Dr Stanisław Frankowski, City Hospital Bydgoszcz, Szpitalna Str. 19, 85- 826 Bydgoszcz, Poland

[2]Eng. Paweł Frankowski, Department of Applied Mechanics, Faculty of Mechanical Engineering, University of Technology and Agriculture in Bydgoszcz, 85-791 Bydgoszcz, Prof. S. Kaliskiego 7, Poland, e-mail: pawfra@atr.bydgoszcz.pl

pair of wires make impossible to fixated the fragments displacement regard to plane of fixator determinated by the operator. After the fixation of the wires the body movement regard to pins assures compression or distraction. Number (6) means bone.

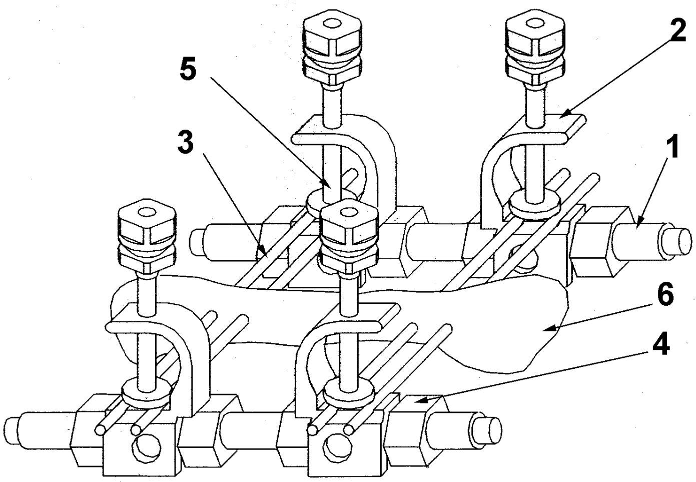

Fig.1. View of stabilizer

Utility of the presented fixator makes possible to realize the following types of osteosynthesis: briding, contact, neutralization, with axial compression of the bone fragments, with possibility for bone broaching.

Fixator testing in specification of monotonic loading

Testing conditions:

The testing of fixator was performed for loads which could be possible during normal treatment end rehabilitation .The model system of osteosynthesis fixator-will be liable to load in the plane of long axis of the bone (the axial longitudinal compression and distraction), torsion round axis of the bone, reach bending in two perpendicular planes.

In testing the growing monotonic loading were used. Every investigations were performed on strength machine type J 8501 by using standard equipment and special holder for non-axial chuck of the stable-bone model system. The force and displacement signal was registrated. As the model of the bones was received a aluminium rod by diameter equals medium diameter of the second finger(∅10 mm). The Kirschner's rods had diameter ∅1,6 mm, and distance between the internal rods amounts 20mm. The distance between parallel axies of two pines amounts 32 mm .For each new test it was used new pair of rods.

The axial tensional load was attained by external load of end fragments of the model – according to scheme.

On the base of the kind of the bone fixation has been separated three groups of the bone fractures. Classification was made by the method of bone fixation in the fixator and basic configuration of the fixator. Three main groups were separated. Group 1.No contact between bone fragments. Kirschner's wires are parallel to the line of the fracture and perpendicular to the bone model. (Fig. 2a). In this group has been separated subgroup with additional Kirschner's wire (Fig. 2b). This group is characteristic for bridging osteosynthesis. In the second group the fracture and Krischner's wires are perpendicular to the bone axis. This group is characteristic for contact osteosynthesis and osteosynthesis with compression between bone fragments. Bone fragments was compressed by the force 600N (Fig. 2c). In third group bone fracture is under 45˚ degree to bone axis. Two outside wires are perpendicular to the bone axis, third is perpendicular to fracture (Fig. 2d).

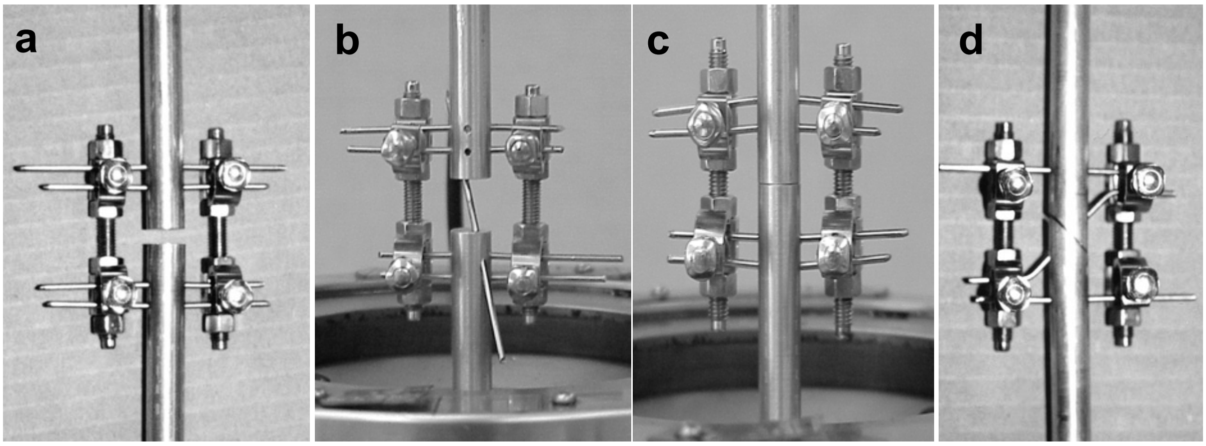

Fig 2. View of the fixator: a- model of bridging osteosynthesis (group 1), b – model of osteosynthesis with additional wire (group 1), c – model of osteosynthesis with compression (group 2), d – model of osteosynthesis with slanting fracture (group 3)

Tests results

Compression

Compression loads was obtained by fixing ends of bone model in strength test machine handles. The test was made to 1 mm displacement of the bone fragments (fig 3).

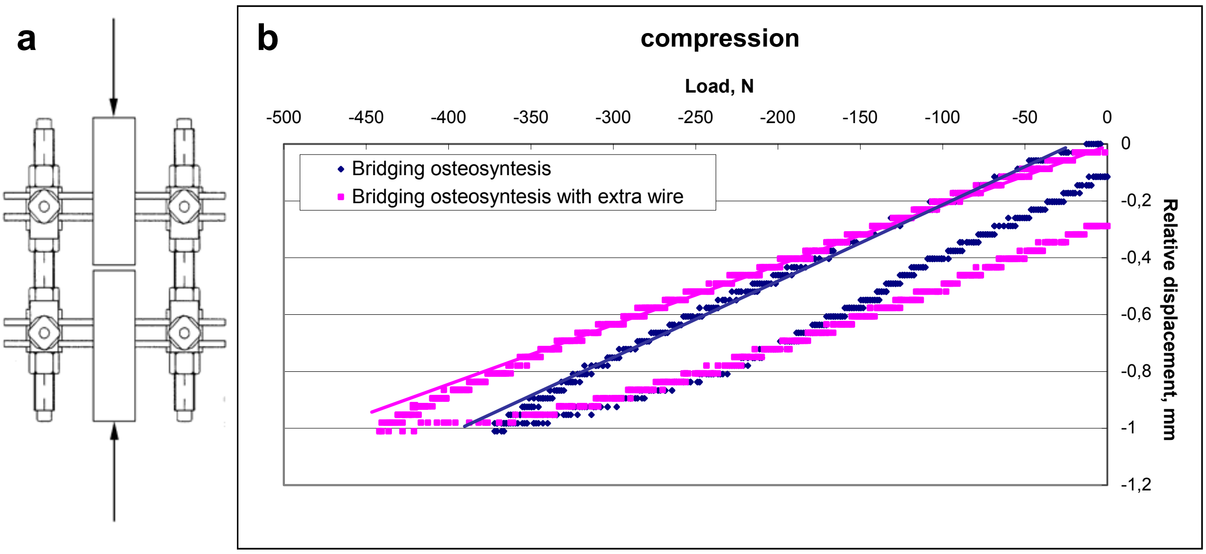

Fig 3. Compression test: a – load scheme, b – research results

Range of elastic work of fixator (fig 3b) is from 0 to 350N for bridging osteosynthesis with extra wire and from 0 to 300N for bridging ostheosynthesis.

Tension

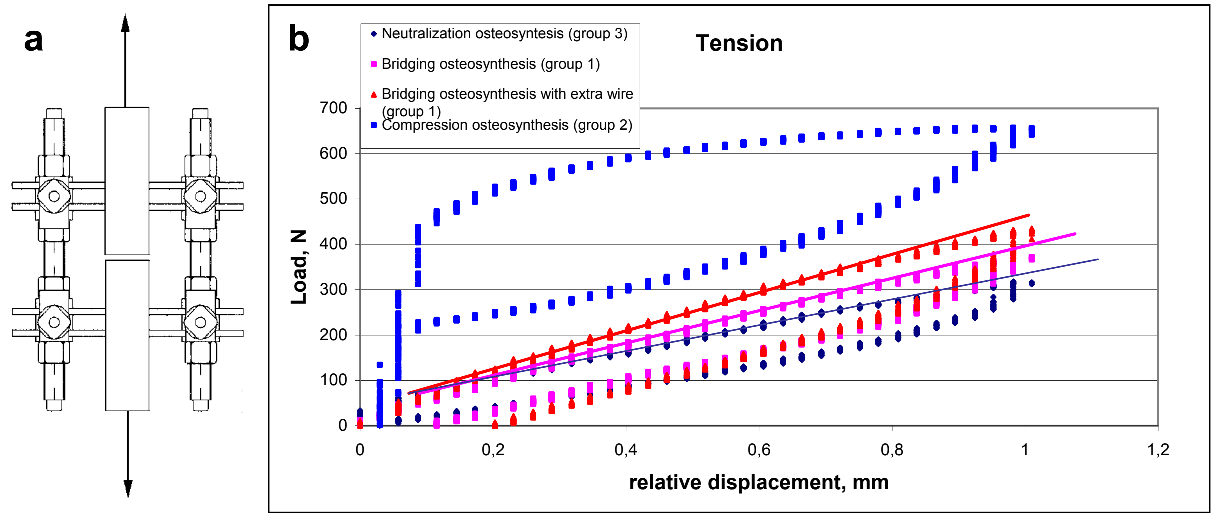

Fig 4. Tension test: a – load scheme, b – research results

The tension tests were made in the same conditions like compression researches.

Range of elastic work of fixator (fig 4b) is from 0 to 370N for bridging osteosynthesis with extra wire, from 0 to 310N for bridging ostheosynthesis and from 0 to 270N for neutralization osteosynthesis. In test for osteosynthesis with compression case the fixator works in plastic strain range.

Torsion

In the torsion test one end of one part of the bone model was fixed. The second part of model was supported. The load was applied into supported part of bone model (fig 5).

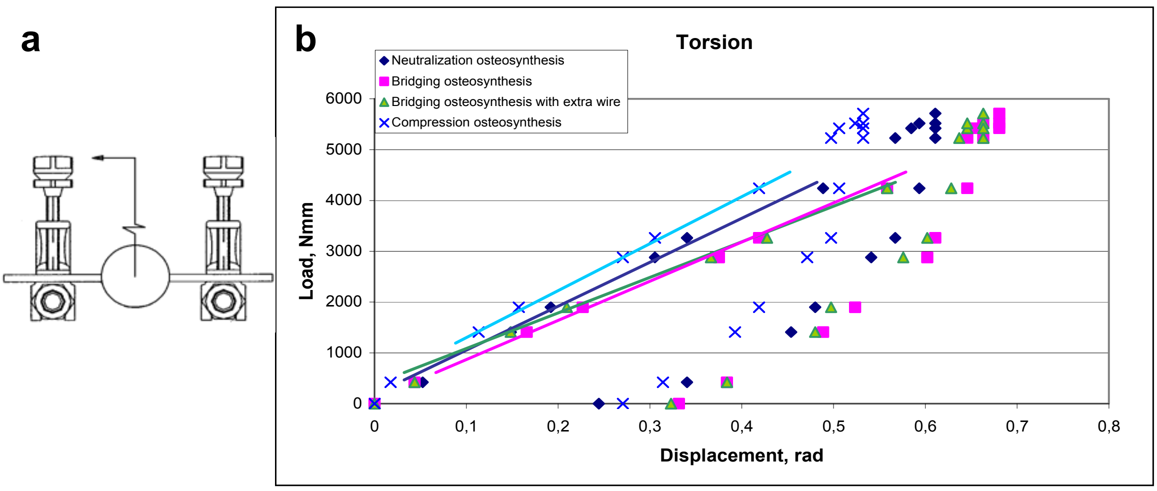

Fig 5. Torsion test: a – load scheme, b – research results

The diagrams are linear to loads about 4,5 Nm for compression osteosynthesis – in this load torsion of bone model was about 15° 30”, about 4 Nm for neutralization osteosynthesis – at this load torsion of bone model was 17° 30” and about 3,5 Nm for bridging osteosynthesis and bridging osteosynthesis with extra wire – in this case torsion of bone model was about 21°.

Bending

Bending in fixator plane

This test were made for all cases of osteosynthesis. Bending of fixator (fig 6b) and bending of bone model have been registered (fig 7).

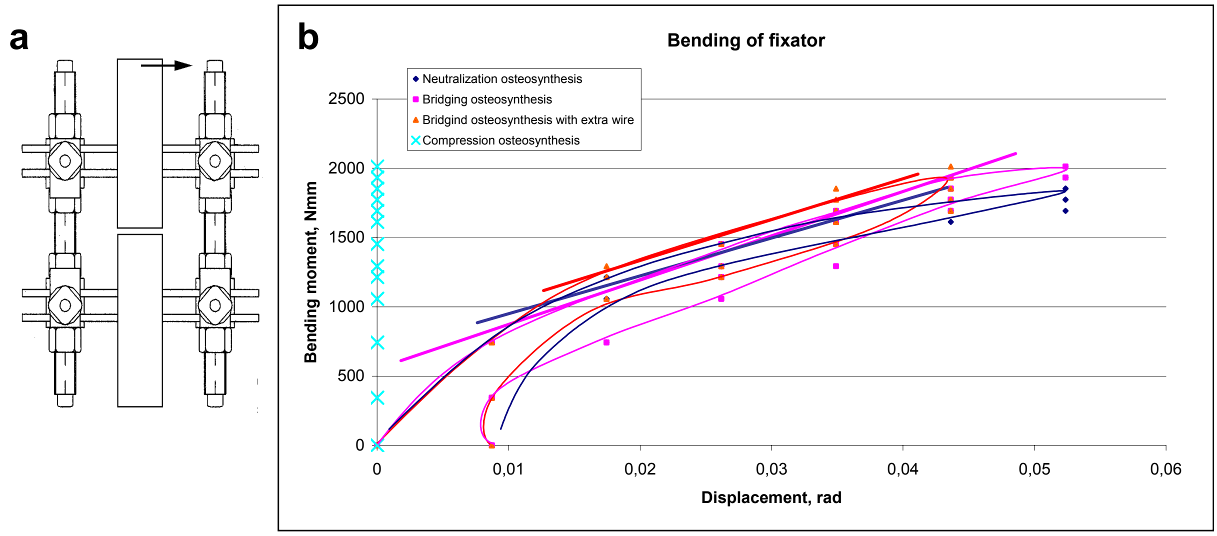

Fig 6. Bending test: a – load scheme, b – research results for bending of fixator

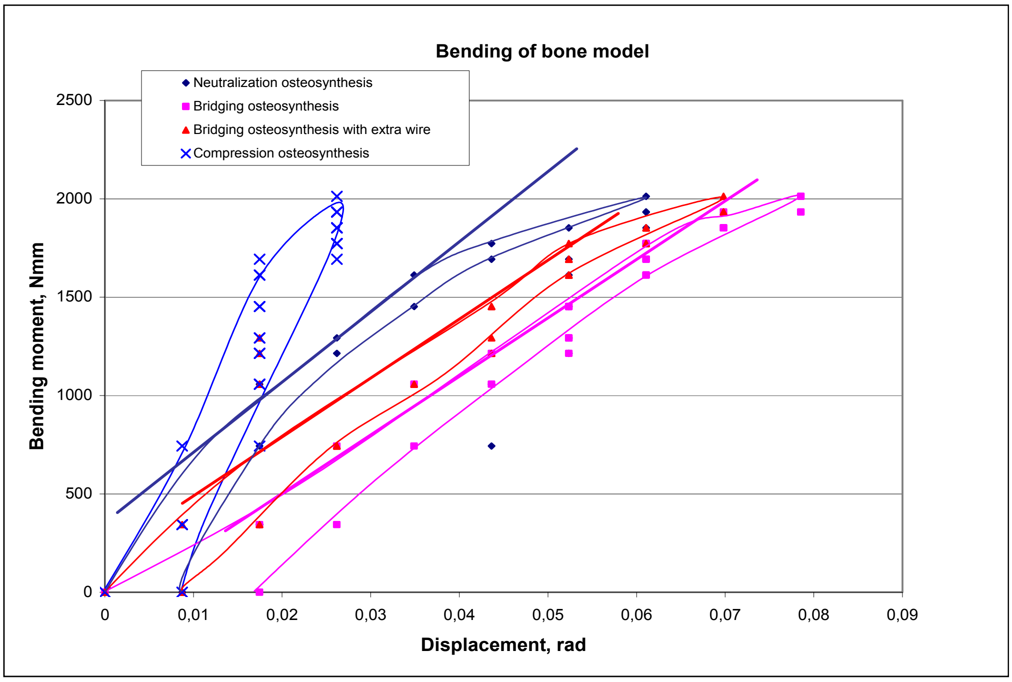

Fig 7. Research results for bending test of bone model

System works in elastic strain range for bridging osteosynthesis for load about 1,8 Nm, for bridging osteosynthesis with extra wire for load about 1,7 Nm and for load about 1,6 Nm for neutralization osteosynthesis. For this load values displacement of fixator is smaller than 3°.

Bending in plane perpendicular to plane of fixator

This test were made for all cases of osteosynthesis. Bending of fixator (fig 8b) and bending of bone model have been registered (fig 9).

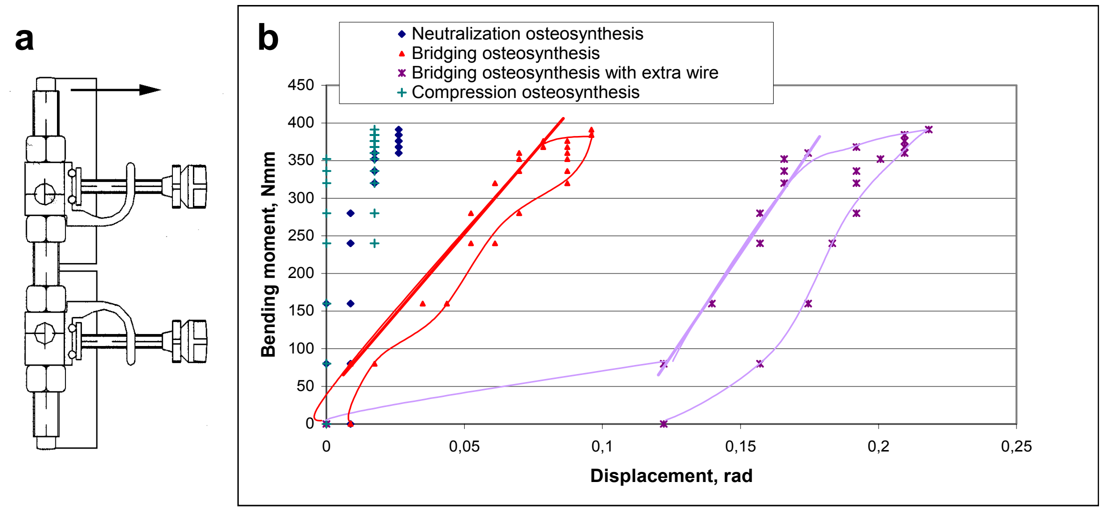

Fig 8. Bending test in plane perpendicular to fixator plane: a – load scheme, b – research results for bending of fixator

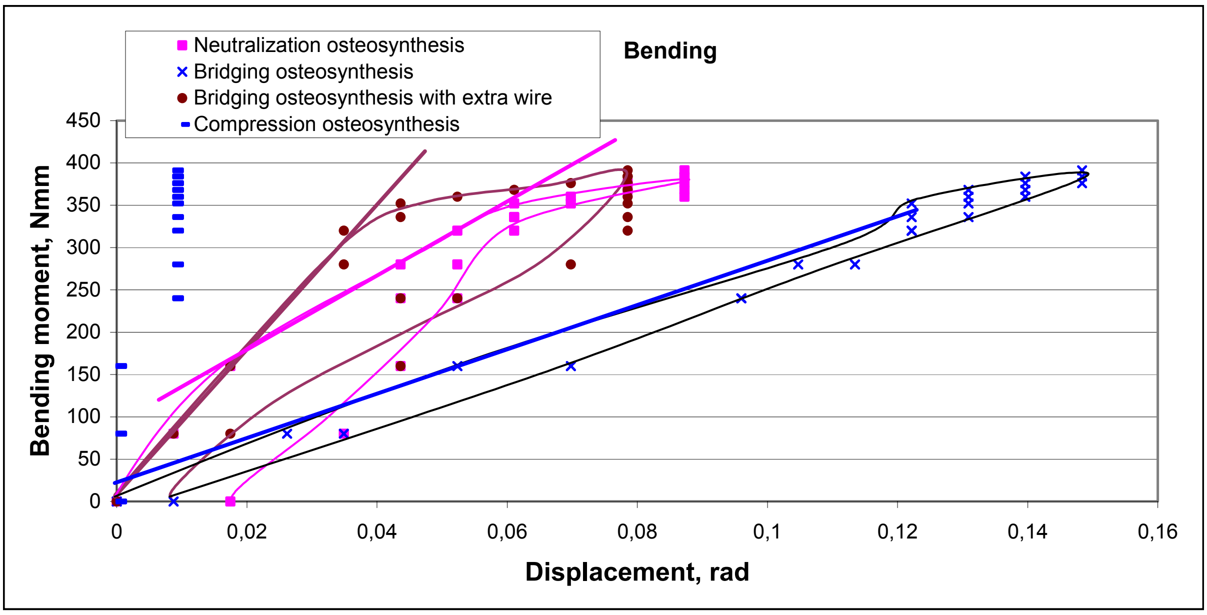

Fig 9. Research results for bending test of bone model in plane perpendicular to fixator plane

On the graphs series the range of points where the system works elastic has been marked. For bridging osteosynthesis fixator works in elastic strain range to load 370 Nmm. At this load deflection of fixator was about 5º30". For bridging osteosynthesis with extra wire fixator works in elastic strain range to load 320 Nmm. At this load deflection of fixator was about 12º. For the other cases the displacement of fixator wasn't observed. Elastic work of the system for model of the bone was to 310 Nmm for Bridging osteosynthesis with extra wire. At this load the displacement of the bone model was about 5º. To about 350Nmm for neutralization osteosynthesis system works in elastic strain range and displacement of the bone model is about 5º.For bridging osteosynthesis the range of elastic strain work was to 250Nmm and displacement was 9º30". For compression osteosynthesis the bone model displacement wasn't observed. In this case the displacement was about 0º30", which value is in the limits of read error.

Conclusions

1. Explorated fixator model for considerable kinds of loads ,except bending in fixator plane ,has better elastic property than occurs during treatment and rehabilitation.
2. During treatment with using above-mentioned fixator the bending loads should be avoided.
3. During treatment – if it is possible – should be used bridging fixation with added Kirschner's wire instead of bridging fixation.
4. Added Kirschner's wire in bridging fixation has increased stiffness of the system comparing bridging fixation without added wire, except torsion loads where displacements are similar.
5. The researched fixator for the accepted loads works in the elastic strain range, except bending in plain perpendicular to fixator plane, for loads much higher than loads are appeared during treatment and rehabilitation.
6. Using external fixator does not require other immobilization in plaster cast and assures active treatment.
7. Analyzing results allow affirm that presented fixator has better elastic property than occurs during treatment and rehabilitation which suggest possibility of dimensions reduce.
8. the external fixator for small bones can be used for:
   - non-stabile fractures
   - osteosynthesis disorders
   - pathological conditions and resections
   - arthrodesis
   - ostheotomies

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