National Conference with International Participation
ENGINEERING MECHANICS 2001
Svratka, Czech Republic, May 14 - 17, 2001

EXTERNAL STABILIZER TO SMALL BONES - DESCRIPTION OF THE OPERATION, WORKINGS IN STATIC LOAD AND RESULTS OF CLINICAL RESEARCH

Stanisław FRANKOWSKI[1], Tomasz TOPOLIŃSKI[2]

Summary: *The aim of the study was to present biplane external stabilizer for small bones. The bone chips are fastened by two pairs of Kirschner's wires settled in the frames which are made of two pins. This stabilization is possible to be with compression and distraction at the same time. Analysis of mechanical maintenance of the stabilizer and results of the first clinical researches show the possibility of using stabilizer in orthopaedic.*

1. INTRODIUCTION

An external stabilization of the bone's fragments is a technique, which is stable enough to not require other immobilization in plaster cast. It leads to earlier rehabilitation of the patient [4, 7]. It concerns not only small bone's [1, 2, 9, 10] fragments but also long bones [5,8] as well as the fractures of the pelvis [3, 6]. The external stabilization although laden with a certain defects in comparison with internal stabilization (e.g. suppuration, injury of nerves end vessels) is less invasive and in some cases could be applied ambulatory.
The aim of the study is:
1) presentation of the multifunctional external fixator,
2) analysis of his stabilizing functions,
3) estimation of his mechanical maintenance by static loading,
4) analysis of the first clinical adaptations.

2. DESCRIPTION

The presented fixator (Fig.1) is the original compression-distraction instrument for external stabilization of small bone's fragments. It is a genuine system of the stabile osteosynthesis. During construction an easiness of assembly and a correction bone chips position was taken to consideration. Steel used for it production does not corrode in stead and chemical sterilization. The Kirschner's wires perform implant's function of bone's grafts.

[1] City Hospital in Bydgoszcz, ul. Szpitalna 19, 85- 826 Bydgoszcz, Poland
[2] Akademia Techniczno-Rolnicza, ul. Kaliskiego 7, 85-763 Bydgoszcz, topol@atr.bydgoszcz.pl, Poland

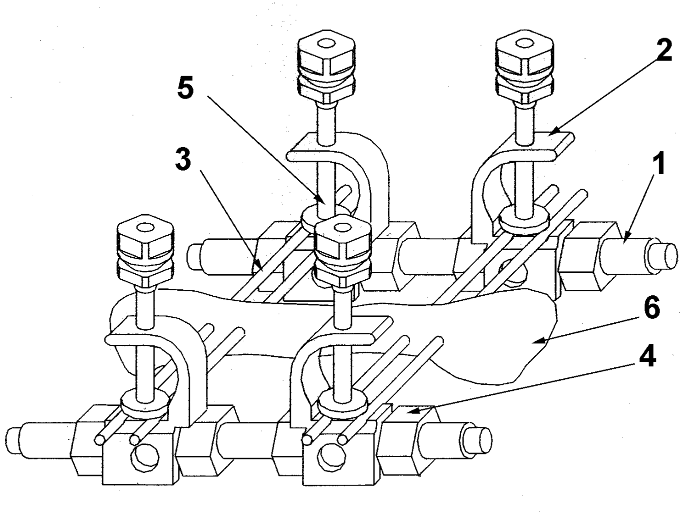


Fig.1. View of stabilizer

The system is consisted of the four equal kinematics pairs. The basis is made of two pines M-5 (1) which are used to situate bodies (2) for fixation of the wires (3). Fixation and positioning the bodies in any place of the pines is defined by two nuts (4) for every kinematic's pairs. There are screws with a plate fixed (5) in the bodies, which locate and fasten the wires, determine simultaneously mutual location of the pines. It influences on rigidity of all system. After the fixation of the wires there is a possibility of compression or distraction. Number (6) means bone.

Using presented fixator makes the realization of following types of osteosynthesis be possible:

1) briding,
2) contact,
3) neutralization,
4) with axial compression of the bone's fragments,
5) with possibility for bone's broaching.

3. FIXATOR TESTING IN SPECIFICATION OF MONOTONIC LAODING

3.1. *Testing conditions*

The testing of fixator was performed for loads, which could be possible during normal treatment and rehabilitation. The model system of osteosynthesis fixator was loaded in the plane of long axis of the bone (the axial compression and tension), torsed round axis of the bone and bended in two perpendicular planes.

In testing the growing monotonic loading were used. Every investigation was performed on Instron type 8501 strength machine 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 the aluminium rod by diameter equals medium diameter of the second finger (∅10 mm) was used. The Kirschner's wires had diameter ∅1,6 mm, and distance between the internal wires amounted 20mm. The distance between parallel axies of two pines amounted 32 mm. For each new test the new pair of wires was used.

3.2 *Testing results*

Obtained results are showed in table 1. There are presented loading schemes and graphs of conducts for those loading. In the table 2 loading partitions, where the fixater works elastic, are performed.

Table 2. Load of elastic range

Kind of load				
Tension	Compression	Torsion	Bending	
a	b	-	a	b
0-350 N	0-350 N	4,5 Nm	200 Nmm	1,5 Nmm

Analysis of the results points at:

1) high strength for all kinds of loads,
2) sufficient rigidity for tension ,compression ,torsion and bending loading (a).

On the contrary the rigidity by bending in perpendicular plane to fixator plane was inconspicuous. Therefore in this plane integrate bone should not be loading in rehabilitation and this type of loading should be avoided during treatment process.

4. Report of cases

4.1. Case 1

G.M., a 28 year-old man, was seen two months after injuring his hand. Anterioposterior radiograph showed non-union fractures of the second metacarpal bone. Before being brought to the City Hospital he had been treated by plaster cart for 2 months. The patient was qualified for an operation. Treatment consisted: open cleanse, reduction and mini external fixation. (Fig. 2, 3).

Fig.2. Postoperative radiograph showing non-union fracture of the second metacarpal bones. Fixation was with a mini external fixator

5. Table 1. The load schemes and research resultes

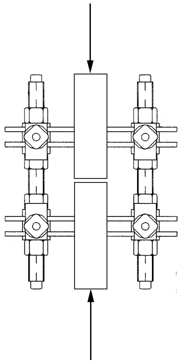
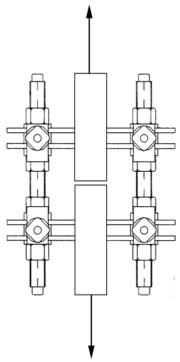
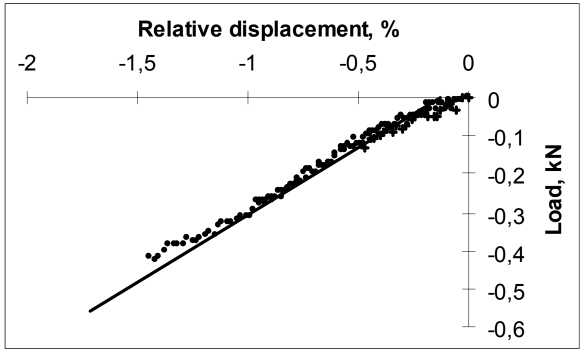
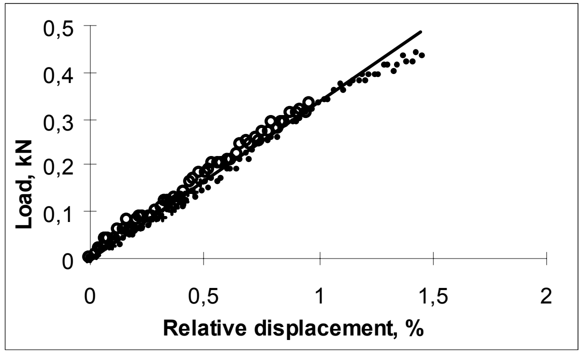
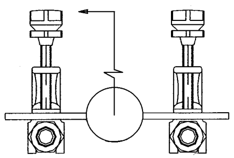
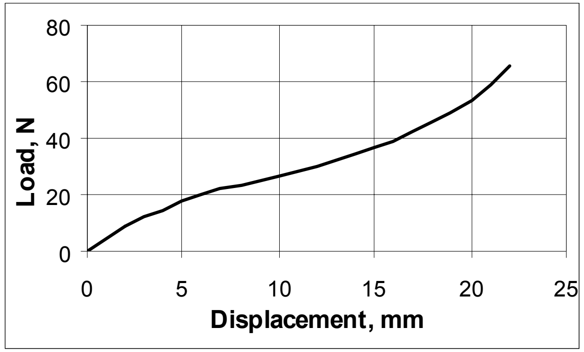
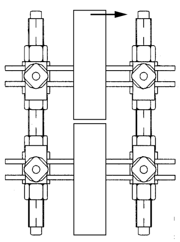
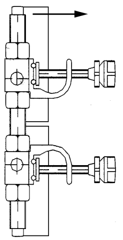
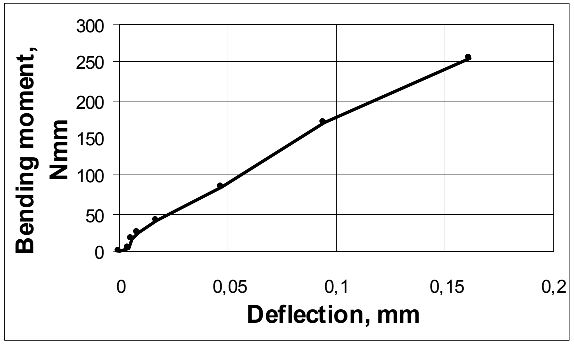
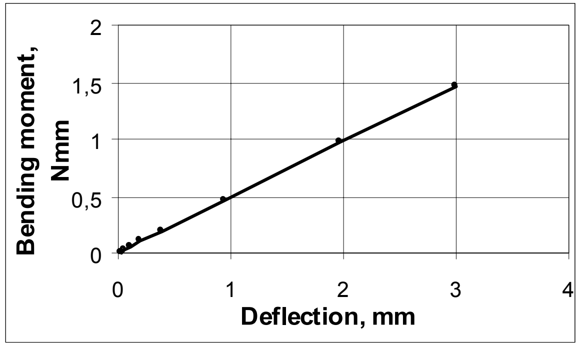
<table>
<tr><th rowspan="2"></th><th colspan="2">Load schemes</th><th colspan="2">Research resultes</th></tr>
<tr><th>a</th><th>b</th><th>a</th><th>b</th></tr>
<tr><td>Tension and compression test</td><td></td><td></td><td>
</td><td>
</td></tr>
<tr><td>Torsion test</td><td colspan="2"></td><td colspan="2">
</td></tr>
<tr><td>Bending test</td><td></td><td></td><td>
</td><td>
</td></tr>
</table>

Fig.3. Postoperative photograph shaving a hand with a mini external fixator

Rehabilitation of the hand started with the day operation. Radiograph was made three weeks after open operation showed progressing union of fractured bone (Fig.4). In Fig. 5 radiograph, which was made five weeks after operation, showed complete union of fractured bone.

Fig.4. Radiograph was made three weeks after open operation showed progressing union of fractured bone

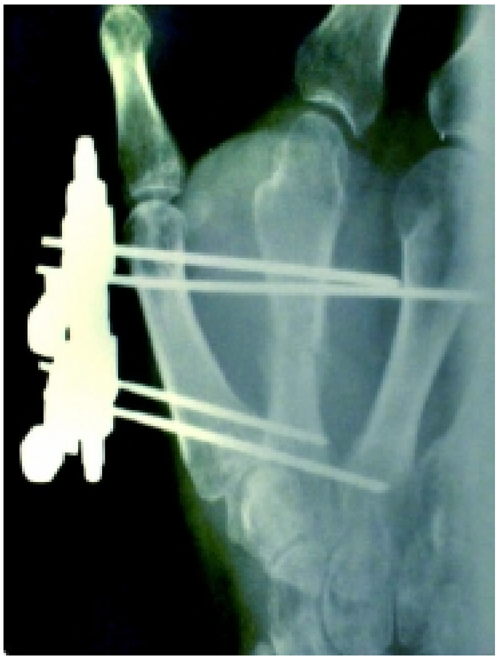


Fig.5. Radiograph was made fifth weeks after operation showed complete union of fractured bone

The fracture healed in near anatomic position and full function resulted. The mini fixator was removed.

4.2. Case 2

L.H., a 45 year-old man was brought to City Hospital in an ambulance on the 25.01.2001 with an open fracture of the proximal phalangx of the second finger in his left hand (Fig 6.).

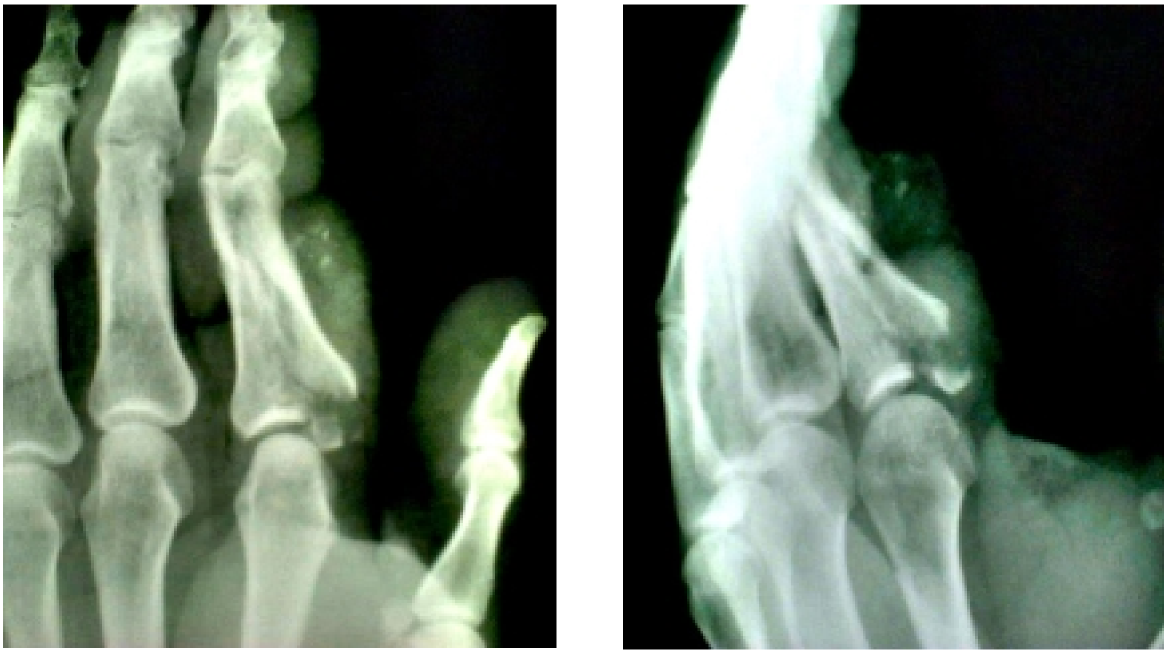


Fig.6. Radiograph showed fracture of the proximal phalangx of the second finger in left hand

The patient was qualified for an operation. Following reparation of the collateral ligament, open reduction and external fixation was showed in Fig. 7 and 8.

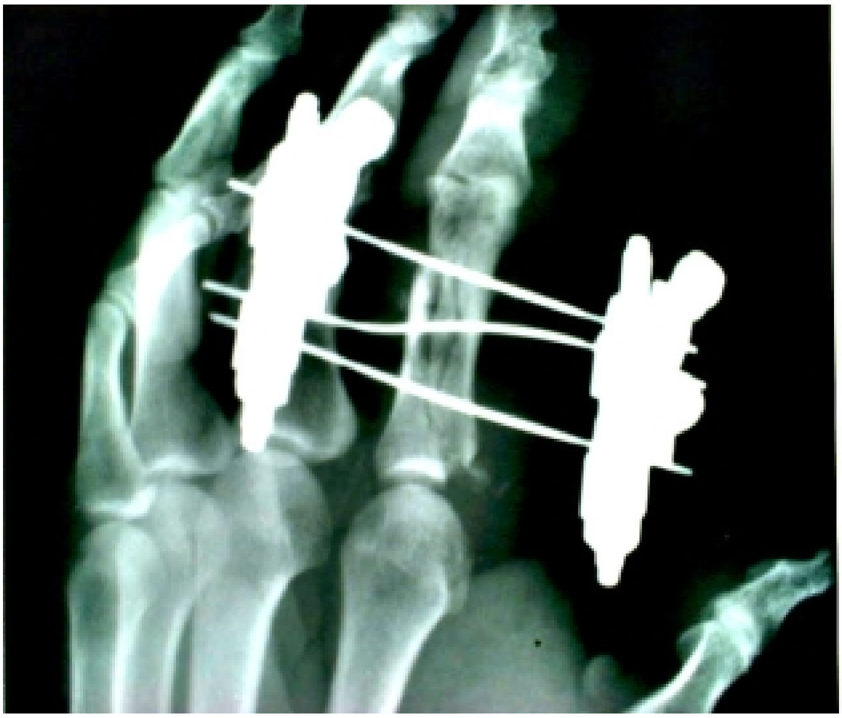


Fig.7. Postoperative radiograph showed a hand with a mini external fixator

Rehabilitation of the hand started with day of the operation. Radiograph, which was made four weeks after operation, showed complete union of fracture bone (Fig. 9).

Fig.8. Postoperative photograph showed a hand with a mini external fixator

Fig.9. Radiograph, which was made four weeks after operation, showed the fracture healed in near anatomic position a full function resulted

The mini fixator was removed.

6. Conclusion

1. Explored fixator model for considerable kinds of loads, except bending in fixator plane, shows good elastic property during treatment and rehabilitation.
2. During treatment with using above-mentioned fixator the bending loads should be avoided.
3. Using external fixator does not require other immobilization in plaster cast and assures active treatment.
4. The shortening of ostheosynthesis time was gained.
5. The external fixator for small bones can be used for:
    - non-stable fractures,
    - osteosynthesis disorders,
    - pathological conditions and resections,
    - arthrodesis,
    - ostheotomies.

7. REFERENCES

1. Adrey J.: Le fixateur externe d'Hoffmann. Couple'on Cader. Paris 1970.
2. Brocker A., Edwards C. (red.): External fixation – the current state of the art. Williams and Wilikns, Baltimore 1979.
3. Brown, T.D., Stone J. P., Schuster J. H. and Mears D. C.: External Fixation of Unstable Pelvic Ring Fractures: Comparative Rigidity of Some Current Frame Configurations. Med. Biol. Eng. Comput. 20:722.1982.
4. Gardiner M.: The principles of exercise therapy. London 1959.
5. Howard F. M.: Fracteres of the basal joint of the thumb. Clin. Orthop. 220:46,1987.
6. Mears D. C. and Rubash H. E.: External and Internal Fixation of the Pelvic Ring. In AAOS. Instructional Course Lectures. Vol. 33 St. Louis C. V. Mosby, 1984
7. Milanowska K.: Rehabilitacja ruchowa osób po urazach. W: Dega W., Milanowska K. (red.) Rehabilitacja medyczna. PZWL, Warszawa 1983.
8. Milford L.: The hand: fractures and dislocations. In Crenshaw AH, editor: Cambell's operative orthopaedics, ed. 7, St. Louis, 1987, Mosby-Year Book, Inc.
9. Ramatowski W., Granowski R., Bielawski J.: Osteosynteza metodą ZESPOL – Teoria i praktyka kliniczna. PZWL Warszawa 1988.
10. Ramatowski W., Granowski R.: Zespol- nowy rodzaj osteosyntezy. Wskazania, narzędzia i technika operacyjna. Chir. Narz. Ruchu Ortop. Pol., 1984, t XLIX/4, ss.307-311.