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The stable-functional osteosynthesis of clavicular fractures with external fixator

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Abstract

Background: Over the past two decades has been paid insufficient attention to the treatment of patients with clavicle fractures. Analysis is of the recent available literature and the personal practice allow us to have a special position to this issue, solving the problem of the clavicle fractures treatment with a new and more efficient method.
Material and methods: For a better deduction and appreciation of the fracture fixation methods results we established a task based on the effectiveness evaluation of the external fixator utilization as a way for a stable osteosynthesis of the fragments performance. It was tested experimentally the efficacy of clavicle fragments fixation with different fixators. The experiment was performed at 30 anatomical specimens of clavicle aged from 38 to 70 years. The mechanical force of the osteosynthesised fragments fixation at flexion and stretching was appreciated in the Alfred G. Amsler German machine with a deviation from 0 to 50 Kn/cm and the capacity of a unit equal to 0.5 Kn/cm.
Results: After the application of the stable-functional osteosynthesis method in clavicle fractures treatment with the external fixator's help, the experimental samples prove objectively the qualities of the proposed fixator, which has an essential priority in the mechanical force of fixing the fragments compared to the traditional fixators used in most cases at the patients with clavicle fractures.
Conclusions: The new method of stable-functional osteosynthesis of the clavicle fractures by using the external fixator, which is simple in assembly and manufacture, excludes the shortcomings of the traditional methods of surgical treatment and allows its application at any level of specialized surgical aid.

Key words: osteosynthesis, external fixation, clavicular fractures.

Introduction

During the past two decades, according to the accessible literature, have been published few scientific papers meant to reflect all aspects of the clavicle fractures treatment problems. Being necessary to substantiate the above mentioned, it is relevant to bring into discussion the fact that in the treatment of patients with clavicle fractures, are used about 300 different constructions, devices, methods which may justify the difficulties faced by doctors when it comes to choose the right method of treatment [1,2,3,4,7,8,9,16,17,18,].

The traumatological practice has a lot of methods for the patient's treatment with both orthopedic and surgical clavicle fractures. According to some authors, the orthopedic method is often used in the clavicle fractures treatment and allows in most cases to achieve good results. Other authors consider that the use of various methods of immobilization is incommode, complicated and difficult to support by the patients, while not ensuring a stable fixation of the fragments [5,6,10,11,19,20].

When analyzing the orthopedic clavicle fractures treatment it can be said that the problem is not so easy to solve. None of the orthopedic treatment methods may exclude the secondary displacements of fragments. As a result, there is an increased number of complications and consequently, unsatisfactory results. At the present stage, it remains indisputable that in cases of ineffective orthopedic treatment or other indications, both absolute and relative, it is possible to go back to the surgical treatment. As a basis for surgical intervention serve the: complicated fractures with neurovascular trunk injury or the danger of their trauma; the ineffectiveness of fragments reduction or retrieval by orthopedic methods; the danger of skin perforation by the fragment and open fractures[12,13,14,15].

The diversity of fixers and constructions highlights the technical difficulties faced by practitioners during surgery. Some of the fixators (metal rod, brooches, screws) are providing a fragments stable fixation and may lead to complications (the migration of the rod or wires, secondary movements, vicious reinforcements, slowing down consolidations, pseudoarthroses, osteomyelitis) and can require additional application of external immobilization. Other machines, fixators mostly increase the stability of osteosynthesis and avoid further immobilisation. However, surgery itself is much more traumatic and all methods require a surgical re-insertion to remove the fixator [25,26,27,28,32,33].

According to the literature, unsatisfactory results from surgical treatment are found in 1.8-30.6% of the patients, mostly returns to slowing down consolidations and pseudoarthroses. The application of compressive devices resulted in some qualitative changes in the clavicular fractures treatment. They lack a number of shortcomings of other treatment methods, offering the possibility of reducing the number of unsatisfactory results to 2.7-3.0% [29,30,31,33,34,35].

However, the clavicular fractures osteosynthesis with existing external fixation devices is only possible in specialized traumatology clinics, appropriately equipped and with high-qualified doctors. Due to these causes, the frequency of its performance in the arsenal of clavicular fracture treatment is insignificant. Therefore, the idea of developing a

safer, less traumatic method in the surgical treatment of clavicular fractures, which would exclude traditional method shortcomings and could be applied at any level of specialized surgical help, is timely and actual.

These proposals are the subject of investigations of the developments contained in this scientific study which has as a purpose the solving of the of clavicle fractures treatment problem.

Biomechanical study

For the purpose of the effectiveness evaluation of the external fixator utilisation as a way for a stable osteosynthesis realization of fragments, has been tested experimentally the effectiveness of the clavicular fragments fixation with different fixators. It was estimated the mechanical force of the the osteosyntesised fragments fixation with the following fixators:

1) The external fixator proposed by us;
2) The rod with 125 mm in lentgh, 2.5 mm in thickness, made of stainless steel of IXI8H9T mark, realized by Bogdanov's example;
3) Two brooches made from stainless steel of IXI8H9T mark, diameter 1.8 and 2.2 mm, based on Kirschner and Elizarov' s example.

The experiment was performed on 30 anatomical specimens of clavicle aged from 38 to 70 years. The location and character of the trajectory in the experimental samples fractures have been identified for each studied fixator.

The location and character of the trajectory of the clavicular fractures in the experimental samples are represented in table 1.

Table 1

The location and character of the trajectory of the clavicular fractures

Location of the fracture	The trajectory character	The number of cases
Third medium	Oblique	12
Third medium	Transversal	6
Third medium	Transversal with oblique trajectory	3
The acromial	Oblique	3
The third-medium region – acromial portion	Oblique	3
The third-medium region – acromial portion	Transversal	3
Total		30

During the experiment the osteosynthesis was performed strictly according to the surgical methods with the same bone material (10 clavicles) and different fixators, thus confirming a comparatively higher degree of assessment and objectivity.

The mechanical fixative force of the osteosynthesised fragments, at the flexure and stretching, was appreciated at the German machine "Alfred G. Robert" brand with deviation from 0 to 50 kN/cm and a capacity of a unit equal to 0.5 kN/cm.

The osteosynthesised clavicula with different fixators has been submitted to the flexure and the stretching on the particular specialized device holder, the pressure gauge which indicates the flexure, continually, being performed a stretch until a fragments diastase equal to 5 mm, concomitant tending to fixate the indicated force on the general pressure gauge of the machine. The mechanical force of the osteosynthesis fragments fixation at the torsion was assessed at the second company machine "Alfred G. Amsler" with deviations from 0 up to 25 Kn/cm and a capacity equal to 0.5 Kn/cm.

The osteosynthesised clavicula was subjected to the torsion being fastened into special brackets of the articular ends of them, therefore, attached fragments were twisted up to 45 degrees, dropping the indicated force on the pressure gauge of the device.

The osteosynthesised clavicula using the proposed external fixator was submitted to the experimental evaluation (30 experimental samples) of mechanical fixative force of the osteosyntesised fragments:

At flexure – 10 experimental samples;
At distraction – 10 experimental samples;
At torsion – 10 experimental samples.

The osteosynthesised clavicula with the rod (mark IXI-8H9T) was subjected to experimental evaluation (30 experimental samples) of mechanical fixative force of the osteosynthesised fragments:

At torsion – 10 experimental samples;
At stretching – 10 experimental samples;
At flexure – 10 experimental samples.

The osteosynthesised clavicula with two brooches (mark IXI8H9T) of the proposed external fixator has been submitted to the experimental appreciation (30 experimental samples) of mechanical fixative force of the osteosynthesised fragments:

At torsion – 10 experimental samples;
At stretching – 10 experimental samples;
At flexure – 10 experimental samples.

Estimation of mechanical force of osteosynthesised fixated fragments at the "Alfred G. Amsler" German device.

The result of the biomechanical study

In total, 90 experimental samples were carried out and their results are presented in the tables 2, 3, 4.

Table 2

The estimation results of experimental samples of the mechanical fixative force of osteosynthesised fragments with an external fixator

Number of the clavicula	The flexure up to 5 mm	The stretching up to 5 mm	The twisting at 45 degrees
1	8.0	7.0	0.3
2	12.0	7.0	0.3
3	15.5	7.0	0.4
4	24.5	5.0	0.22
5	20.5	3.9	0.4
6	22.0	3.0	0.25

Table 3

The estimation results of experimental samples of mechanical fixative force of the osteosynthesised fragments with the rod with 125 mm in lentgh, 2.5 mm in thickness, made of stainless steel of IXI8H9T mark, realized by Bogdanov's example

Number of clavicula	The flexure up to 5 mm	The stretching up to 5 mm	The twisting at 45 degrees
1	8.9	1.2	0.13
2	6.5	2.0	0.11
3	5.5	1.8	0.2
4	9.4	3.3	0.2
5	7.5	4.1	0.18
6	11.5	3.0	0.12
7	13.0	6.7	0.16
8	9.0	5.2	0.18
9	5.0	6.5	0.14
10	4.5	1.0	0.11
M-m	8.29-2.0	4.81-2.89	0.178-0.05

Table 4

The results of experimental samples estimation of mechanical fixative force of the osteosyntesised fragments with two brooches made from stainless steel of IXI8H9T mark, diameter 1.8 and 2.2 mm, based on Kirschner and Elizarov' s example

Number of clavicula	The flexure up to 5 mm	The stretching up to 5 mm	The twisting at 45 degrees
1	2.7	3.5	0.1
2	1.2	2.7	0.08
3	1.4	2.8	0.12
4	3.0	2.2	0.07
5	1.4	2.0	0.2
6	2.0	1.2	0.2
7	1.5	2.5	0.13
8	1.3	1.5	0.1
9	1.8	5.0	0.16
10	2.0	1.5	0.6
M-m	1.83-0 609	2.21-1.5	0.13-0.05

The results of the experimental samples were subjected to statistical synthesis after the normative methodology (tab. 5). In the result of the synthesis we obtained arithmetic environmental parameter (M) and probable error parameter (m).

Table 5

Comparative results of mechanical fixative force of osteosynthesised fragments with different fixators

The fixator type	Flexure in kN/cm	stretching in kN/cm	Torsion in kN
External Fixator	M = 16.47 m = 5.31	M = 5.49 m = 1.74	M = 0.382 m = 0.091
Rod length 125 mm, thickness 3.5 mm	q	M = 4.81 m = 2.8876	M = 0.178 m = 0.054
Two brooches	M=1.83 m=0.609	M=2.71 m=1.518	M=0.126 m = 0.054

It was analysed the mechanical fixative force of the fragments at the flexure, stretching and torsion with different fixators (fig. 1, 2 , 3).

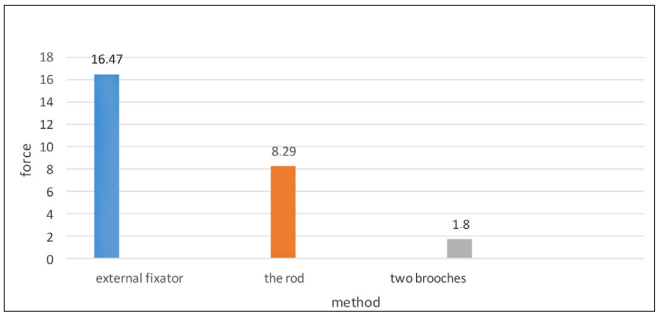

Fig. 1. The comparability of the mechanical fixative force of the fragments with different fixators at the flexure.

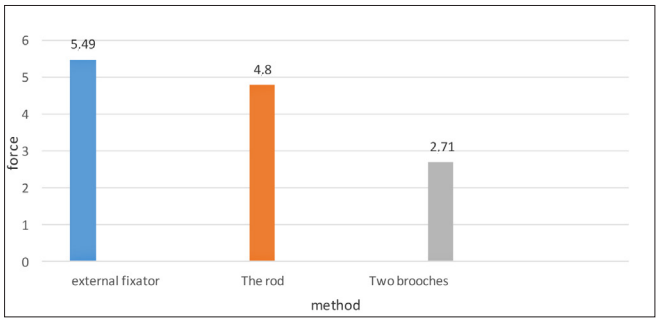

Fig. 2. The comparability of the mechanical fixative force of the fragments with different fixators at the stretch.

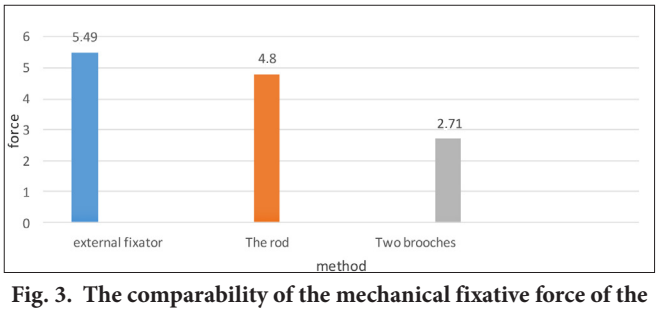

Fig. 3. The comparability of the mechanical fixative force of the fragments with different fixators at the torsion.

Conclusions

In this article the comparative calculations of reliability difference results were performed after Student's criteria:

Therefore, the comparativity of the mechanical fixative force of osteosynthesised fragments after calculated norm "t", which corresponds to the probability P<0.05 indicates an essential prospective of the external fixator, where:

t – the calculated norm Student's criteria for the comparison string;

P – the truthfulness of the difference.

On the basis of those exposed, we may conclude the following:

1. The fixative force of the osteosynthesised fragments with the external fixator at the flexure is 3 times greater than the fixative force of the osteosynthesised fragments

with the rod mark IXI8H9T and than the fixing force with 2 wires made by using the Kirschner and Elizarov's example – 6.7 times (P <0.01).

2. The fixative force of the osteosynthesised fragments with the external fixator at the stretch is 3 times greater (P< 0,01) than the fixative force of the osteosynthesised fragments with mark IXI8H9T and than the fixing force with 2 wires made by using the Kirschner and Elizarov's example by 4.3 times(P < 0, 05).

3. The fixative force of the osteosynthesised fragments with the external fixator at the torsion is 1.9 times greater (P<0.001) than the fixative force of the osteosynthesised fragments with mark IXI8H9T and than the fixing force with 2 wires made by using the Kirschner and Elizarov's example – 2.7 times (P <0.001).

Therefore, the performed experimental samples argue objectively the qualities of the proposed external fixator which has an essential priority in mechanical fixative force of the fragments in comparison with traditional fixators, used in clinic in most cases with clavicular fractures.

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