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EXOSKELETON FOR LOWER JAW FRACTURES TREATMENT

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ABSTRACT — The aim of this study was to study the possibility of the lower jaw exoskeleton as a means of treating its fractures. The analysis took into account the ability of the extrafocal osteosynthesis apparatus to maintain the spatial orientation of bone fragments under load. For this, the apparatus was analyzed by the finite element method on 3D models and a study was carried out in a special stand on the bones of the human lower jaw. As a result of the analysis, it was revealed that the lower jaw exoskeleton makes it possible to qualitatively fix the fragments of the lower jaw for the period of fracture healing.

KEYWORDS — lower jaw, fracture, application, apparatus, treatment.

INTRODUCTION

In modern maxillofacial traumatology, there is a tendency to increase the prevalence of injuries to the maxillofacial region (from 3 to 8%) [1, 2].

The nature of fractures of the lower jaw is due to the peculiarities of its anatomical structure [3–9]. In this regard, the issue of injuries of the maxillofacial region can be attributed to topical issues of modern dentistry [10], which allows us to judge the economic, social and medical significance of solving the problem of complex treatment of fractures of the lower jaw [11, 12].

We have developed and patented the device "Exoskeleton of the lower jaw" (Patent for invention No. 2655086 dated 23.05.2018). During the development of which its characteristics were given using the finite element method and bench tests (Fig. 1).

The aim of the study is to analyze the use of exoskeleton in the treatment of fractures of the lower jaw

MATERIALS AND METHODS

The study involved 36 bones of the human lower jaw, an apparatus for external fixation of the human lower jaw exoskeleton, consisting of parts of the Ilizarov apparatus.

3D bone scanning was carried out according to the author's method (application for invention No. 2020,107,207 from 19.02.2020) in the Agisoft PhotoScan program based on internal algorithms, positioning accuracy was > 99.95%.

To represent and analyze the obtained data on real objects during the development of the design of the lower jaw exoskeleton, a study on 3D models in the Solidworks mathematical analysis program for finite elements (Fig. 2) is necessary.

In order to study the stability of the fixation of the fragments of the lower jaw bones using the apparatus for external fixation of the lower jaw exoskeleton, a loading stand was created to simulate the load on the lower jaw, to which the lower jaw with the exoskeleton was fixed. For modeling, various weights weighing 2–12 kg were consistently suspended. The results were evaluated by computer analysis immediately after the study.

RESULTS AND DISCUSSION

During the experiment, almost complete immobility of bone fragments relative to each other was established at a load of 2 kg, which corresponds to the force of chewing muscles from the fracture side when treated with external fixation devices in the period after the fracture. This allows us to talk about the high quality of fixation of bone fragments for healing a bone wound at the initial stages. With a load of 7 kg, there was a displacement of bone fragments within the range of 7 kg — 0.04 ± 0.01 cm. The load of 6.5 kg corresponds to a period of 1 month after fracture of the lower jaw from the side of the fracture when treated with external fixation devices. At this point, primary stabilization of bone fragments occurs, which will prevent minimal possible displacements. By the time of 28–36 days (duration of treatment with a mandibular exoskeleton), after radiological confirmation, the external fixation apparatus is dismantled. With a load of 12 kg, which corresponds to 2–3 months after a fracture of the lower jaw, from the side of the fracture, when treated with external fixation devices, there is a divergence of bone fragments by a distance of 0.3 ± 0.05 cm. In this time period after the fracture, the patient does not use an external fixation device, the fragments of the lower jaw are fixed due to the newly formed bone connection (Fig. 3).

In the graph of the change in the width of the gap between the bone fragments, an exact coincidence of

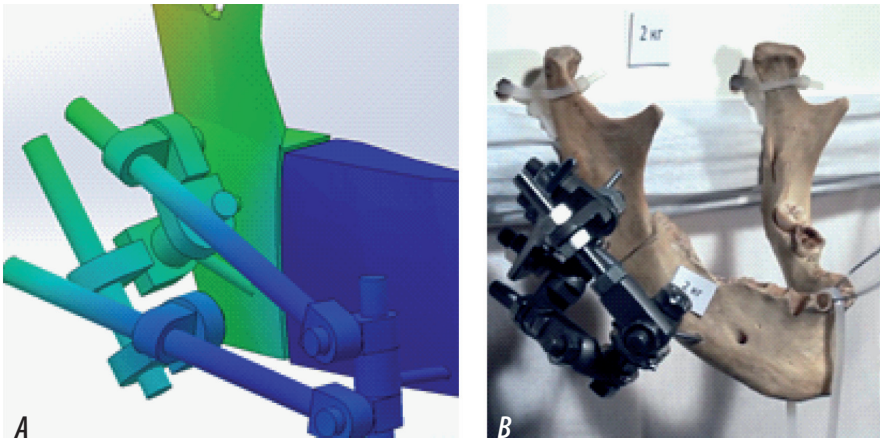

Fig. 1. A — Finite Element Motion Analysis in Computer Environment, B — Experimental Load Test

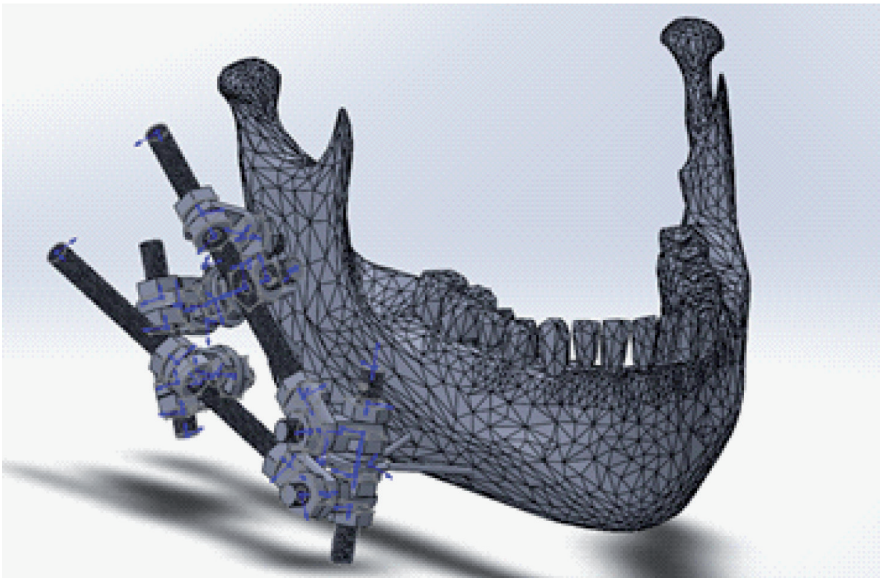

Fig. 2. Reposition of bone fragments in Solidworks

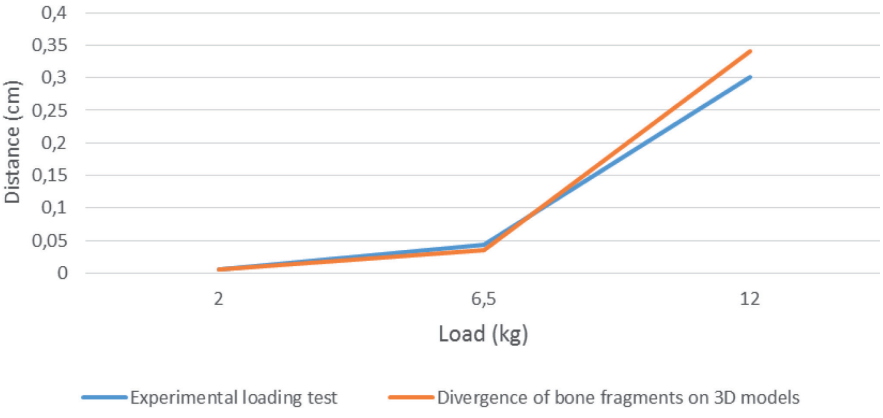

Fig. 3. Change of slit width between bone fragments in experimental loading test

the data of the computer simulation and the experimental load test is clearly observed, which is once again confirmed by the Student coefficient (Table 1).

CONCLUSION

Thus, we can state that the proposed apparatus for external fixation of the lower jaw exoskeleton

Table 1. *Student coefficient at different bone loads*

Change in fracture slit width when simulating fractures on lower jaw bones (kg)	Change in fracture slit width when simulating fractures on lower jaw bones (kg)	Student Coefficient Value
2	1,9	2,85
7	6,5	5,07
12	13	3,58

works in the area of maxillofacial region. It performs reposition and fixation of the bone fragments of the lower jaw under conditions of chewing functioning of the restored fracture of the lower jaw.

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