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ASSESSMENT OF THE EFFECTIVENESS OF INDIVIDUAL BONE PLATES IN THE SURGICAL TREATMENT OF MANDIBULAR ANGLE FRACTURES

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Abstract

Adequate immobilization of mandibular fragments is a key prerequisite for successful treatment of mandibular fractures. Fractures located in the angle region of the mandible present significant challenges for intraoral fixation due to the complex anatomical geometry, often requiring extensive bending of standard plates, which leads to increased operative time and reduction in plate strength. To address these limitations, an original design of an individualized incisal plate was developed for intraoral osteosynthesis in the mandibular angle region. A virtual stress–strain analysis of the mandible under physiological loading demonstrated the biomechanical advantages of the individualized plates compared with standard configuration plates. The plate consists of two fixing arms of different lengths connected by an intermediate segment, with geometry tailored to each patient's mandibular anatomy. Plates were manufactured using high-precision milling technology (Roland MDX-540). Clinical application involved intraoral access, stepwise elevation of a mucoperiosteal flap, anatomical repositioning of fragments, and sequential fixation with intraosseous screws. The individualized plate enabled stable fixation with minimal tissue trauma and reduced operative time due to its anatomical congruence. Early postoperative rehabilitation was possible owing to the favorable distribution of functional loads. The use of patient-specific incisal plates represents an effective and minimally invasive method for treating fractures of the mandibular angle.
Keywords: *mandibular angle fracture; individualized incisal plate; intraoral fixation; osteosynthesis; virtual modeling; stress-strain analysis; maxillofacial surgery; custom bone plate; 3D planning; Roland MDX-540 milling; biomechanical justification; minimally invasive fixation; intraosseous screws.*

1. Introduction

Adequate immobilization of the fragments is a crucial factor ensuring the success of treating patients with mandibular fractures. In modern traumatology, two main groups of immobilization methods are distinguished: external and internal [1]. In recent decades, numerous systems for fixing mandibular fragments have been developed in maxillofacial surgery. New methods of both conservative and surgical treatment have been developed [2, 3]. At the same time, internal devices significantly reduce mobility compared to external fixing devices [5].

When the fracture cleft is localized in the area of the mandibular angle, problems often arise with fixing the fragments through intraoral access. This circumstance is related to the complex

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geometry of the mentioned region. The modeling of the plate, as a rule, is achieved by significantly changing its configuration by repeatedly bending it in different planes. In addition to the fact that such a modeling process significantly increases labor costs and operation time, it contributes to a noticeable deterioration of the plate's strength properties and the development of fatigue changes [6]. We have proposed an original design of an incisal plate, specifically designed for intraoral fixation of mandibular fragments in the angle area (Figures 1, 2).

Fig. 1. Individual costal plate for fixing fragments in the area of the lower angle oral access to the jaws:
1 - intermediate part; 2 - distal fixing shoulder; 3 - medial fixing shoulder; 4 - opening for intraosseous fixing screws To justify the legal validity of the execution

To justify the validity of using individual incisal plates of the proposed form, a virtual model of the stress-strain state of the bone tissue of the lower jaw under physiological stress conditions was used. Comparison of the stresses developing in the bone after fixation of fragments with bone marrow plates of standard configuration and plates designed by the Department of Maxillofacial Surgery and Stomatology showed a noticeable advantage of individual bone marrow plates [4].

Fig. 2. Virtual model of individual costal plate location (B)
for intraoral fixation of fragments on the jaw (A)

Structurally, the plate consists of two different-sized fixing arms and an intermediate part. The distal shoulder [2] has a length of 15 mm and is designed to fix the distal fragment of the mandible. The shoulder [2] during surgery is placed on a branch of the mandible or in the retromollary space, reaching the distal surface of the last molar. This plate segment has two holes [4] for inner bone fixing screws with a diameter of 2 mm. The medial, longer, shoulder [3] has a length of 20-25 mm depending on the individual geometric characteristics of the lower jaw. The medial shoulder is located along the outer oblique line and is designed to fix the central fragment. On the medial shoulder, there are three openings [4] with a diameter of 2 mm for intraosseous fixing screws. The locking shoulders are rigidly connected by an intermediate part [1]. The length of the intermediate part is a variable quantity, as is the angle under which the fixing parts are positioned relative to each other. These variables depend on the individual geometry of the lower jaw, ensuring the correct placement of the fixing elements. The width of the fixing arms [2, 3] in the area of the holes [4] is 5 mm. The width of the intermediate part is 4 mm. The thickness of the plate is 0.8 mm.

2. Material and methods

The production of individual bone plates was carried out at the Tashkent State Medical University on a Roland MDX-540 machine with a preparation accuracy of 1 micron.

When used for fixing mandibular fragments in the area of the individual costal plate angle, after antiseptic treatment and achieving adequate pain relief, an incision approximately 15 mm long was made along the inner slope of the pterygomandibular fold. The oral mucosa, submucosa, and periosteum were dissected. The incision was extended in the retromollary space to the distal surface of the crown of the last molar. The circular ligament was cut along

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the distal surface of the last molar's crown and anteriorly along the cheek surface to the level of the next interdental papilla. undefined In this way, a step-by-step mucosal-periosteal scrap was cut.

The cut-out scrap was separated using a splitter, pushed away, and held with blunt hooks. At the same time, the end sections of the fragments and the fracture cleft were exposed.

Reposition of fragments was carried out using the usual method. During the repositioning operation, congruence was used as a criterion for the correct alignment of fragments wound surfaces of the bones facing the fracture cleft (Figure 3).

Fig. 3. A step-by-step mucosal-periosteal scrap was cut.
The fragments were skeletonized and repositioned: A - cut line; B - fracture line

After the primary repositioning of the fragments, individual bone plates were attached. For this, the plate was placed on the aligned fragments in the correct position and its position in the wound was assessed. The plate was to be located freely, as closely as possible to the bone along its entire length. The short arm of the plate was placed in the retromollary space or on the branches of the mandible when the teeth were in a tight position in the dental row and there was no space behind the last molar. undefined The intermediate part of the plate, when correctly modeled, adjoined the distal surface of the crown of the last molar. undefined In some cases, with a less pronounced oblique line, it was necessary to perform slight additional modeling of the medial arm, bending the intermediate part along the plane.

After ensuring the correct modeling of the plate and its correct placement on the bone, they began to fix it with intraosseous screws. For the fixation of the plates, intraosseous screws from standard sets for osteosynthesis from the "Konmet" and "Stryker" firms were used.

To fix the plate, first of all, intraosseous channels for fixing screws were formed. The opening for the fixing screw was formed without strong pressure on the instrument (to avoid its fracture) along the entire thickness of the bone in the direction perpendicular to the surface of the cortical plate of the mandible. When working with the cutting tool in the bone, it was constantly cooled with antiseptic solutions to prevent overheating of the bone tissue and its burning.

Then, the fixing screw channel was washed with an antiseptic solution. Additional cutting of the thread would not be required, as most screws for fixing the shear plates have a self-cutting thread profile.

In accordance with the general principles of fixing the costal plates, fixation began with an opening located on the short arm of the plate, closer to the fracture cleft. Then, a screw located on the medial arm, also closer to the fracture cleft, was inserted. The third was fitted with a screw on the medial arm following the first.

After fixing the third screw, the position of the fragments was assessed, and if they were matched satisfactorily, the installed screws were tightened, after which the most distal and most medial screws were tightened sequentially (Fig. 4).

Fig. 4. The fragments (A) are fixed by an individual incisal plate (B) and intraosseous "Stryker" screws (C). The plate is tightly attached to the bone.

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Polypropylene thread was used on an atraumatic needle to suture the wound. First, the upper obtuse angle of the mucosal-periosteal scrap was sutured to the mucous membrane in the area of the lingual-distal angle of the last molar's crown.

Then, the second rectangular corner of the piece is sutured in the interdental space. After this, the remaining seams were applied (Fig. 5).

Fig. 5. The same patient. The wound is sutured with polypropylene. The arrow indicates the seam line.

The thread was removed on the tenth day after the surgical intervention.

3. Results

The use of individual bone marrow plates of the proposed design in the surgical treatment of patients with mandibular fractures allows achieving stable fixation of the fragments in the least traumatic way. At the same time, the operation time is reduced due to the correspondence of the plate shape to the individual geometry of the lower jaw of a specific patient. The loads developing in the bone tissue during the operation of the plate do not exceed permissible loads, which allows for the use of active therapeutic gymnastics in the early postoperative period.

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