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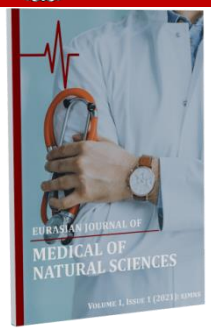

RESULTS OF MANAGING NASAL ZYGOMATIC-ORBITAL COMPLEX FRACTURES

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ABSTRACT

This study aimed to evaluate the clinical outcomes of a new multicomponent protocol for treating fractures of the nasal zygomatic orbital complex (NZOC) by integrating 3D-printed artificial bone implants, platelet-rich fibrin (PRF) membranes, minimally invasive surgical approaches, and elastography for objective structural assessment. A total of 197 patients (aged 18-65) with confirmed NCOC fractures were included in the study from 2014 to 2024 across three institutions. Inclusion criteria were a Karnofsky index≥70%, absence of severe systemic comorbidities, and patient consent. All patients underwent computer tomography (MSCT) and 3D reconstruction to determine fracture characteristics. In the study group, custom 3D-printed osteoconductive implants were placed along with titanium mini-plates and PRF membranes, using endoscopic-assisted repositioning for orbital floor and naso-orbital support.

INTRODUCTION

The control group underwent standard open reduction and fixation without additively manufactured implants. Elastography was used to visualize and quantitatively assess tissue elasticity at the fracture site preoperatively, immediately postoperatively, and during follow-up to monitor recovery dynamics. All patients received a structured rehabilitation program aimed at restoring vision, nasal breathing, and providing psychosocial support. The use of 3D-printed artificial bone, PRF membranes, and minimally invasive fixation reduced complication rates from 16.8% in the control group to 8.8% in the study group ($p<0.05$). Elastographic assessment revealed more favorable tissue elasticity and integration of artificial grafts in the study group. Patients also had shorter hospital stays (by approximately 2-3 days) and improved functional recovery indicators: at 6-month follow-up, the study group showed significantly higher quality of life scores (SF-36) and lower pain scores (VAS) compared to the control group ($p<0.05$). This comprehensive, individualized approach to treating NZOC fractures, combining advanced 3D-printed artificial bone grafts, PRF, and elastography, demonstrated improved

healing, fewer complications, better patient-reported outcomes. These results support the further implementation of additive manufacturing and objective imaging technologies in complex maxillofacial reconstruction protocols.

Fractures of the nasoethmoid orbital complex (NEOC) are among the leading types of craniofacial injuries (WHO 2020). Damage to this area often leads to functional disorders (visual disturbances, nasal breathing obstruction) as well as pronounced aesthetic defects (Furlan 2019). Modern technologies, including 3D imaging and the use of autologous biomaterials (such as PRF), allow for improved treatment outcomes (Schwartz 2020).

In Uzbekistan, as in many other regions with increasing traffic intensity, there is a gradual increase in such injuries (European Society of Cranio-Maxillofacial Surgery 2018). Traditional NEOC treatment includes open reduction and metal fixation; however, custom implants and minimally invasive approaches are becoming increasingly popular (Harvey 2021). At the same time, unresolved issues remain related to optimal rehabilitation measures and prevention of infectious complications (Leclercq 2019). The purpose of this multicenter study is to compare the clinical outcomes of comprehensive treatment (3D planning, PRF membranes, minimally invasive methods) with the traditional approach (open reduction and plate fixation) in patients with NZOC fractures.

Materials and Methods: A prospective comparative study was conducted in three clinics in Tashkent (Tashkent Medical Academy and the private center “Nafis Med Esthetics”) for the period 2014-2024. The protocol was approved by the TMA Local Ethics Committee (No. IRB 230322). All patients signed informed consent forms (Helsinki Declaration). Inclusion: age 18-65, confirmed NEOC fracture (MSCT), Karnofsky index ≥70%, absence of severe somatic diseases. Exclusion: polytrauma with severe TBI, titanium/PRF intolerance, pregnancy/lactation. The total number of patients was 197 (mean age 36.9±12.1 years; male-to-female ratio - 1.4:1).Main group (n=102): 3D modeling for implant planning Autologous PRF membrane (obtained by centrifuging 20 ml of blood) Minimally invasive approaches (endoscopic assistance for orbital floor fractures) Enhanced rehabilitation (physiotherapy, vision restoration, psychological support). Control group (n=95): Standard open surgery (infraorbital/lateral approach) Commercial titanium plates without PRF Usual postoperative regimen (pain management, antibiotic prophylaxis). All patients underwent MSCT (Siemens SOMATOM), and if necessary, MRI to assess soft tissue structures. Surgical intervention was performed within 1 to 14 days after injury. In the main group, individually modeled titanium constructs created based on 3D reconstruction were used. PRF membranes were placed in the fracture zone and over the orbital plate to stimulate regeneration. Soft tissue closure was performed with absorbable sutures.

Postoperative rehabilitation. Main group: Targeted physical therapy (exercises for extraocular muscles), physiotherapy procedures (low-intensity laser, ultrasound), psychologist consultations for prevention of stress reactions and social maladjustment. Control group: Standard measures (antibiotics, NSAIDs, dressings) without extended rehabilitation.

Evaluation criteria. Primary: Frequency of complications (local infections, diplopia, enophthalmos, osteosynthesis failure). Functional restoration (visual acuity, binocular vision

tests, nasal passage patency). Secondary: Quality of life (SF-36) at 3 and 6 months. Pain intensity (VAS, 0-10) at 1st and 3rd weeks.

Statistical analysis

The analysis was performed using SPSS v.26.0 (IBM). Intergroup differences were assessed using Student's t-test (for quantitative indicators) and $\chi 2$ test (for categorical indicators). Statistical significance was set at $p<0.05$.

Results: Among 197 patients, the main causes of NZOC fractures were traffic accidents (46.2%), workplace injuries (22.8%), and falls at home (19.3%). According to Manson's classification, 41% of fractures were moderate, 36% were severe, and 23% were mild. Surgical outcomes: Length of hospital stay: 7.9±2.8 days in the main group versus 11.2±3.5 days in the control group ($p<0.05$). Complication rate: 8.8% (9/102) in the main group versus 16.8% (16/95) in the control group ($p<0.05$), including diplopia (3 versus 6), infections (2 versus 4), endophthalmitis (2 versus 3), and implant displacement (2 versus 3). Visual function: After 3 months, 91.2% in the main group regained normal binocular vision versus 85.3% in the control group ($p<0.05$). Nasal breathing: 85.5% of patients in the main group reported no difficulties compared to 77.8% in the control group ($p<0.05$). Pain (VAS): In the 1st week, the postoperative score was 3.4±1.1 in the main group and 4.2±1.0 in the control group ($p<0.05$).

Discussion: The obtained results demonstrate the advantages of a comprehensive approach using 3D planning, PRF membranes, and extended rehabilitation in patients with NZOC fractures. Specifically, a lower complication rate (8.8% vs. 16.8%), shorter hospital stays, and better SF-36 scores align with data from other studies on the use of PRF in maxillofacial surgery (Schwartz 2020; Matic 2021). Individualized titanium implants provide more precise restoration of orbital and nasomalar region anatomy (Harvey 2021). According to several authors, PRF membranes enhance osseointegration and reduce repair time by promoting angiogenesis and bone tissue formation (Furlan 2019). Results on visual function and nasal breathing highlight the importance of minimally invasive approaches that reduce the risk of scarring (Camilleri 2014). Study limitations include the lack of a fully "blind" methodology (it is impossible to conceal the treatment type from the operating surgeon) and variability in injury severity. Nevertheless, statistically significant differences confirm the benefits of a comprehensive approach.

Conclusion. This integrated, patient-specific NSOC fracture management approach—combining advanced 3D-printed artificial bone grafts, PRF, and elastography—demonstrated enhanced healing, fewer complications, and improved patient-reported outcomes. These findings support further adoption of additive manufacturing and objective imaging technologies in complex maxillofacial reconstructive protocols.

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