Disaster Med. 2016. Vol. 31. No. 1. P. 79-84. DOI: https://doi.org/10.1017/S1049023X15005427

10. Stefanopoulos P. K., Filippakis K., Soupiou O. T., Pazarakiotis V. C. Wound ballistics of firearm-related injuries--part 1: missile characteristics and mechanisms of soft tissue wounding. *Int J Oral Maxillofac Surg*. 2014. Vol. 43, No. 12. P. 1445-1458. DOI: https://doi.org/10.1016/j.ijom.2014.07.013

11. Stefanopoulos P. K., Pinialidis D. E., Hadjigeorgiou G. F., Filippakis K. N. Wound ballistics 101: the mechanisms of soft tissue wounding by bullets. *Eur J Trauma Emerg Surg.* 2017. Vol. 43, No. 5. P. 579-586. DOI: https://doi.org/10.1007/s00068-015-0581-1

12. The burn wound exudate – an under-utilized resource / Widgerow A. D. et al. *Burns*. 2015. Vol. 41, No. 1. P. 11-17. DOI: https://doi.org/10.1016/j.burns.2014.06.002

13. The First Aid and Hospital Treatment of Gunshot and Blast Injuries / A. Franke et al. *Dtsch Arztebl Int*. 2017. Vol. 114, No. 14. P. 237-243. DOI: https://doi.org/10.3238/arztebl.2017.0237

14. Willy C., Hauer T., Huschitt N., Palm H. G. "Einsatzchirurgie" – experiences of German military surgeons in Afghanistan. *Langenbecks Arch Surg*. 2011. Vol. 396, No. 4. P. 507-522. DOI: https://doi.org/10.1007/s00423-011-0760-4

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BIOMECHANICAL GROUNDING OF THE TRANSALVEOLAR OSTEOSYNTHESIS OF EDENTULOUS MANDIBLE FRACTURES

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Ключові слова: *перелом нижньої щелепи, трансальвеолярний остеосинтез, комп'ютерне 3Д моделювання*
Ключевые слова: *перелом нижней челюсти, трансальвеолярный остеосинтез, компьютерное 3Д моделирование*

Abstract. Biomechanical grounding of the transalveolar osteosynthesis of edentulous мandible fractures. Idashkina N.H., Hudarian O.O., Chernov D.V., Samoilenko I.A. *The purpose of the work is improvement of the effectiveness of the mandibular fractures treatment in patients with partial or complete adentia by developing and experimental testing of transalveolar osteosynthesis technique. An experimental study was carried out by 3D computer* *simulation modeling by the final element analysis to assess the efficiency of mandibular fractures fixation in partial or complete adentia using the Ш-shaped plate, with transalveolar osteosynthesis method. Calculations of the immobilized fractures for static (own weight) and dynamic (functional) loads were performed according to the author's method, taking into account pronounced resorptive processes in the bone from the beginning of the reparative reaction to assess the rigidity of fragments fixation during the entire period of the fractures healing. Under the conditions of the same three-dimensional model of the mandible, calculations were performed when the fracture was fixed with ordinary linear titanium osseous plates. It is proved that at functional load the new plate provides a compression effect in the fracture region, as evidenced by the negative displacements in the final elements of the mental region according to the results of design load combination 2-3. The maximum efforts in the screws of the calculation model with a conventional bone plate were 136.955 N, which is almost ten times more than on the model with a Ш-shaped titanium retainer (12.656 N).*

Реферат. Биомеханическое обоснование трансальвеолярного остеосинтеза переломов при адентии нижней челюсти. Идашкина Н Г., Гударьян А.А., Чернов Д.В., Самойленко И.А. *Цель работы – повышение эффективности лечения переломов нижней челюсти у пациентов с полной или частичной адентией путем разработки и экспериментальной апробации методики трансальвеолярного остеосинтеза. Проведено экспериментальное исследование путем компьютерного имитационного 3Д моделирования методом конечных элементов для оценки эффективности фиксации перелома нижней челюсти при частичной или полной адентии с помощью разработанной нами Ш-образной пластины с использованием метода трансальвеолярного остеосинтеза. Расчеты зафиксированного перелома для статической (собственный вес) и динамической (функциональной) нагрузок выполнены по авторской методике, учитывающей выраженные резорбтивные процессы в кости с начала репаративной реакции для оценки ригидности фиксации отломков в течение всего периода заживления перелома. В условиях той же трехмерной модели нижней челюсти были выполнены расчеты при фиксации перелома обычными линейными титановыми накостными пластинками. Доказано, что при функциональной нагрузке новая пластина обеспечивает компрессионный эффект в области перелома, о чем свидетельствуют отрицательные перемещения в конечных элементах подбородочного отдела по результатам расчетов сочетания нагрузок 2-3. Максимальные усилия в винтах расчетной модели с обычной накостной пластиной составили 136,955 Н, что почти в десять раз больше, чем на модели с Ш-образным титановым фиксатором (12,656 Н).*

Year after year, maxillofacial injuries demonstrate the dynamics of growth, primarily due to road accidents, industrial injuries, the spread of a zone of hybrid hostilities. Among all injuries of the maxillofacial area, the proportion of mandibular fractures (MF) is 74-95% of cases [6].

Despite the development of modern methods of treatment of MF, their choice in patients with complete or partial adentia causes some difficulties and remains the subject not only of purely scientific discussions, but also a significant practical problem that needs to be addressed urgently [11].

It is well known that a device for the treatment of MF should provide reliable fixation of fragments and maintain it until consolidation. According to experts, such requirements are met by titanium miniplates for bone osteosynthesis of the mandible (M) according to M. Champy (1985) [14]. The success of treatment depends on the precise location of the plate, additional stability of the plates is provided by the dynamic compressive forces that occur during functioning the M, but to overcome the current torsional forces require two or more plates, which increases the trauma in surgical intervention and probability of possible complications [3]. Another area of ensuring the stability of post-operative fixation is the involvement of additional orthopedic support after surgeries on osteosynthesis for MF [2]. Additional immobilization is usually performed using dental bimaxillary splinting, which requires the presence of at least three stable teeth on each of the bone fragments and a fixed bite on the antagonist teeth [4]. In the case of partial or complete adentia, this type of fixation becomes impossible, which requires surgeons to involve an individual approach to the choice of treatment. In such circumstances, the refuse of a single algorithm for managing patients, unfortunately, leads to an increase in the total number of complications [6]. In Ukraine, plates of complex geometric configuration (triangular and rectangular, π-shaped, etc.) are becoming more and more popular, which correspond more to the anatomical structure of the M and are justified from the standpoint of biomechanics, but the question of their use remains debatable [3]. However, in patients with adentia and significant atrophy of the M, there is a high risk of injury to the mandibular nerve during fixation of the miniplate with screws, which limits the use of surgical techniques for the treatment of MF. Often in clinical conditions, the so-called "functional" methods of treatment are preferred, which involve the rejection of any surgical interventions, being the subject to criticism of the experts [9]. Therefore, osteosynthesis with the involvement of short screws is becoming an increasingly common method of treating

MF in patients with complete or partial adentia. Such forced "minimalism" does not contribute to the stability of osteosynthesis. Some authors envisage the solution of this problem in the involvement of massive titanium plates, which are located along the entire body of the M "from corner to corner", which increases the trauma of the operation and threatens the development of numerous inflammatory complications [15].

At the department of oral surgery, implantology and periodontology of the SE “DMA”, a bone plate was developed for osteosynthesis of the M with transverse petals to ensure stable fixation of fragments [5]. However, this design was used for extraoral osteosynthesis, which is significantly inferior to less traumatic intraoral techniques [10].

In recent years, it has been proven that more intensive formation of new bone tissue occurs in cases of osteosynthesis of the M at the level of its alveolar part, while after synthesis in the lower edge of the M, consolidation of fragments is slower and occurs with significant formation of callus [1]. In our development we tried to maintain the benefits associated with intraoral access and transalveolar fixation of M fragments, and to keep the fragments from secondary twisting. Having determined, as some authors insist [13], that only under the conditions of lingual fixation it is possible to keep fragments from rotation, we tried to provide lingual stabilization and avoid difficulties with fixing the device from the lingual side.

The aim of the work is to improve the effectiveness of MF treatment in patients with complete or partial adentia by developing and experimental testing the method of transalveolar osteosynthesis.

MATERIALS AND METHODS OF RESEARCH

Based on the biomechanical features of displacement of fragments and the solution of general problems that arise after repositioning and fixation of fragments of the M, at the department of oral surgery, implantology and periodontology of the SE “DMA” an innovative method of transalveolar osteosteal osteostenosis treatment of MF in patients with complete or partial adentia was developed (Patent of Ukraine for invention № 120811) [7]. The developed plate consists of a base tape and petals located with it in one plane. A general view of the development is shown in Figure 1.

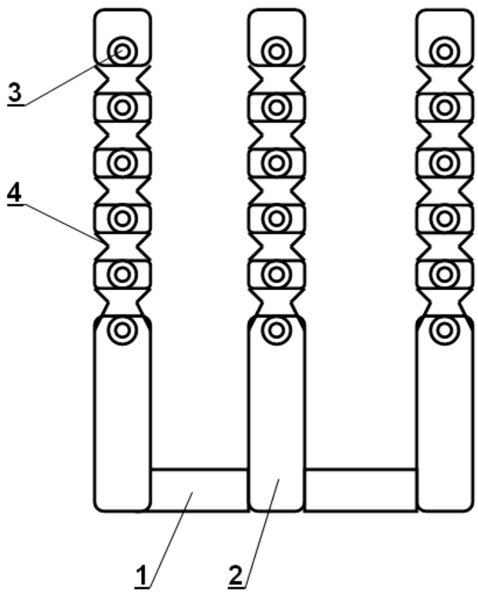


Fig. 1. Schematic view of the Ш-shaped plate for osteosynthesis of the M in partial or complete adentia: 1 – jumper, 2 – transverse petals, 3 – series of fixing holes, 4 – triangular slots

Intraoral access should be used to fix the Ш-shaped plate: an incision is made along the crest of the M, after detachment of the mucoosseous flap, the jumper of the plate is adapted as tightly as possible to the lingual surface of the M and transverse petals are bent to the M crest so, that the structure covers the M crest as clamp and the holes for the locking screws are located in front of the jumper, which in such circumstances works by the principle of brackets. The petals are fixed with screws. The petals should be located on both sides of the crack at a distance of at least 2-3 mm from it. If necessary, the plate petals are additionally fixed with vertical screws along the crest of the M (Fig. 2).

Fig. 2. Appearance of fixation of the Ш-shaped plate on the crest of the M on the model

Evaluation of the efficiency of MF fixation using our developed Ш-shaped plate by the method of transalveolar osteosynthesis in partial or complete adentia was performed experimentally on a computer three-dimensional model by the finite element method (FE) using the software package "Lira 9.6" (license number 92066390, license N 1/398 for the transfer of the non-exclusive right to use the LIRA® software package, Ukraine). This 3D – CAD program for engineering design allows to determine with high accuracy the distribution of local stresses, the direction and range of deformations in individual volumes and points (nodes) of the model, its degree of safety and failure features under ultimate stresses.

The computer model of the M was created according to the anatomical structure, taking into account the generally accepted geometric mean values. To solve the tasks, the state of complete adentia was modeled, and the thickness of the cortical and spongy bones of different jaw zones was taken into account. Fractures of the M body were created according to the typical localization. For maximum approximation to clinical conditions during the calculations of the fixed MF, the resorptive processes in the bone from the beginning of the reparative reaction and the presence of granulations just before the maturation of bone tissue were taken into account, so it was assumed that the fragments do not touch the entire surface and create only point contact above the lower edge of the M [12].

The calculation was performed for the following loads: Load 1 – constant from the own weight of the FE, taken into account by the program automatically; Load 2 – vertical load on the M from chewing in the area of the angle opposite to the fracture; Load 3 – vertical load on the M from biting in the area of the frontal axis of the chin. Also for calculation the following combinations of loadings (CL) were set: Combination of CL 1 – constant from own weight Load 1; Combination of CL 2 – constant from own weight Load 1 and from Load 2 on the M from chewing; Combinations of CL 3 – constant from own weight Load 1 and from Load 3 on the M from biting.

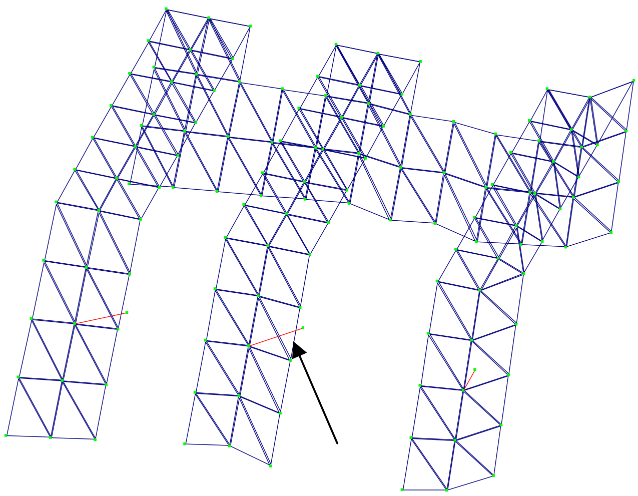
To estimate the distribution of forces and stresses, we used the color scale of the program "Lira 9.6", which has colors from dark blue to bright red, each color corresponds to a specific pressure level.

A three-dimensional model of the retainer with screws with the imposition of a FE grid with some conditional simplification of the form was also created (Fig. 3).

To fill in the data on the bone tissue of the M, empirical formulas given by A.N. Chuiko, M.S. Drahomyretska et al. were used (2011) [8]: the modulus of elasticity was calculated by the formula:

$$\mathbf{E=2195\,\rho^3,}$$

resistance limits (allowable bone tissue stresses):$\sigma=60\ \rho^2$,
where E – modulus of elasticity, ρ – density of bone tissue.



Note. Screws are shown in red color (indicated by arrow).

Fig. 3. Calculation three-dimension model of retainer with screws

The characteristics of titanium retainer and screws were taken according to ASTM F67 as for Grade 3. Under the conditions of the same three-dimensional model of the M, calculations were performed when fixing the fracture with ordinary linear titanium bone plates according to M. Champy (1985). The efficiency of the proposed technique was evaluated by comparing the digital data obtained during the experimental study and comparing the mosaics of isopoles of the finite element grid under the influence of load.

RESULTS AND DISCUSSION

The analysis of displacements along X, Y, Z from CL showed a uniform distribution of stresses and forces in the FE of the retainer and the M both under the influence of its own weight and during the functional load (biting and chewing). The calculated combination of constant loads from the own weight of the FE along the X axis showed that for almost all FE of the M body the main displacements occurred in the lingual direction, to a lesser extent – in the FE of the coronal and cervical processes and only in the FE of the alveolar part of the M – in the vestibular direction. However, they were quite uniform, balanced and had no critical values (Fig. 4).

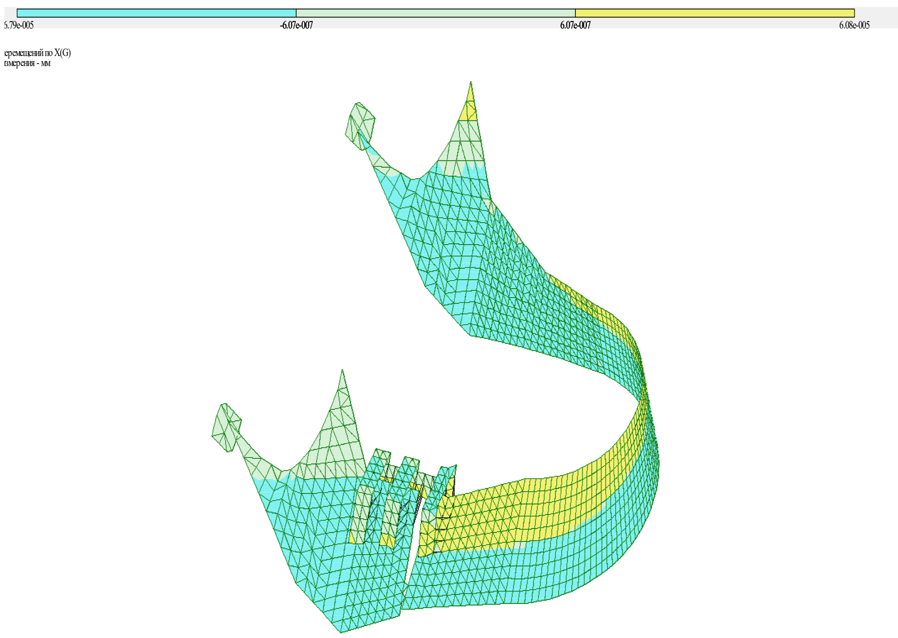
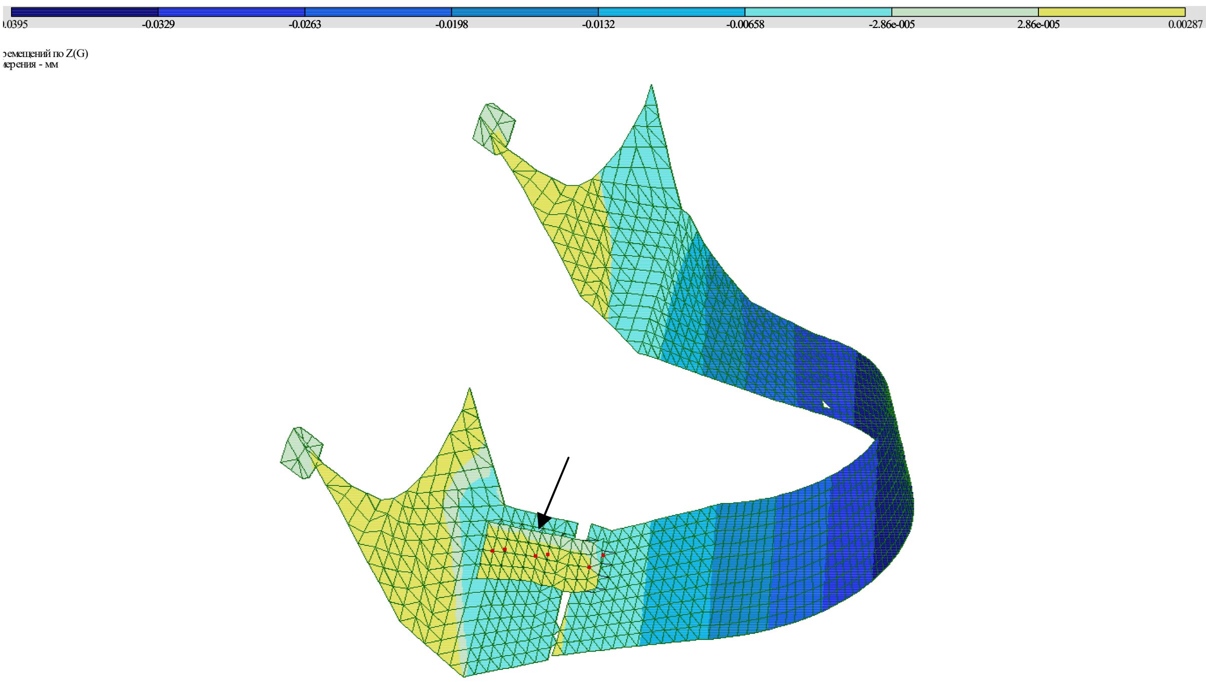


Fig. 4. Displacement along X from CL 1

A similar picture was established when analyzing the displacement in the FE along the Y and Z axes. Thus, we can say that the retainer stabilizes the two fragments of the jaw and restores the anatomical continuity of its structure, due to which there is a uniform distribution of forces and stresses in the M. However, when comparing the isopoles of the displacements along X, Y, Z from CL 1 in the case of using a conventional plate, significant stresses were established in the fixing screws of the structure, which was not observed in the case of using a retainer. Also, for displacements along the X-axis for CL 1 in the case of fixation of MF with a normal bone plate, there were no negative displacements in the FE of a large fragment in the chin area, this state in clinical conditions will contribute to the divergence of fragments in the horizontal plane, unlike the case with Ш-shaped plate, where there was a compression effect, which was indicated by negative displacements in the CE of the chin area. The same regularities were established during the analysis of displacements along X, Y, Z from CL 2. However, the fact that in case of fixing of MF by a usual bone plate, limiting stresses arose not only in fixing screws, but also in the plate with registered negative displacements, which in clinical conditions can lead to deformations of the structure and deterioration of its stability (Fig. 5).



Note. *red color of the locking screws indicates that they exceed the maximum allowable stress (indicated by an arrow)

Fig. 5. Displacement along Z from CL 2

The dynamics of isopoles during the functional load of the M was the most significant. The calculation of the vertical load on the M from biting food in the area of the frontal axis of the chin also showed a uniform distribution of stresses and forces in the FE of the retainer and the M for the Ш-shaped plate and negative displacement in the FE of the chin, indicating the presence in a new fixing device of compression effect even during functioning of the M (Fig. 6).

When analyzing the forces in the screws that fix the Ш-shaped plate, it is necessary to emphasize their minimality and homogeneity. The forces in the screws are insignificant and do not exceed the bearing capacity of the connection. On the contrary, similar calculations for a conventional miniplate have shown an increase in the forces in the fixing screws, which can lead to their fragmentation and instability of the entire “bone-fixator” system. The maximum Qy efforts in the screws of the computational model with the usual bone plate were 136.955 N, which was almost ten times higher than in the model of transalveolar osteosynthesis (Qy for the W-shaped retainer was 12.656 N).

Thus, the calculations confirmed the effectiveness of the developed technique of transalveolar osteosynthesis using a Ш-shaped titanium retainer and proved its advantages over traditional miniplates.

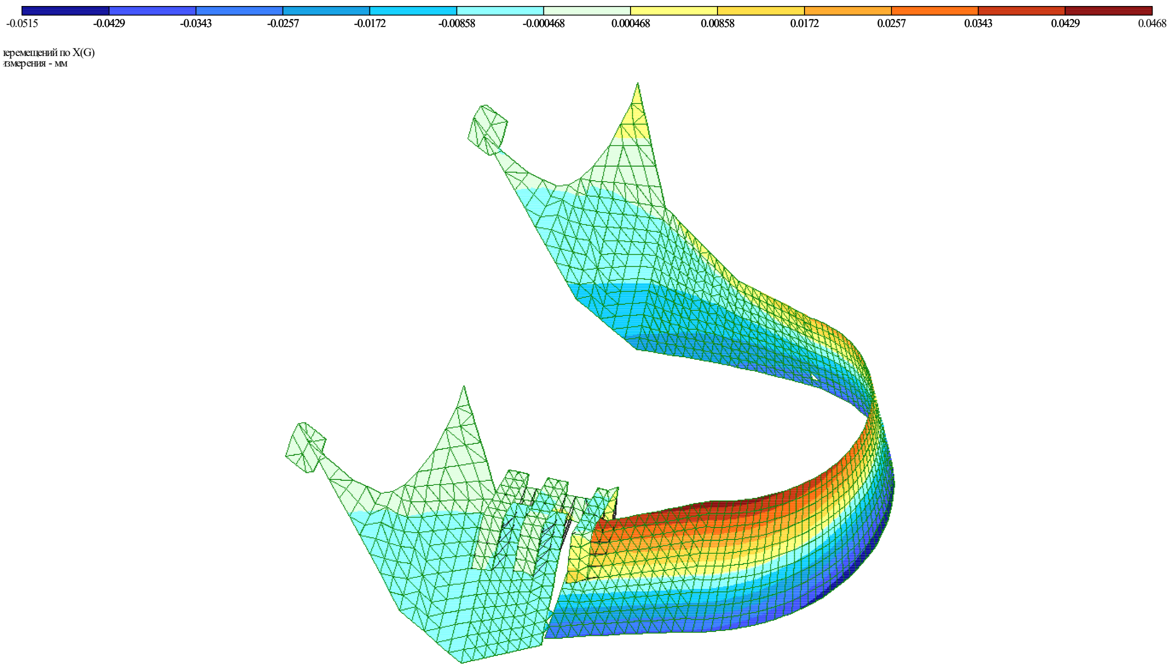


Fig. 6. Displacement along X from CL 3

CONCLUSIONS

1. Developed a new transalveolar fixation system for intraoral osteosynthesis in patients with MF and partial or complete adentia provides stable fixation of the M fragments and allows for early functional loading of the M to prevent inflammatory complications.
2. Substantiation of the method from the standpoint of biomechanical properties of the system "bone-fixator" proved the advantages of the device, especially under functional load, when the design of the plate provides a compression effect in the area of MF, as evidenced by negative displacements in FE of the chin area by the results of CL 2 and CL 3.
3. The displacements and deformations of the calculation model established in the experiment with the proposed retainer for all load combinations do not have a traumatic effect on the regenerate.
4. Given the above, a new concept of minimally invasive surgery of MF using transalveolar osteosynthesis, which reduces the volume of intraoperative trauma, provides stable fixation of bone fragments at all stages of reparative osteogenesis and early functional load to minimize complications during treatment can be recommended for extensive clinical practice.

Conflict of interest. The authors declare no conflict of interest.

REFERENCES

1. Artiushkevych AS. [Injuries and reconstructive surgery of the maxillofacial region]. Minsk: Vysheishaya shkola. 2016. p. 255. Russian.

2. Komok OA, Idashkina NG, Tereshkov DYu. [Usage of new wire splints in the treatment of bilateral fractures of the mandibule in combination with osteosynthesis]. Medicni perspektivi. 2012;17(1):122-127. Ukrainian. Available from: https://medpers.dsma.dp.ua/2012-summary/2012-n1/#Komok

3. Kopchak AV, Krishuk MG. [Stress distribution in the "fixer-bone" system during osteosynthesis of the mandible by ankinal mini-plates]. Ukrayinskyi zhurnal hirurgii. 2014;(1):44-49. Ukrainian. Available from: http://www.mif-ua.com/archive/article/37980

4. Palchikova IO, et al. Interventions for the management of mandibular fractures in patients with acquired partial or complete adentia (Review). Clinical and experimental pathology. 2019;18(1):132-7. Ukrainian. doi: https://doi.org/10.24061/17274338.XVIII.1.67.2019.219

5. [Bone plate for mandibular fracture osteosynthesis]. Pat. 39746 Ukraine: A61B 17/064, A61B 17/58. N 2001010705; st. 31.01.01; publ. 15.06.01. Bul. N 5. Ukrainian. Available from: http://uapatents.com/4-39746-nakistkova-plastina-dlya-osteosintezu-zlamu-nizhno-shhelepi.html

6. Pohranychna KhR. [Principles of treatment of mandibular fractures]. Medycyna transportu Ukrainy.

2013;(3):86-90. Ukrainian. Available from: http://nbuv.gov.ua/UJRN/MTU_2013_3_24

7. [Method of surgical treatment of mandibular fractures and bone plate for its implementation]: pat. 120811 Ukraine: A61B 17/58, A61B 17/80. N a201810385; st. 22.10.18; publ. 10.02.20. Bul. N 3. Ukrainian. Available from: https://base.uipv.org/searchINV/search.php?action=viewdetails&IdClaim=265628

8. Chujko AN, Dragomireckaya MS, Mirza RA. [Primary (elastic) and secondary (residual) deformation of the mandible and its effect on the dental occlusion]. Ukrayinskyi stomatologichnyi almanah. 2011;(5):39-51. Ukrainian. Available from: http://nbuv.gov.ua/UJRN/Usa_2011_5_10

9. Carlson AR, et al. A Technique for Reduction of Edentulous Fractures Using Dentures and SMARTLock Hybrid Fixation System. Plastic Reconstr Surg. 2017;5(9):1473-7. doi: https://doi.org/10.1097/GOX.0000000000001473

10. Emam HA, Ferguson HW, Jatana CA. Management of atrophic mandible fractures: an updated comprehensive review. Oral Surg. 2018;(1):79-87. doi: https://doi.org/10.1111/ors.12300

11. Krishnan S, et al. Fracture management of an edentulous mandible in a geriatric osteoporotic patient. Ind J Dent Research. 2015;(5):542-4. doi: https://doi.org/10.1097/GOX.0000000000001473

12. Idashkina NG. Computer modeling and biological processes: new opportunities for experimental estimation of stable mandibular osteosynthesis. Modern Scientific Researches. 2018;(5):47-60. doi: https://doi.org/10.30889/2523-4692.2018-05-03-039

13. Balasubramanian SP, et al. Lingual Splint for Sagittal Fractures of Mandible; An Effective Adjunct to Contemporary Osteosynthesis: A Case Series with Review of Literature. Craniomaxillofacial Trauma & Reconstruction Open. 2017;(1):9-14. doi: https://doi.org/10.1055/s-0037-1603578

14. Zaky MM, et al. The use of microplates for fixation of mandibular fractures: a systematic review. J Med Sci Res. 2019;(2):1-7. doi: https://doi.org/10.4103/JMISR.JMISR_9_19

15. Van der Kolk – Bender CA, Koudstaal MJ, Wolvius EB. Treatment of Severely Atrophic Edentulous Mandible Fractures: Load-Bearing or Load-Sharing? Craniomaxillofac Trauma Reconstruction Open. 2018;(2):55-60. doi: https://doi.org/10.1055/s-0038-1667295

СПИСОК ЛІТЕРАТУРИ

1. Артюшкевич А. С. Травмы и восстановительная хирургия челюстно-лицевой области. Минск: Вышэйшая школа, 2016. 255 с.

2. Комок О. А., Ідашкіна Н. Г., Терешков Д. Ю. Використання нових дротяних шин при лікуванні двобічних переломів нижньої щелепи у комбінації з остеосинтезом. *Медичні перспективи*. 2012. Т. 17, № 1. С. 122-127. URL: https://medpers.dsma.dp.ua/2012-summary/2012-n1/#Komok

3. Копчак А. В., Кріщук М. Г. Розподіл напружень у системі "Фіксатор-кістка" при проведенні остеосинтезу нижньої щелепи накістковими мініпластинами. *Укр. журнал хірургії*. 2014. № 1. С. 44-49. URL: http://www.mif-ua.com/archive/article/37980

4. Методи лікування переломів нижньої щелепи з вродженою та набутою адентією (Огляд літератури) / Я. О. Пальчікова та ін. *Клінічна та експериментальна патологія.* 2019. Т. 18, № 1. С. 132-137. DOI: https://doi.org/10.24061/17274338.XVIII.1.67.2019.219

5. Накісткова пластина для остеосинтезу зламу нижньої щелепи: пат. 39746 Україна: A61B 17/064, A61B 17/58. № 2001010705; заяв. 31.01.01; опубл. 15.06.01. Бюл. № 5. URL: http://uapatents.com/4-39746-nakistkova-plastina-dlya-osteosintezu-zlamu-nizhno-shhelepi.html

6. Погранична Х. Р. Принципи лікування переломів нижньої щелепи. *Медицина транспорту України.* 2013. № 3. С. 86-90. URL: http://nbuv.gov.ua/UJRN/MTU_2013_3_24

7. Спосіб хірургічного лікування переломів нижньої щелепи та накісткова пластина для його здійснення: пат. 120811 Україна: A61B 17/58, A61B 17/80. № a201810385; заяв. 22.10.18; опубл. 10.02.20. Бюл. № 3. URL: https://base.uipv.org/searchINV/search.php?action=viewdetails&IdClaim=265628

8. Чуйко А. Н., Драгомирецкая М. С., Мирза Р. А. Первичная (упругая) и вторичная (остаточная) деформация нижней челюсти и ее влияние на окклюзионное соотношение зубов. *Укр. стоматологічний альманах.* 2011. № 5. С. 39-51. URL: http://nbuv.gov.ua/UJRN/Usa_2011_5_10

9. A Technique for Reduction of Edentulous Fractures Using Dentures and SMARTLock Hybrid Fixation System / A. R. Carlson et al. *Plastic Reconstr Surg.* 2017. Vol. 5, No. 9. P. 1473-1477. DOI: https://doi.org/10.1097/GOX.0000000000001473

10. Emam H. A., Ferguson H. W., Jatana C. A. Management of atrophic mandible fractures: an updated comprehensive review. *Oral Surg*. 2018. Vol. 11, No. 1. P. 79-87. DOI: https://doi.org/10.1111/ors.12300

11. Fracture management of an edentulous mandible in a geriatric osteoporotic patient / S. Krishnan et al. *Ind J Dent Research.* 2015. Vol. 26, No. 5. P. 542-544. DOI: https://doi.org/10.1097/GOX.0000000000001473

12. Idashkina N. G. Computer modeling and biological processes: new opportunities for experimental estimation of stable mandibular osteosynthesis. *Modern Scientific Researches.* 2018. No. 5. P. 47-60. DOI: https://doi.org/10.30889/2523-4692.2018-05-03-039

13. Lingual Splint for Sagittal Fractures of Mandible; An Effective Adjunct to Contemporary Osteosynthesis: A Case Series with Review of Literature / S. P. Balasubramanian et al. *Craniomaxillofacial Trauma*

& Reconstruction Open. 2017. Vol. 1. P. 9-14. DOI: https://doi.org/10.1055/s-0037-1603578

14. The use of microplates for fixation of mandibular fractures: a systematic review / M. M. Zaky et al. *J Med Sci Res.* 2019. Vol. 2. P. 1-7. DOI: https://doi.org/10.4103/JMISR.JMISR_9_19

15. Van der Kolk – Bender C. A, Koudstaal M. J., Wolvius E. B. Treatment of Severely Atrophic Edentulous Mandible Fractures: Load-Bearing or Load-Sharing? *Craniomaxillofac Trauma Reconstruction Open*. 2018. Vol. 2. P. 55-60. DOI: https://doi.org/10.1055/s-0038-1667295

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