Review | DOI: https://doi.org/10.17816/KMJ531480

Efficiency of chewing load deficiency correction in clinical dental practice

Said S. Ksembaev[1], Albert K. Salakhov[1], Gulshat T. Saleeva[1], Ildar N. Musin[2], Rinat A. Saleev[1]

[1]Kazan State Medical University, Kazan, Russia;
[2]Kazan National Research Technological University, Kazan, Russia

ABSTRACT

Weakening of the chewing act, typical for modern humans due to consumption of soft food, causes a deficit of chewing load and has a negative effect on the dental system. To combat hypodynamia of the masticatory apparatus with the aim of preventing destructive processes in its structures, a gnathotraining system was developed, including electrical stimulation of the masticatory muscles themselves in physiological parameters, which develops the effect of "imaginary chewing", and gnathotraining using chewing gum. In addition, functional training of the masticatory apparatus using chewing exercises was proposed. Considering that chewing gum practically does not compensate for the deficit of chewing load observed in modern society, the staff of the Kazan State Medical University and the Kazan National Research Technological University developed the "Denta Fit" dental trainer and a dental training system. It has been established that dental and jaw training stimulates secretion of saliva, its mineralizing potential, functional resistance of tooth enamel, allows achieving a good level of oral hygiene, reduces the rate of increase in the intensity of dental caries, as well as the severity of muscular-articular disorders of the temporomandibular joints, enhances neuromuscular activity of the masticatory muscles and regional blood flow. In children with permanent bite, dental and jaw training maintains the hydrogen index (pH) of oral fluid at a neutral level and provides, in combination with a toothbrush, optimal hygienic dental care, contributes to the formation of a correct dental occlusion. Thus, the effects of increased neuromuscular activity of the masticatory muscles, as well as regional vascular tone, arising during dental and jaw training, indirectly indicate that the dental and jaw system receives adequate mechanical loads necessary for the normal functioning of all its links. The results of the conducted studies indicate the effectiveness and feasibility of using dental training to improve dental status, which serves as a new approach to the prevention and treatment of dental diseases.

Keywords: dentistry; dental training; dental simulators; functional prevention.

To cite this article:
Ksembaev SS, Salakhov AK, Saleeva GT, Musin IN, Saleev RA. Efficiency of chewing load deficiency correction in clinical dental practice. *Kazan Medical Journal.* 2024;105(6):1023–1028. doi: https://doi.org/10.17816/KMJ531480

Received: 07.07.2023 **Accepted:** 27.04.2024 **Published:** 02.11.2024

DOI: https://doi.org/10.17816/KMJ531480
Обзорная статья | УДК 616-039.71: 616.31

Эффективность коррекции дефицита жевательной нагрузки в клинической стоматологической практике

С.С. Ксембаев[1], А.К. Салахов[1], Г.Т. Салеева[1], И.Н. Мусин[2], Р.А. Салеев[1]

[1] Казанский государственный медицинский университет, г. Казань, Россия;
[2] Казанский национальный исследовательский технологический университет, г. Казань, Россия

АННОТАЦИЯ

Ослабление акта жевания, свойственное современному человеку вследствие потребления мягкой пищи, вызывает дефицит жевательной нагрузки и оказывает негативное влияние на зубочелюстную систему. Для борьбы с гиподинамией жевательного аппарата с целью профилактики деструктивных процессов в его структурах была разработана система гнатотренинга, включавшая электростимуляцию собственно жевательных мышц в физиологических параметрах, которая развивает эффект «мнимого жевания», и гнатодинамотренинг с помощью жевательной резинки. Кроме того предложена функциональная тренировка жевательного аппарата с помощью жевательных упражнений. Учитывая, что жевательная резинка практически не восполняет дефицит жевательной нагрузки, наблюдаемый в современном обществе, сотрудниками Казанского государственного медицинского университета и Казанского национального исследовательского технологического университета были разработаны зубочелюстной тренажёр «Дента Фит» и система зубочелюстного тренинга. Установлено, что зубочелюстной тренинг стимулирует секрецию слюны, её минерализующий потенциал, функциональную резистентность эмали зубов, позволяет достичь хорошего уровня гигиены рта, снижает показатель прироста интенсивности кариеса зубов, а также выраженность мышечно-суставных нарушений височно-нижнечелюстных суставов, усиливает нейромышечную активность жевательных мышц и регионарный кровоток. У детей с постоянным прикусом зубочелюстной тренинг поддерживает водородный показатель (pH) ротовой жидкости на нейтральном уровне и обеспечивает в комплексе с зубной щёткой оптимальный гигиенический уход за зубами, способствует формированию правильного зубного прикуса. Таким образом, возникающие при зубочелюстном тренинге эффекты усиления нейромышечной активности жевательных мышц, а также регионарного сосудистого тонуса, косвенно свидетельствуют о получении зубочелюстной системой адекватных механических нагрузок, необходимых для нормального функционирования всех её звеньев. Результаты проведённых исследований свидетельствуют об эффективности и целесообразности использования зубочелюстного тренинга для улучшения стоматологического статуса, что служит новым подходом к профилактике и лечению стоматологических заболеваний.

Ключевые слова: стоматология; зубочелюстной тренинг; зубочелюстные тренажёры; функциональная профилактика.

Как цитировать:
Ксембаев С.С., Салахов А.К., Салеева Г.Т., Мусин И.Н., Салеев Р.А. Эффективность коррекции дефицита жевательной нагрузки в клинической стоматологической практике // Казанский медицинский журнал. 2024. Т. 105, № 6. С. 1023–1028. doi: https://doi.org/10.17816/KMJ531480

Рукопись получена: 07.07.2023 **Рукопись одобрена**: 27.04.2024 **Опубликована**: 02.11.2024

Chewing contributes to the normal functioning of the dental system, plaque removal from teeth, and saliva production. Poor chewing has negative effects, especially on the periodontium [1].

Additionally, eating soft foods does not remove food particles from teeth's surface. Heat processing, softening, and crushing of food improves the taste of food and reduces time for chewing and eating. Concentrated food reduces eating and chewing time, time spent in the mouth, and stress on the dental system. This gradually contributes to lazy chewing and decreases the load on the entire dental system. Lazy chewing and concentrated food consumption significantly contribute to the decreased natural self-cleaning ability of the human mouth, which, along with sugar consumption, leads to tooth decay [1, 2].

Study of the functional morphology of a human skull revealed the main trend of its evolution: progressive size reduction of the chewing system, including the upper and lower jaws and teeth. For example, the chewing surface of human teeth has nearly halved over the past 100,000 years [1]. Additionally, changes in the way the third molars (wisdom teeth) form, develop, and erupt are obvious, visible, and well-known signs [1].

Jaw reduction has led to the fact that in the majority of the general population, even immature third molars are undetected; in many cases, they form inside the jaw and do not erupt [1]. When they do erupt, they are difficult to erupt or should be removed owing to lack of space [1]. Therefore, eventually, humans are predisposed to complete loss of the third molars, which is one of the main consequences of dental system reduction [1].

In addition to microbial factors, local hemodynamic and tissue perfusion abnormalities are believed to be crucial in the pathogenesis of periodontal and dental diseases [2]. They are pathogenetically triggered by functional changes in the periodontal vessels due to decreased masticatory load, which leads to tissue hypoxia [3].

Masticatory load is the main functional load applied to periodontal tissues, resulting in functional hyperemia. The response of the periodontal vasculature to masticatory load depends on the use of available functional reserves and status of blood flow regulation [2, 3].

Moreover, the mechanical factor of masticatory load increases the mineralization level of the hard tissues of the intact masticatory teeth and decayed teeth, which can be used to prevent dental decay when employing the optimal additional masticatory load [4].

A gnathotraining system guided by functional diagnostic techniques was developed to hinder hypodynamia of the masticatory apparatus to prevent destructive processes in its structures [5]. It includes electrical stimulation of the masseter muscles for physiological parameters mimicking a chewing effect and gnathodynamic training using chewing gum. Electrical stimulation is used in cases of significant chewing dysfunction.

A study by Park et al. showed that neuromuscular electrical stimulation synchronized with chewing exercises is more effective in increasing biting force and masseter muscle thickness [6]. Functional training improves chewing in patients with mandibular prognathism [7].

It was found that jaw exercises are an effective treatment and are recommended for patients with temporomandibular joint (TMJ) pain and jaw dysfunction [8, 9].

A systematic review revealed the beneficial effect of exercise in treating myogenic and arthrogenic TMJ dysfunction. Notably, active and passive oral exercises may be effective in reducing musculoskeletal pain and improving oromotor function [10].

Considering the fact that chewing gum does not compensate the deficit of masticatory load in modern society, so-called gnatotraining (use of chewing gum) by NK Loginova was developed in 2000 by authors from the Kazan State Medical University headed by Professor SS Ksembaev, which was joined in 2008 by the Department of Medical Engineering of the Kazan National Research Technological University headed by Associate Professor IN Musin [11]. The result of this joint work was a Russian Denta Fit dental trainer, which was then scaled up for industrial production [12].

The dental jaw trainer was developed using IR-21 silicone rubber and manufactured at the Department of Chemistry and Technology of Elastomer Processing of the Kazan National Research Technological University [13].

The potential of including dental and jaw training in a program of treatment and preventive measures has been demonstrated, which allows to improve dental status and in turn prevent dental decay and periodontal diseases and form an appropriate dental occlusion in children [13].

The use of the dental trainer increased the neuromuscular activity of the masseter muscles and improved regional blood flow (i.e., increased linear velocity of blood flow and decreased resistance coefficients). The stimulating effect of dental and jaw training on the rate of saliva secretion and its mineralizing potential and the functional resistance of tooth enamel have been demonstrated. Regular use of the dental trainer was shown to decrease the rate of decay progression [14].

The stimulating effects of dental and jaw training on the functional status of the salivary glands and periodontal microvascular network were a relevant increase in the salivary flow rate, a decrease in the total white blood cell (WBC) count, and an increase in the live WBC count in oral fluid. During the rehabilitation period, dental and jaw training combined with toothbrushing improved personal oral hygiene in patients [15].

Mathematical modeling of the hydrodynamic effect confirmed the effectiveness of using a dental trainer to clean the vestibular, palatal, lingual, and buccal surfaces of teeth. Study of the effects of dental training on the composition and properties of the oral fluid revealed no abnormalities in the periodontium. This indicated that dental training does not

activate the prooxidant system, which prevents an abnormal reaction resulting in degenerative lesions and periodontium destruction [16].

The need for myofunctional disorder treatment in combination with orthodontic treatment is well established. The authors noted that treating myofunctional disorders with appropriate loading during exercise may reduce treatment time for dentoalveolar anomalies [17].

The effectiveness of this approach has been confirmed in patients with mandibular fractures. Dentoalveolar training improved severity of muscular and articular TMJ disorders (using the short Hamburg test), bringing the parameters of the main group almost to the functional norm, compared to those of the control group, which remained at risk. Therefore, adding dental and jaw training to a rehabilitation program for mandibular fractures was found to reduce associated musculoskeletal disorders [18].

Dental and jaw training in children with permanent occlusion induces a stimulating effect on the salivary secretion rate, maintains the hydrogen index (pH) of the oral fluid at a neutral level, and, in combination with toothbrushing, provides optimal dental hygiene [13].

New challenges stimulate improvement of the dental trainer. For example, devices for treating myofunctional disorders of the dental system [19] and TMJ dysfunction [20] associated with adverse changes in masseter muscle function have been developed.

Studies confirmed the effectiveness and feasibility of using dental trainers to improve dental health as a new approach for the prevention and treatment of dental disease.

The effects of increased neuromuscular activity of the masseter muscles and regional vascular tone indirectly indicate that the dental system receives adequate mechanical load for the normal functioning of all its elements.

ADDITIONAL INFORMATION

Authors' contribution. S.S.K., A.K.S. — conceptualization, formal analysis, writing — review and editing, supervision; I.N.M. — methodology, validation, investigation, writing — original draft; G.T.S., R.A.S. — writing — review and editing, supervision.
Funding source. The study had no sponsorship.
Competing interests. The authors declare that there is no conflict of interest in the presented article.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. С.С.К. и А.К.С. — концептуализация, анализ, редактирование рукописи, общее руководство; И.Н.М. — методология, валидация, исследование, создание черновика; Г.Т.С. и Р.А.С. — редактирование рукописи, общее руководство.
Источник финансирования. Исследование не имело спонсорской поддержки.
Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов по представленной статье.

REFERENCES

1. Leont'yev VK. Environmental and medicosocial aspects of the main stomatological diseases. *Biosfera.* 2009;1(2): 230–236. (In Russ.) EDN: QZOGIF
2. Sabeeva MA, Sabeeva IA, Hetagurov SK, Kokaev RI. Comparative evaluation of the efficiency of removal of defects of hard tissues of teeth chewing group method of sealing and composite tabs, made indirectly. *Zdorov'e i obrazovanie v XXI veke*. 2016;18(1):73–76. (In Russ.) EDN: VPUHSX
3. Grudyanov AI, Ovchinnikova VV. *Profilaktika vospalitel'nykh zabolevanii parodonta.* (Prevention of inflammatory periodontal diseases.) Moscow: Meditsinskoe informatsionnoe agentstvo; 2007. 80 p. (In Russ.)
4. Schunke S. Funkciya "v" ili "vne"? 1 chast'. Gnatology. *Kvintessenciya.* 2005;1:25–32. (In Russ.)
5. Loginova NK. The gnat training method. *Novoe v stomatologii.* 2003;1:21–24. (In Russ.)
6. Park JS, Jung YJ, Kim MJ. Effects of neuromuscular electrical stimulation synchronized with chewing exercises on bite force and masseter muscle thickness in community-dwelling older adults in South Korea: A randomized controlled trial. *Int J Environ Res Public Health.* 2020;17(13):4902. doi: 10.3390/ijerph17134902
7. Kawai N, Shibata M, Watanabe M. Effects of functional training after orthognathic surgery on masticatory function in patients with mandibular prognathism. *J Dent Sci.* 2020;15(4):419–425. doi: 10.1016/j.jds.2020.01.006
8. Lindfors E, Arima T, Baad-Hansen L. Jaw exercises in the treatment of temporomandibular disorders-an international modified Delphi study. *J Oral Facial Pain Headache.* 2019;33(4):389–398. doi: 10.11607/ofph.2359
9. Armijo-Olivo S, Pitance L, Singh V. Effectiveness of manual therapy and therapeutic exercise for temporomandibular disorders: Systematic review and meta-analysis. *Phys Ther.* 2016;96(1):9–25. doi: 10.2522/ptj.20140548
10. Lindfors E, Magnusson T, Ernberg M. Effect of therapeutic jaw exercises in the treatment of masticatory myofascial pain: A randomized controlled study. *J Oral Facial Pain Headache.* 2020;34(4):364–373. doi: 10.11607/ofph.2670
11. Ksembaev SS, Vavilov YG, Andreev IM. *Stomatologicheskii massazher*. Ofitsial'nyi byulleten' komiteta RF po patentam. (Dental massager. Official Bulletin of the Russian Patent Committee.) Byull. No. 4. 2007;82. (In Russ.)
12. Ksembaev SS, Musin IN, Vol'fson SI, Salakhov AK, Khaliullina AA, Khadyeva MN, Razina IS. *Stomatologicheskii massazher*. (Dental massage machine.) Patent No. 2493806. Byul. No. 27 from 27.09.2013. (In Russ.) EDN: ZGUJCP
13. Yakovleva MV, Ksembaev SS, Musin IN, Salakhov AK. *Zubochelyustnoi trening v praktike individual'noi gigieny rta u detei*. (Dental training in the practice of individual oral hygiene in children.) Kazan: Brig; 2019. 140 p. (In Russ.)

14. Ksembaev SS, Musin IN, Salakhov AK. Dentition simulator "Dentafit" — innovation to improve dental health. *Ural medical journal.* 2018;(6):59–61. (In Russ.) doi: 10.25694/URMJ.2018.04.097
15. Salakhov AK, Ksembaev SS, Baykeev RF, Haliullina AA. The effect of dental training on the improvement of physiological parameters of the oral cavity. *Ural medical journal*. 2018;(6):30–34. (In Russ.) doi: 10.25694/URMJ.2018.04.096
16. Khadyeva MN, Ksembaev SS. *Khronicheskii generalizirovannyi parodontit: sorbtsionno-applikatsionnaya terapiya i zubochelyustnoi trening.* (Chronic generalized periodontitis: sorption-application therapy and dental training.) Kazan': Brig; 2015. 135 p. (In Russ.)
17. Khamitova NKh, Ignat'eva LA. *Ustroistvo dlya korrektsii miofunktsional'nykh narushenii.* (Evaluation of functional training in stabilizing the level of oral hygiene in adolescents.) Patent No. 174592. Bul. No 30 from 23.10.2017. (In Russ.) EDN: YXBEMF
18. Gasymzade DK, Ksembaev SS, Takhavieva FV, Salakhov AK, Ivanov OA. *Perelomy nizhnei chelyusti: kinezioteipirovanie i zubochelyustnoi trening.* (Fractures of the mandible: kinesiotaping and dental training.) Kazan': MeDDoK; 2024. 160 p. (In Russ.)
19. Saleeva GT, Saleev RA, Saleeva LR, Saleev NR, Salakhov AK, Ksembaev SS, Musin IN, Kuznetsov EY. *Ustroistvo dlya korrektsii miofunktsional'nykh narushenii zubochelyustnoi sistemy*. (Device for correction of myofunctional disorders of the dental system.) Patent №206220. Byul. No. 25 from 31.08.2021. (In Russ.) EDN: FVZGQH
20. Salakhov AK, Ksembaev SS, Musin IN, Eliseeva KS. *Ustroistvo dlya lecheniya disfunktsii visochno-nizhnechelyustnogo sustava*. (Device for the treatment of temporomandibular joint dysfunction.) Patent No. 201136. Byul. No. 34 from 30.11.2020. (In Russ.) EDN: POGYOY

СПИСОК ЛИТЕРАТУРЫ

1. Леонтьев В.К. Экологические и медико-социальные аспекты основных стоматологических заболеваний // Биосфера. 2009. Т. 1, № 2. С. 230–236. EDN: QZOGIF
2. Сабеева М.А., Сабеева И.А., Хетагуров С.К., Кокаев Р.И. Изменения микрогемодинамики в тканях пародонта и функционального состояния жевательных мышц при долговременной жевательной нагрузке // Здоровье и образование в XXI веке. 2016. Т. 18, № 1. С. 73–76. EDN: VPUHSX
3. Грудянов А.И., Овчинникова В.В. Профилактика воспалительных заболеваний пародонта. М.: Медицинское информационное агентство, 2007. 80 с.
4. Schunke S. Функция «в» или «вне»? 1 часть. Гнатология // Квинтэссенция. 2005. Т. 1. С. 25–32.
5. Логинова Н.К. Метод гнатотренинга // Новое в стоматологии. 2003. Т. 1. С. 21–24.
6. Park J.S., Jung Y.J., Kim M.J. Effects of neuromuscular electrical stimulation synchronized with chewing exercises on bite force and masseter muscle thickness in community-dwelling older adults in South Korea: A randomized controlled trial // Int J Environ Res Public Health. 2020. Vol. 17, N. 13. P. 4902. doi: 10.3390/ijerph17134902
7. Kawai N., Shibata M., Watanabe M. Effects of functional training after orthognathic surgery on masticatory function in patients with mandibular prognathism // J Dent Sci. 2020. Vol. 15, N. 4. P. 419–425. doi: 10.1016/j.jds.2020.01.006
8. Lindfors E., Arima T., Baad-Hansen L. Jaw exercises in the treatment of temporomandibular disorders-an international modified Delphi study // J Oral Facial Pain Headache. 2019. Vol. 33, N. 4. P. 389–398. doi: 10.11607/ofph.2359
9. Armijo-Olivo S., Pitance L., Singh V. Effectiveness of manual therapy and therapeutic exercise for temporomandibular disorders: Systematic review and meta-analysis // Phys Ther. 2016. Vol. 96, N. 1. P. 9–25. doi: 10.2522/ptj.20140548
10. Lindfors E., Magnusson T., Ernberg M. Effect of therapeutic jaw exercises in the treatment of masticatory myofascial pain: A randomized controlled study // J Oral Facial Pain Headache. 2020. Vol. 34, N. 4. P. 364–373. doi: 10.11607/ofph.2670
11. Ксембаев С.С., Вавилов Ю.Г., Андреев И.М. Стоматологический массажёр. Официальный бюллетень комитета РФ по патентам. Бюлл. №4. 2007. с. 82.
12. Ксембаев С.С., Мусин И.Н., Вольфсон С.И., и др. Стоматологический массажёр. Патент №2493806. Бюл. №27 от 27.09.2013. EDN: ZGUJCP
13. Яковлева М.В., Ксембаев С.С., Мусин И.Н., Салахов А.К. Зубочелюстной тренинг в практике индивидуальной гигиены рта у детей. Казань: Бриг, 2019. 140 с.
14. Ксембаев С.С., Мусин И.Н., Салахов А.К. Зубочелюстной тренажёр «Denta fit» — инновация для улучшения стоматологического здоровья // Уральский медицинский журнал. 2018. № 6. С. 59–61. doi: 10.25694/URMJ.2018.04.097
15. Салахов А.К., Ксембаев С.С., Байкеев Р.Ф., Халиуллина А.А. Влияние зубочелюстного тренинга на улучшение физиологических параметров полости рта // Уральский медицинский журнал. 2018. № 6. С. 30–34. doi: 10.25694/URMJ.2018.04.096
16. Хадыева М.Н., Ксембаев С.С. Хронический генерализированный пародонтит: сорбционно-аппликационная терапия и зубочелюстной тренинг. Казань: Бриг, 2015. 135 с.
17. Хамитова Н.Х., Игнатьева Л.А. Устройство для коррекции миофункциональных нарушений. Патент №174592. Бюл. №30 от 23.10.2017. EDN: YXBEMF
18. Гасымзаде Д.К., Ксембаев С.С., Тахавиева Ф.В., и др. Переломы нижней челюсти: кинезиотейпирование и зубочелюстной тренинг. Казань: МеДДок, 2024. 160 с.
19. Салеева Г.Т., Салеев Р.А., Салеева Л.Р., и др. Устройство для коррекции миофункциональных нарушений зубочелюстной системы. Патент на полезную модель №206220. Бюл. №25 от 31.08.2021. EDN: FVZGQH
20. Салахов А.К., Ксембаев С.С., Мусин И.Н., Елисеева К.С. Устройство для лечения дисфункции височно-нижнечелюстного сустава. Патент №201136. Бюл. №34 от 30.11.2020. EDN: POGYOY

AUTHORS' INFO

Said S. Ksembaev, MD, Dr. Sci. (Med.), Prof., Head of Depart., Depart. of Maxillofacial Surgery and Surgical Dentistry, Kazan State Medical University, Kazan, Russia;
ORCID: 0000-0002-5712-9601;
eLibrary SPIN: 7775-0599;
e-mail: ksesa@mail.ru

*__Albert K. Salakhov__, MD, Cand. Sci. (Med.), Assoc. Prof., Depart. of Maxillofacial Surgery and Surgical Dentistry, Kazan State Medical University, Kazan, Russia;
ORCID: 0000-0002-0791-1363;
eLibrary SPIN: 2910-8480;
e-mail: albert-salahov@yandex.ru

Gulshat T. Saleeva, MD, Dr. Sci. (Med.), Prof., Head of Depart., Depart. of Prosthetic Dentistry, Kazan State Medical University, Kazan, Russia;
ORCID: 0000-0001-9751-0637;
eLibrary SPIN: 9140-1093;
e-mail: gulshat.saleeva@kazangmu.ru

Ildar N. Musin, Cand. Sci. (Tech.), Assoc. Prof., Head of the Depart., Depart. of Medical Engineering, Kazan National Research Technological University, Kazan, Russia;
ORCID: 0000-0003-4516-4183;
eLibrary SPIN: 3662-7200;
e-mail: ildarmusin@mail.ru

Rinat A. Saleev, MD, Dr. Sci. (Med.), Prof., Depart. of Prosthetic Dentistry, Kazan State Medical University, Kazan, Russia;
ORCID: 0000-0003-3604-7321;
eLibrary SPIN: 6693-0241;
e-mail: rinat.saleev@kazangmu.ru

ОБ АВТОРАХ

Ксембаев Саид Сальменович, д-р мед. наук, проф., зав. каф., каф. челюстно-лицевой хирургии и хирургической стоматологии, ФГБОУ ВО Казанский ГМУ Минздрава России, г. Казань, Россия;
ORCID: 0000-0002-5712-9601;
eLibrary SPIN: 7775-0599;
e-mail: ksesa@mail.ru

***Салахов Альберт Кирамович**, канд. мед. наук, доц., каф. челюстно-лицевой хирургии и хирургической стоматологии, ФГБОУ ВО Казанский ГМУ Минздрава России, г. Казань, Россия;
ORCID: 0000-0002-0791-1363;
eLibrary SPIN: 2910-8480;
e-mail: albert-salahov@yandex.ru

Салеева Гульшат Тауфиковна, д-р мед. наук, проф., зав. каф., каф. ортопедической стоматологии, ФГБОУ ВО Казанский ГМУ Минздрава России, г. Казань, Россия;
ORCID: 0000-0001-9751-0637;
eLibrary SPIN: 9140-1093;
e-mail: gulshat.saleeva@kazangmu.ru

Мусин Ильдар Наилевич, канд. технич. наук, доц., зав. каф., каф. медицинской инженерии, Казанский национальный исследовательский технологический университет, г. Казань, Россия;
ORCID: 0000-0003-4516-4183;
eLibrary SPIN: 3662-7200;
e-mail: ildarmusin@mail.ru

Салеев Ринат Ахмедуллович, д-р мед. наук, проф., каф. ортопедической стоматологии, ФГБОУ ВО Казанский ГМУ Минздрава России, г. Казань, Россия;
ORCID: 0000-0003-3604-7321;
eLibrary SPIN: 6693-0241;
e-mail: rinat.saleev@kazangmu.ru

* Автор, ответственный за переписку / Corresponding author