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The effect of extrusion of the filling material on the periapical status

Mikhail Yu. Pokrovsky[1] ✉, **Tatiana P. Goryacheva**[2,3], **Andrew M. Pokrovskiy**[4], **Olga A. Aleshina**[3]

[1] Scientific Center for Continuing Professional Education "Sadko", Nizhny Novgorod, Russian Federation
[2] Lobachevsky State University, Nizhny Novgorod, Russian Federation
[3] Institute of Medical Postgraduate Education "Priority", Nizhny Novgorod, Russian Federation
[4] Privolzhsky Research Medical University, Nizhny Novgorod, Russian Federation
✉ pokrowsky@mail.ru

Abstract

AIM. To identify the relationship between the extrusion of filling material and the periapical status when using CBCT.
MATERIALS AND METHODS. 500 CBCT scans of patients were studied, the condition of 2915 teeth and 6142 root canals were assessed. The cases of endodontic treatment, which are associated with the overfilling (extrusion) of the filling material, are analyzed. Canals with an apical level of the root seal – 0–2 mm from the X-ray apex of the root (3533 root canals) were considered as a control group. In all cases, the periapical status was assessed. Methods of medical statistics have been applied.
RESULTS. Extrusion of the filling material was determined in 10.7% of the total number of endodontically treated root canals. The material was located: 81.7% in bone tissue, 13% in the maxillary sinus, 4.7% under oral mucosa of the alveolar process, 0.6% in the mandibular canal and/or mental foramen. In the control group, the periapical status "unchanged" was noted in 89.5% of cases, pathological changes were detected in 10.5% of cases. The remaining percentage of the total number of root canals was made up of underfilled or missed root canals without taking into account the periapical status. A lower incidence of periapical changes was determined when filling material was extruded into bone tissue (7.4%), than at the optimal level of root canal filling (11.7%). The differences between the groups were found to be statistically significant. Practical recommendations have been formulated to improve the accuracy of diagnosis, proper planning and increase the effectiveness of endodontic treatment.
CONCLUSIONS. Extrusion of filling material into bone tissue is more often associated with effective endodontic treatment than optimal filling of the root canal along the apical border of the root filling. In this regard, the extrusion of the filling material into the bone tissue, in the case of a formed apical stop, can be considered a sign of successful obturation of the root canal.

Keywords: overfilling of filling material, extrusion of filling material, periapical changes, periapical status, CBCT, endodontic treatment, endodontic failure, prognosis, iatrogenic complications of endodontic treatmentextrusion of filling material, overfilling, periapical changes, periapical status, CBCT, endodontic treatment, endodontic failure, prognosis.

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Влияние экструзии пломбировочного материала на периапикальный статус

М.Ю. Покровский[1] ✉, **Т.П. Горячева**[2,3], **А.М. Покровский**[4], **О.А. Алешина**[3]

[1] Научный центр дополнительного профессионального образования «Садко», г. Нижний Новгород, Российская Федерация
[2] Нижегородский государственный университет им. Н.И. Лобачевского, г. Нижний Новгород, Российская Федерация
[3] Институт медицинского последипломного образования «Приоритет», г. Нижний Новгород, Российская Федерация
[4] Приволжский исследовательский медицинский университет, г. Нижний Новгород, Российская Федерация
✉ pokrowsky@mail.ru

Резюме

ЦЕЛЬ. Выявить зависимость между выведением пломбировочного материала и периапикальным статусом при использовании КЛКТ.
МАТЕРИАЛЫ И МЕТОДЫ Изучено 500 компьютерных томограмм пациентов, оценено состояние 2915 зубов, 6142 корневых каналов. Проанализированы случаи эндодонтического лечения, которые связаны с выведением (экструзией) пломбировочного материала. В качестве контрольной группы

рассматривали каналы с апикальным уровнем корневой пломбы – 0-2 мм от рентгенологической верхушки корня (3533 корневых канала). Во всех случаях оценен периапикальный статус. Применены методы медицинской статистики.
РЕЗУЛЬТАТЫ. Экструзия пломбировочного материала определена в 10,7% случаев от общего числа эндодонтически леченных корневых каналов. При этом материал располагался: в 81,7% в костной ткани, в 13% в верхнечелюстной пазухе, в 4,7% под слизистой оболочкой альвеолярного отростка, в 0,6% в нижнечелюстном канале и/или ментальном отверстии. В контрольной группе периапикальный статус «без изменений» был отмечен в 89,5% случаев, патологические изменения были выявлены в 10,5% случаев. Остальной процент от общего числа корневых каналов составили недопломбированные или пропущенные корневые каналы без учета периапикального статуса. Определена меньшая встречаемость периапикальных изменений при выведении пломбировочного материала в костную ткань (7,4%), чем при оптимальном уровне пломбирования корневого канала (11,7%). Различия между группами признаны статистически значимыми. Сформулированы практические рекомендации, способствующие повышению точности диагностики, правильному планированию и повышению эффективности эндодонтического лечения.
ВЫВОДЫ. Выведение пломбировочного материала в костную ткань чаще ассоциируется с эффективным эндодонтическим лечением, чем оптимальное пломбировании корневого канала по апикальной границе корневой пломбы. В связи с этим, экструзия пломбировочного материала в костную ткань, в случае сформированного апикального упора, может считаться признаком успешной обтурации корневого канала.

Ключевые слова: выведение пломбировочного материала, экструзия пломбировочного материала, периапикальные изменения, периапикальный статус, КЛКТ, эндодонтическое лечение, эндодонтическая ошибка, прогноз, ятрогенные осложнения эндодонтического лечения

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INTRODUCTION

Endodontic treatment is completed with the permanent obturation of the root canal, followed by restorative treatment. The outcome of obturation is typically evaluated using radiological methods and may vary, including cases where the filling material extends beyond the apex of the root – referred to as the extrusion of filling material (EFM). In dental practice, the assessment of endodontic treatment often focuses on the quality of root canal system (RCS) obturation, with EFM frequently being viewed negatively [1–12].

The literature provides contradictory information regarding the relationship between root canal obturation and the outcome of endodontic treatment. Some studies suggest that root canal obturation has the weakest correlation with the success of endodontic treatment compared to the mechanical and chemical preparation of the RCS [13–16]. It has also been noted that the hermetic seal of a root canal filling cannot be reliably evaluated using radiological methods [16].

International studies distinguish cases of EFM based on their underlying causes: as a result of high-quality obturation (overfilling) or as a consequence of the absence of an apical stop due to a challenging initial condition or over-enlargement of the apical foramen (overextension) caused by improper mechanical preparation of the root canal (lack of an apical stop or ledge), which is associated with poor-quality obturation [14]. Histological studies indicate the absence of inflammatory processes around extruded materials or, in some cases, a transient irritant effect from certain materials [15–18].

In dental practice, the presence of material beyond the apex of a tooth is often associated with inadequate quality of endodontic treatment. This circumstance may have legal implications, reclassifying many cases of effective treatment (aligned with specific objectives and goals of endodontic intervention) as “poor-quality” treatment based on the formal criterion of material extrusion (EFM). Furthermore, the question remains open regarding the ability of the endodontist to control root canal obturation in a way that prevents the extrusion of filling material beyond the root canal.

Aim: to identify the relationship between EFM and periapical status based on CBCT data.

MATERIALS AND METHODS

A total of 500 computed tomograms of patients (209 males and 291 females) aged between 13 and 82 years (mean age: 42 years) were randomly selected from the database of the “Sadko” clinic network (Nizhny Novgorod, Russia). This database was formed during the referral of patients for examination by dentists, maxillofacial surgeons, and otorhinolaryngologists.

Inclusion criteria:

1. The study area included the complete dental arches of the maxilla and mandible.

2. The presence of at least one tooth after endodontic treatment.

3. If multiple radiographic examinations were available for a single patient, only the earliest computed tomogram was used.

Cases were identified by the patient's full name and research ID. Cone-beam computed tomography (CBCT) was performed using Pax-Rev 3D and Pax-i3D Smart devices (Vatech). Visualization of tomograms was carried out using Easy Dent V4 Viewer software. The following tools were employed to optimize imaging: "magnifier", "contrast", "sharpness filter", and "ruler". In doubtful cases, the "histogram" tool was used to compare bone density (in grayscale) in the periapical area and the adjacent spongy bone.

In total, 2,915 teeth were studied, comprising 6,142 root canals (100%) after endodontic treatment.

Periapical status was evaluated using the following parameters:

1. Absence of visible changes in the periodontium.
2. Widening of the periodontal ligament space (thickening by a factor of 2 relative to adjacent unaffected sections of the ligament).
3. Presence of a periapical radiolucency.
4. Localized thickening of the maxillary sinus mucosa in the projection of the studied tooth roots, where bone tissue was not identified periapically.
5. Extensive maxillary sinus opacification (total or subtotal).
6. Maxillary sinus cyst: a round-shaped sinus opacity.
7. Extensive bone tissue destruction involving not only the periapical area but also the furcation and interproximal septa of the alveolar process, including cases with bone pockets.
8. Post-endosurgical operation status.

Criteria for evaluating EFM:

1. Presence of radiopaque material beyond the visible outline of the tooth root.
2. A sharp change in the contour of the radiopaque material from linear to rounded.
3. Location of radiopaque material either near the root apex or at a distance from it.
4. Radiolucent areas around radiopaque material observed exclusively in the axial plane were interpreted as artifacts of the "filling defect" type.
5. The presence of radiopaque material in cases of missing teeth was not considered.

For clinically significant evaluation of filling material extrusion, specific cases were identified where the material was located:

1. In the bone tissue.
2. Beneath the oral mucosa (vestibularly, palatally, or lingually).
3. In the maxillary sinus.
4. In the mandibular canal (including the area of the mental foramen).

Statistical data analysis was performed using a four-field contingency table with the resource available at https://medstatistic.ru.

RESULTS

A total of 656 cases of EFM were identified, accounting for 10.7% of all root canals examined (Fig. 1).

EFM located in bone tissue was detected in 536 cases, representing 81.7% of all cases. Among these, no pathological changes in the periapical region were observed in 499 cases (93.1%) (including 14 cases of artifacts), while in 37 cases (6.9%), radiolucent areas were detected in the periapical region (including 3 cases of extensive bone tissue destruction) (Fig. 2).

EFM located under the mucosa of the alveolar process on the palatal, lingual, but most frequently on the vestibular surface, was identified in 31 cases (4.7% of all EFM cases).

Within the maxillary sinus, EFM was identified in 85 cases (13%). Among these, in 2 cases (2.4%), it was associated with a sinus cyst; in 38 cases (44.7%), with localized thickening of the mucosa; in 10 cases (11.8%), with subtotal or total sinus opacification; and in 35 cases (41.1%), no changes in the maxillary sinus were detected (Fig. 3).

Within the mandibular canal and mental foramen, EFM was detected in 4 cases, accounting for 0.6% of all EFM cases.

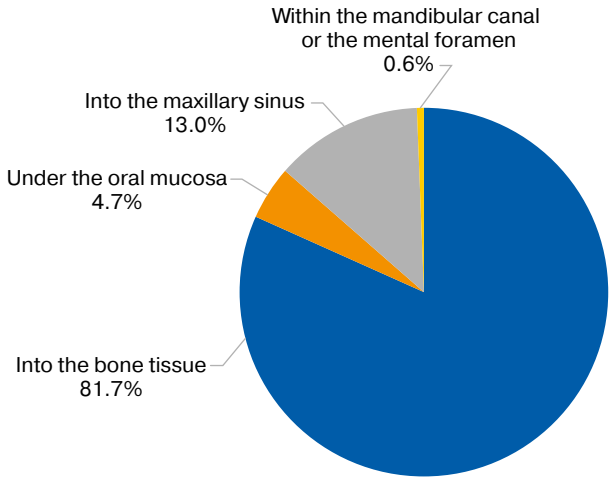

Fig. 1. Extrusion of the filling material beyond the root

Рис. 1. Выведение пломбировочного материала за пределы корня

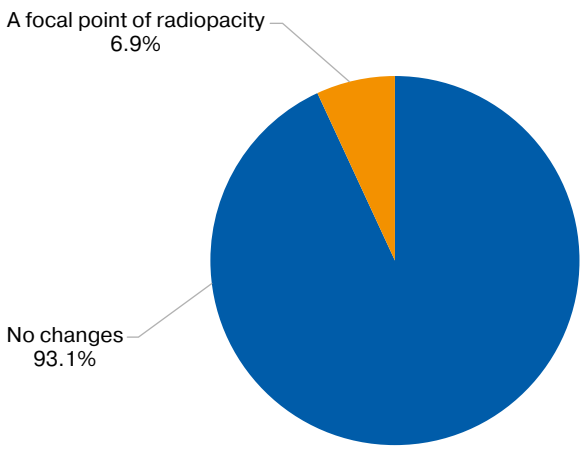

Fig. 2. Extrusion of filling material into bone tissue: periapical status

Рис. 2. Выведение пломбировочного материала в костную ткань: периапикальный статус

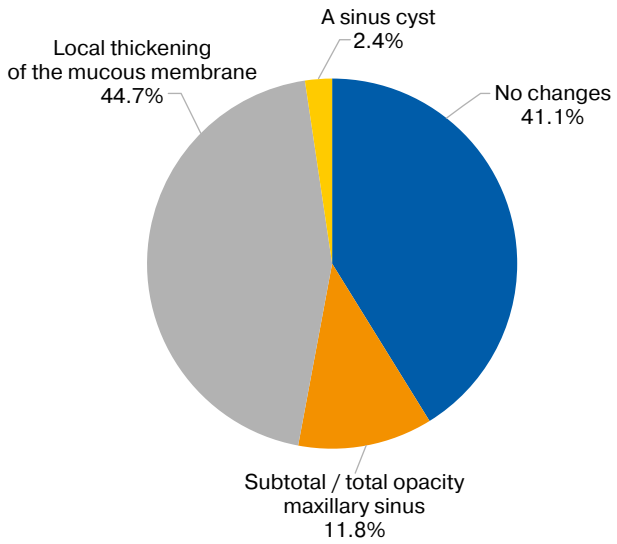

Fig. 3. Extrusion of filling material into the maxillary sinus

Рис. 3. Выведение пломбировочного материала в верхнечелюстную пазуху

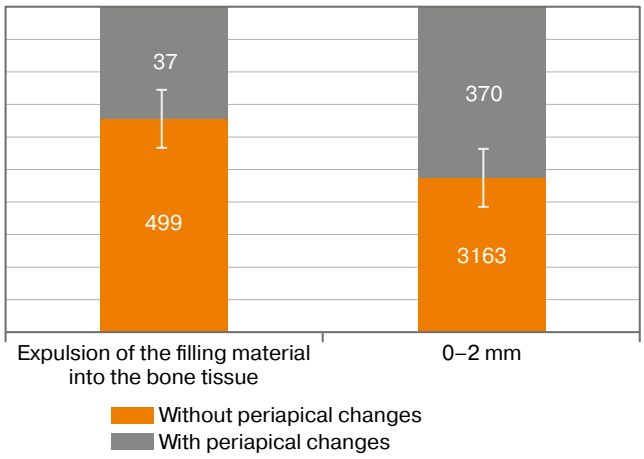

Fig. 4. Comparison of the periapical status of the group with optimal filling of the root canal and the group with extrusion of filling material into bone tissue

Рис. 4. Сравнение периапикального статуса группы с оптимальным пломбированием корневого канала и группы с выведением пломбировочного материала в костную ткань

As a control group, canals with an apical level of root filling 0–2 mm from the radiological apex of the root (3,533 root canals) were examined. A periapical status of "no changes" was noted in 3,163 cases (89,5%), while pathological changes were identified in 370 cases (10,5%) (Fig. 4).

DISCUSSION

Extrusion of filling material (EFM) is a common outcome of root canal obturation, with reported prevalence rates in the literature ranging from 8% to 15% [3; 6; 8; 10; 19]. The influence of root canal obturation techniques, endodontist actions, and the role of EFM in determining the outcome of endodontic treatment or the development of iatrogenic complications remain subjects of debate. These uncertainties complicate the clinical assessment of endodontic treatment outcomes and the justification of treatment strategies during follow-up.

Batyukov et al. compared root canal obturation techniques, finding that lateral condensation resulted in EFM in 62.3% of cases (sealer or gutta-percha), while three-dimensional obturation led to EFM in 21.1% of cases [20]. In a study by Da Silva et al., evaluating various obturation techniques, 100% of cases using the "ThermaFil" technique were associated with EFM [21].

Currently, the optimal apical level for root canal obturation is considered to be within 0–2 mm of the radiographic apex of the root [10; 22–26]. This level corresponds to the physiological root apex (apical constriction). One argument for limiting obturation within the apical constriction is that it minimizes the wound surface area and maximizes the likelihood of successful endodontic treatment [27]. However, in clinical practice, it is impossible to precisely determine the level of the physiological root apex. The aforementioned range of apical obturation levels relative to the radiographic apex reflects only an average anatomical trend, disregarding variations in root anatomy.

The apical level of root canal obturation is significantly influenced by the variability of tooth anatomy in the apical region and the effect of projection distortions when using intraoral radiography methods [28–31]. For instance, D. Song et al. evaluated the diagnostic potential of CBCT for detecting EFM, reporting a sensitivity of 0.66 and specificity of 1.0 [32]. In another study, Cheng et al. found that in 13.8% of cases, EFM occurred despite the obturation being within 0–2 mm of the radiographic apex [33].

Some researchers suggest that foreign materials in the periapical region can sustain apical periodontitis, even in the absence of pathogenic organisms. Indeed, the literature describes inflammatory reactions to some filling materials, which diminish over time, rendering the materials inert [17; 18]. Histological studies have demonstrated encapsulation of larger gutta-percha fragments with a collagen layer, while smaller gutta-percha fragments provoke a foreign body reaction characterized by multinucleated giant cells and macrophages [15; 16]. Reactions associated with gutta-percha contamination by talc or microbes have also been described. Studies indicate that no filling material causes progressive bone destruction. Long-term observations have noted cases of filling material resorption over time. Two studies with extended follow-up periods concluded that minor radiolucent areas observed with overfilling, alongside otherwise satisfactory treatment parameters and no clinical symptoms, should not be considered treatment failures [16; 34].

Another factor associated with endodontic treatment failure, apart from EFM, is iatrogenic damage to anatomical structures near the root apex caused by excessive instrumentation. Over-instrumentation of the root apex eliminates the apical stop, preventing adequate root canal obturation, leading to EFM, and allowing tissue fluid to infiltrate the root canal, sustaining the survival of residual microorganisms. In some cases, creating an adequate apical stop is challenging due to incomplete root formation or pathological resorption of the root apex. Identifying the cause of EFM radiographically is difficult; however, the combination of EFM beyond the root apex with nonhomogeneous obturation or its absence in the apical region is considered a specific indicator of the absence of an apical stop.

The clinical significance of EFM also depends on the anatomical structure in which the filling material is located. According to the literature, EFM most frequently occurs in bone tissue, which is an important factor when evaluating periapical status and the effectiveness of endodontic treatment. In this study, a comparison of periapical status between optimally obturated root canals and cases of EFM into bone tissue (Table 1) revealed a lower frequency (7.4%) of periapical changes in cases with EFM into bone tissue than in optimally obturated canals (11.7%). The differences between groups were statistically significant ($p < 0.05$, Chi-square test; $p < 0.01$, Chi-square test with Yates correction and likelihood ratio correction). Although the study design does not establish a causal relationship between the level of root canal obturation and the development of pathological changes in the periodontium, it suggests that EFM is more often associated with effective endodontic treatment than optimal root canal obturation at the apical level. It can be hypothesized that in many clinical cases, high-quality three-dimensional root canal obturation is linked to EFM beyond the root.

EFM into the mandibular canal, maxillary sinus, or beneath the oral mucosa, when symptomatic, is considered an iatrogenic complication that may require surgical intervention [5; 35].

EFM beneath the oral mucosa is generally not associated with adverse endodontic treatment outcomes. However, isolated cases of facial pain that resolved following surgical removal of the material have been reported [35; 36].

EFM into the maxillary sinus is the least studied outcome. It is often associated with the development of chronic sinusitis or fungal infections (aspergillosis). Although no cases of aspergillosis were observed in this study, A.M. Sipkin et al. reported a 15% prevalence of fungal infections in chronic sinusitis, with half of these cases associated with endodontic treatment [37]. The pathogenesis of these conditions is linked to dysfunction of the ciliated epithelium, the ability of microorganisms to adhere to the material's surface and persist in the maxillary sinus, and the potential of some filling materials to serve as sources of essential elements for fungal growth (e.g., heavy metal salts). Direct toxic effects of certain filling materials (e.g., those based on eugenol or paraformaldehyde) have also been described [37–43]. In this study, pathological changes (e.g., cysts, localized mucosal thickening, subtotal or total opacification), presumably associated with EFM in the maxillary sinus, were detected in 58.9% of all EFM cases involving the maxillary sinus.

EFM into anatomical structures containing neurovascular bundles is considered an iatrogenic complication requiring immediate intervention. The treatment of choice is surgical removal of the filling material. Mechanisms of neurovascular damage include direct mechanical effects of the filling material, toxic effects, and inflammatory processes associated with apical periodontitis [44–48].

Table 1. Criteria for assessing the significance of differences in outcomes depending on the impact of the risk factor

Таблица 1. Критерии оценки значимости различий исходов в зависимости от воздействия фактора риска

Criterion Name	Criterion Value	Significance Level
Chi-square criterion	6.588	0.011
Chi-square criterion with Yates correction	6.197	0.013
Chi-square criterion with likelihood correction	7.203	0.008
Fisher's exact test (two-tailed)	NaN	$p > 0.05$
Minimum value of the expected event – 53.61		
Criteria for assessing the strength of the association between the risk factor and the outcome		
Criterion Name	Criterion Value	Strength of association*
Criterion φ Cramér's V Criterion* Tschuprow's T Criterion**	0.040	Insignificant
Pearson's Contingency Coefficient (C)	0.040	Insignificant
Normalized Pearson's Contingency Coefficient (C')	0.057	Insignificant

Note: * interpretation of the obtained values of statistical criteria is based on the recommendations of Rea & Parker; ** for the four-field table used in this calculator, all three criteria (φ, Cramér's V, Tschuprow's T) yield the same value.

Примечания: * интерпретация полученных значений статистических критериев согласно рекомендациям Rea & Parker; ** для четырехпольной таблицы, используемой в данном калькуляторе, все три критерия (ф, Крамера, Чупрова) принимают одно и то же значение.

CONCLUSIONS

Extrusion of filling material is a common outcome of endodontic treatment. Currently, there is no convincing evidence in the literature to suggest that the actions of an endodontist or any specific root canal obturation technique can completely eliminate this outcome. However, extrusion of filling material into bone tissue in most cases corresponds to effective endodontic treatment and, in the presence of a well-formed apical stop, serves as an indicator of successful root canal obturation.

The likelihood of filling material extrusion increases when it is impossible to create an apical stop due to improper canal preparation, incomplete root apex formation, or pathological root apex resorption. Improper canal preparation reflects the endodontist's manual skills, which can be improved through professional development and training.

Common radiographic signs of the absence of an adequate apical stop, in addition to extrusion of filling material, include the absence of filling material, non-homogeneous root canal obturation, and lack of marginal adaptation of the filling material to the root walls in the apical third.

Extrusion of filling material into bone tissue or beneath the oral mucosa should not be considered a failure of endodontic treatment. In such cases, follow-up does not require any special considerations.

When selecting filling materials, preference should be given to those that do not induce or only cause short-term inflammation in the contact area with surrounding tissues and do not contribute to the development of aspergillosis when extruded into the maxillary sinus.

Extrusion of filling material into the maxillary sinus presents the most uncertain outcome in terms of iatrogenic complications. The results of current studies lack high reliability, making it difficult to determine a prognosis. In such clinical situations, or when this is suspected, CBCT imaging is recommended, both at the diagnostic stage and during follow-up.

Extrusion of filling material into the area of the neurovascular bundle requires prompt consultation with an oral or maxillofacial surgeon to prevent irreversible damage. In such cases, the treatment of choice is surgical removal of the filling material. If root canal obturation of the affected tooth is inadequate, re-obturation should be completed prior to surgical treatment.

The use of CBCT enables safe endodontic treatment with predictable outcomes, as this diagnostic method provides comprehensive information about the anatomical features of the periapical area.

It is advisable to inform the patient about the possibility of filling material extrusion and related iatrogenic complications before beginning endodontic procedures. This information should be included in the informed consent for treatment.

The presented information contributes to improved diagnostic accuracy, proper treatment planning, and enhanced effectiveness of endodontic treatment.

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INFORMATION ABOUT THE AUTHORS

Mikhail Yu. Pokrovsky – Cand. Sci. (Med.), Leading Specialist, Dentist, Scientific Center for Continuing Professional Education "Sadko"; 13a Beketova Str., Nizhny Novgorod 603057, Russian Federation; https://orcid.org/0000-0003-4478-1091

Tatiana P. Goryacheva – Cand. Sci. (Med.), Associate Professor of the Department of Clinical Dentistry, Lobachevsky State University, 23 Gagarin Avenue, Nizhny Novgorod 603022, Russian Federation; Senior Researcher, Institute of Medical Postgraduate Education "Priority", 25 Rodionova St., Nizhny Novgorod 603093, Russian Federation; https://orcid.org/0000-0002-9514-8897

Andrew M. Pokrovskiy – Student of the Faculty of Dentistry, Privolzhsky Research Medical University, 10/1 Minin and Pozharsky Square, Nizhny Novgorod 603005, Russian Federation; https://orcid.org/0009-0001-9640-1196

Olga A. Aleshina – Cand. Sci. (Med.), Associate Professor, Director, Institute of Medical Postgraduate Education "Priority", 25 Rodionova St., Nizhny Novgorod 603093, Russian Federation; https://orcid.org/0000-0002-7990-6459

ИНФОРМАЦИЯ ОБ АВТОРАХ

Покровский Михаил Юрьевич – к.м.н., ведущий специалист, врач-стоматолог, ООО «Научный центр дополнительного профессионального образования "Садко"»; 603057, Российская Федерация, Нижний Новгород, ул. Бекетова, 13а; https://orcid.org/0000-0003-4478-1091

Горячева Татьяна Петровна – к.м.н., доцент кафедры клинической стоматологии, ФГАОУ ВО «Национальный исследовательский Нижегородский государственный университет им. Н.И. Лобачевского», 603022, Российская Федерация, г. Нижний Новгород, пр. Гагарина, д. 23; старший научный сотрудник, Институт медицинского последипломного образования «Приоритет»; 603093, Российская Федерация, Нижний Новгород, ул. Родионова, д. 25; https://orcid.org/0000-0002-9514-8897

Покровский Андрей Михайлович – студент стоматологического факультета, ФГБОУ ВО «Приволжский исследовательский медицинский университет»; 603005, Российская Федерация, г. Нижний Новгород, пл. Минина и Пожарского. д. 10/1; https://orcid.org/0009-0001-9640-1196

Алешина Ольга Александровна – к.м.н., доцент, директор, Институт медицинского последипломного образования «Приоритет»; 603093, Российская Федерация, Нижний Новгород, ул. Родионова, д. 25; https://orcid.org/0000-0002-7990-6459

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