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Specific aspects of the radiographic morphometric and densitometric characteristics of mandible of the rats with experimental diabetes mellitus after tooth extraction

A. V. Abramov[A], K. S. Hanchev*[,B–D,F], Ye. V. Kadzharian[E]

Zaporizhzhia State Medical University, Ukraine

A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of the article

Diabetes mellitus is regarded today as a metabolic disease, which is considered to be a modulator of endodontic infections, is responsible for altering the immune and inflammatory responses, impedes the healing process, and contributes to damage of organs and tissues of the body, including tooth pulp and periapical tissues.

The aim of the work is to study the radiographic characteristics of the dental septum of the alveolar crest of the mandible, crown and root of the low molars of rats with experimental streptozotocin diabetes at different times of the post-extraction period (the 1st, 7th and 14th day).

Materials and methods. Studies were conducted on 120 male Wistar rats, 8–10 months old, divided into eight groups of 15 animals each. The experimental diabetes mellitus was modelled in 45 animals by a single administration of streptozotocin interperitoneally (SIGMA Chemical, the USA) at a dose of 50 mg/kg, diluted in 0.5 ml of 0.1 M citrate buffer (pH 4.5) ex tempore, on the 21st day after its induction the level of fasting glucose was determined (by the glucose oxidise method using standard test strips Test Strip II, glucometer Glucocard, Japan), which was 24.7 ± 2.2 mM/l. The extraction of the first low molar of the right mandible was realised using thiopental anaesthesia (40 mg / kg dose) with additional local infiltration anaesthesia with Ubistesine (3M Deutschland GmbH, Germany).On the 1st, 7th, and 14th day, dates that correspond to the experiment after the extraction of the tooth, the rats were decapitated using thiopental anaesthesia (dose 40 mg/kg).The visiography of the mandible was performed using a computerized 3D CBCT tomograph Panoura 18S Panoramic 3D. With the help of digital image analysis the radiographic density of tissues of the alveolar socket of the removed 1st molar, crown of the 1st, 2nd and 3rd molars, their root and dental septum of the alveolar crest were determined.

The results. Radiological density of the interalveolar and interradicular septa between the 1st–3rd molar and the 1st molar root, which is the most traumatized and loaded rats' tooth, is decreased in the rats with experimental diabetes mellitus. Tooth extraction in the rats with diabetes mellitus results in the increase (not in the decrease as it is observed in control group) of radiological density a day after in the alveolar socket and the adjacent 2nd and 3rd molars, that may be caused by significant infiltration related to the secondary alteration. The final stage of the local inflammatory reaction resorptive phase that corresponds to the 7th day of post-extraction period is characterized by almost complete restoration of the alveolar socket radiological density in the control rats, whereas in the rats with diabetes mellitus radiological density of the studied sites decreases and this process continues on the 14th day.

Conclusions. In the work it was found out that the extraction of a tooth in rats with normal carbohydrate metabolism is accompanied by dynamic changes in radiological density not only in the extraction area of the 1st molar (it decreases on the 1st day in the area of the root more than 2.7 times and by 65 % in the area of interalveolar and interradicular septa with its restore to the 14th day), the inflammatory process affects the adjacent 2nd and 3rd molars, leading to its decrease on the 1st day in the area of interalveolar and interradicular septa of the 2nd molar by 24.4 % and 3rd molar – by 16.8 % with its restore to the 7th day. It was revealed that the pre-existing early resorptive phase of the local inflammatory reaction ends by the 7th day of the post-extraction period, changing to the reparative by the 14th day. The development of experimental diabetes mellitus in rats leads to an increase in resorptive processes in the mandible bone tissue, which is manifested by a decrease in radiological density in the area of the 1st molar root by 2.27 times along with its increase in the interalveolar and interradicular septa area of all three low molars by 22.0 %, 21.8 % and 18.3 %, respectively. Experimental diabetes contributes to the particular course of the wound process after tooth extraction. At the same time, it is an important pathogenetic link for the formation of complications due to the disturbance of the resorption-reparative relationship in the area of the alveolar socket and the adjacent molars.

Key words: diabetes mellitus, tooth extraction, radiography, mandible, rats.

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***E-mail:** gancheva@zsmu.pp.ua

Особливості радіографічних морфоденситометричних характеристик мандибули щурів з експериментальним цукровим діабетом після екстракції зуба

А. В. Абрамов, К. С. Ганчев, Є. В. Каджарян

Цукровий діабет є метаболічним захворюванням, яке вважають модулятором ендодонтичних інфекцій, зумовлює зміну імунної та запальної відповідей, порушує процес загоєння, спричиняє пошкодження органів і тканин організму, включаючи пульпу зуба й періапікальні тканини.

Мета роботи – вивчити радіографічні характеристики кісткових перетинок альвеолярного гребеня мандибули, коронки й кореня нижніх молярів у щурів з експериментальним стрептозотоциновим діабетом у різні терміни постекстракційного періоду (1, 7 та 14 доба).

Ключові слова: цукровий діабет, екстракція зуба, радіографія, мандибула, щури.

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Матеріали та методи. Дослідження виконали на 120 щурах-самцях лінії Wistar віком 8–10 місяців, яких поділили на 8 груп по 15 тварин у кожній. Експериментальний цукровий діабет моделювали 45 тваринам одноразовим введенням внутрішньочеревно стрептозотоцину (SIGMA Chemical, США) в дозі 50 мг/кг, розведеного в 0,5 мл 0,1 М цитратного буфера (pH 4,5) ex tempore; на 21 день після його індукції рівень глюкози натще (глюкозооксидазним методом, використовуючи стандартні тест-смужки TestStrip II, глюкоментр Glucocard, Японія) становив 24,7 ± 2,2 мМ/л. Видалення перших нижніх молярів правої мандибули виконали під тіопенталовим наркозом (доза 40 мг/кг) з додатковою місцевою інфільтраційною анестезією «Убістезин» (3МДойчландГмбХ, ФРН). На 1, 7 та 14 добу, відповідні експерименту терміни після екстракції зуба, щурів декапітували під тіопенталовим наркозом (доза 40 мг/кг). Візіографію мандибули виконали за допомогою комп'ютерного 3D томографа для проведення конусно-променевої томографії Panoura 18S Panoramic 3D. За допомогою цифрового аналізу зображення визначали радіографічну щільність тканин альвеолярної лунки видаленого 1 моляра, коронки 1, 2 і 3 молярів, їхніх коренів і кісткових перетинок альвеолярного гребеня.

Результати. Встановили, що у щурів з експериментальним цукровим діабетом спостерігають зниження радіологічної щільності кореня зуба 1 моляра як найбільш травмованого через навантаження зуба в щурів, а також інтеральвеолярно-радикулярних перетинок у регіоні 1–3 молярів. Видалення зуба на тлі цукрового діабету призводить до підвищення, а не зниження показника радіологічної щільності на 1 добу в області альвеолярної лунки та поруч розташованих 2 і 3 молярів, що може бути наслідком значної інфільтрації, яка пов'язана з розвитком вторинної альтерації. Завершальний етап резорбтивної фази місцевої запальної реакції, якому відповідає 7 доба постекстракційного періоду, в контрольних щурів характеризується майже повним відновленням радіологічної щільності кісткової тканини, а на тлі цукрового діабету радіологічна щільність вивчених ділянок знижується, і цей процес триває і на 14 добу.

Висновки. Видалення зуба щурам із нормальними показниками вуглеводного обміну супроводжується динамічними змінами радіологічної щільності не тільки в області екстракції 1 моляра (на 1 добу її зниженням в області кореня видаленого зуба більш ніж у 2,7 раза та на 65 % в області інтеральвеолярно-радикулярних перетинок із відновленням до 14 доби), запальний процес включає і 2, 3 моляри, призводячи до зниження її на 1 добу в області інтеральвеолярно-радикулярних перетинок 2 моляри на 24,4 %, 3 – на 16,8 % з відновленням показника на 7 добу. Виявлено, що рання резорбтивна фаза місцевої запальної реакції закінчується до 7 доби постекстракційного періоду, змінюючись до 14 доби на репаративну. Розвиток експериментального цукрового діабету в щурів призводить до посилення резорбтивних процесів у кістковій тканині мандибули, що виявляється зниженням радіологічної щільності в області кореня 1 моляра у 2,27 раза, але підвищенням в області інтеральвеолярно-радикулярних перетинок усіх 3 нижніх молярів на 22,0 %, 21,8 % та 18,3 % відповідно. Експериментальний цукровий діабет впливає і на особливості перебігу ранового процесу після видалення зуба. Він є важливою патогенетичною ланкою формування ускладнень через порушення резорбційно-репаративних зв'язків в області альвеолярної лунки та прилеглих молярів.

Ключевые слова: сахарный диабет, экстракция зуба, радиография, мандибула, крысы.

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Особенности радиографических морфоденситометрических характеристик мандибулы крыс с экспериментальным сахарным диабетом после экстракции зуба

А. В. Абрамов, К. С. Ганчев, Е. В. Каджарян

Сахарный диабет – метаболическое заболевание, которое считают модулятором эндодонтической инфекции, способствует повреждению органов и тканей организма, включая пульпу зуба и периапикальные ткани.

Цель работы – изучить радиографические характеристики костных перегородок альвеолярного гребня мандибулы, коронки и корня нижних моляров у крыс с экспериментальным стрептозотоциновым диабетом в разные сроки постэкстракционного периода (1, 7 и 14 сутки).

Материалы и методы. Исследования проведены на 120 крысах-самцах линии Wistar, возрастом 8–10 месяцев, распределенных на 8 групп по 15 животных в каждой. Экспериментальный сахарный диабет моделировали 45 животным однократным введением внутрибрюшинно стрептозотоцина (SIGMA Chemical, США) в дозе 50 мг/кг, разведенного в 0,5 мл 0,1 М цитратного буфера (pH 4,5) ex tempore, на 21 день после его индукции уровень тощаковой глюкозы (глюкозооксидазным методом с использованием стандартных тест-полосок TestStrip II, глюкоментр Glucocard, Японія) составил 24,7 ± 2,2 мМ/л. Удаление первого нижнего моляра правой мандибулы проводили под тиопенталовым наркозом (доза 40 мг/кг) с дополнительной местной инфильтрационной анестезиею «Убистезином» (3М Дойчланд ГмбХ, ФРГ). На 1, 7 и 14 сутки, соответствующие эксперименту сроки после экстракции зуба, крыс декапитировали под тиопенталовым наркозом (доза 40 мг/кг). Визиографию мандибулы проводили с помощью компьютерного 3D томографа для проведения конусно-лучевой томографии Panoura 18S Panoramic 3D. С помощью цифрового анализа изображения определения радиографическую плотность тканей альвеолярной лунки удаленного 1 моляра, коронки 1, 2 и 3 моляров их корня и костных перегородок альвеолярного гребня.

Результаты. Установлено, что у крыс с экспериментальным сахарным диабетом наблюдают снижение радиологической плотности корня зуба 1 моляра как наиболее травмируемого и нагружаемого зуба у крыс, а также интеральвеолярно-радикулярных перегородок в регионе 1–3 моляров. Удаление зуба на фоне сахарного диабета приводит к повышению, а не снижению показателя радиологической плотности на 1 сутки в области альвеолярной лунки и рядом стоящих 2 и 3 моляров, что может быть следствием значительной инфильтрации, связанной с развитием выраженной вторичной альтерации. Завершающий этап резорбтивной фазы местной воспалительной реакции, которому соответствуют 7 сутки постэкстракционного периода, у контрольных крыс характеризуется практически полным восстановление радиологической плотности костной ткани, а на фоне сахарного диабета радиологическая плотность изученных участков снижается, и этот процесс продолжается на 14 сутки.

Выводы. Удаление зуба крысам с нормальными показателями углеводного обмена сопровождается динамичными

изменениями радиологической плотности не только в области экстракции 1 моляра (на 1 сутки ее снижением в области корня удаленного зуба более чем в 2,7 раза и на 65 % в области интеральвеолярно-радикулярных перегородок с восстановлением к 14 дню), воспалительный процесс затрагивает рядом стоящие 2 и 3 моляры, приводя к ее снижению на 1 сутки в области интеральвеолярно-радикулярных перегородок 2 моляра на 24,4 %, 3 – на 16,8 % с восстановлением показателя на 7 день. Установлено, что ранняя резорбтивная фаза местной воспалительной реакции заканчивается к 7 суткам постэкстракционного периода, сменяясь к 14 дню репаративной. Развитие экспериментального сахарного диабета у крыс приводит к усилению резорбтивных процессов в костной ткани мандибулы, что проявляется снижением радиологической плотности в области корня 1 моляра в 2,27 раза, но повышением в области интеральвеолярно-радикулярных перегородок всех трех нижних моляров на 22,0 %, 21,8 % и 18,3 % соответственно. Экспериментальный сахарный диабет вносит свой вклад в особенности течения раневого процесса после удаления зуба. Он является важным патогенетическим звеном формирования осложнений из-за нарушения резорбционно-репаративных взаимоотношений в области альвеолярной лунки и прилежащих моляров.

Diabetes mellitus (DM) is regarded today as a metabolic disease, which is considered to be a modulator of endodontic infections [1], is responsible for altering the immune and inflammatory responses, impedes the healing process, contributes to damage of organs and tissues of the body, including tooth pulp and periapical tissues [2,3]. Moreover, numerous clinical observations have shown that DM can not only affect the pathogenesis of dental nosologies, but the bidirectional mutually confounding connection between apical periodontitis, periostitis, gingivitis and the systemic diabetes effects has been also proven. It has been established that in case of DM patients, on the background of an infectious process in the maxillofacial area were noted to have more evident resorption of the bone and hard tissues of the tooth, sluggish inflammatory processes in the periapical area and periodontal [1–6].

A cross-sectional study realized among the patients with diabetes showed that the worst periapical status correlated with a higher level of glycated hemoglobin (HbA1c), and each further examination after endodontic treatment was increasing the level of HbA1c [7]. In addition, the presence of DM in a patient was connected with a decrease of the successful therapy results [8]. There are reports of cases that mark a sudden increase of glucose level in the blood of patients during exacerbation of a combined endodontic-periodontal lesion [17].

The aim

The aim of the work is to study the radiographic characteristics of the dental septum of the alveolar crest of the mandible, crown and root of the low molars of rats with experimental streptozotocin diabetes at different times of the post-extraction period (the 1st, 7th and 14th day).

Materials and methods

The experimental part of the research was carried out in accordance with the national "Common Ethical Principles of Animal Experiments" (Ukraine, 2001), which are coordinated with Council Directive 2010/63EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes. The study protocol is agreed with the local ethics committee. Studies were conducted on 120 male Wistar rats, 8–10 months old, divided into eight groups of 15 animals each:

– the 1st group – rats that did not have the extraction of a tooth (Control-0);

– the 2nd group – rats that were removed from the experiment a day after the extraction of the tooth (Control-1);

– the 3rd group – rats that were removed from the experiment 7 days after the extraction of the tooth (Control-7);

– the 4th group – rats that were removed from the experiment 14 days after the extraction of the tooth (Control-14);

– the 5th group – a group of rats with experimental streptozotocin diabetes that did not have the extraction of a tooth (Diabetes-0);

– the 6th group – a group of rats with experimental streptozotocin diabetes that were removed from the experiment a day after the extraction of the tooth (Diabetes-1);

– the 7th group – a group of rats with experimental streptozotocin diabetes that were removed from the experiment 7 days after the extraction of the tooth (Diabetes-7);

– the 8th group – a group of rats with experimental streptozotocin diabetes that were removed from the experiment 14 days after the extraction of the tooth (Diabetes-14).

In groups of rats with experimental diabetes mellitus (EDM), which was modelled by a single administration of streptozotocin interperitoneally (SIGMA Chemical, the USA) at a dose of 50 mg/kg, diluted in 0.5 ml of 0.1 M citrate buffer (pH 4.5) ex tempore, on the 21st day after its induction was determined the level of fasting glucose (by the glucose oxidise method using standard test strips Test Strip II, glucometer Glucocard, Japan), which was 24.7 ± 2.2 mM/l.

In the morning at 10:00 AM the extraction of the first low molar of the right mandible of the rats was carried out in six groups of 45 control animals and 45 animals with simulated EDM using thiopental anaesthesia (40 mg/kg dose) with additional local infiltration anaesthesia with Ubistesine (3M Deutschland GmbH, Germany).

On the 1st, 7th, and 14th day, dates that correspond to the experiment after the extraction of the tooth, the rats were decapitated using thiopental anaesthesia (dose 40 mg/kg).

Radiographic images of the semi-mandibles of rats were taken after the removing of the animals from the experiment by single-step decapitation under thiopental anaesthesia (40 mg/kg body weight). The jaw bone was immediately separated from animal's head, soft tissues were removed and placed in a cold NaCl solution of 0.9 %. The visiography of the mandible was performed no later than 2-3 hours after the release of the gross specimen. Images of the semi-mandibles were obtained using a computerized 3D CBCT tomograph Panoura 18S Panoramic 3D.

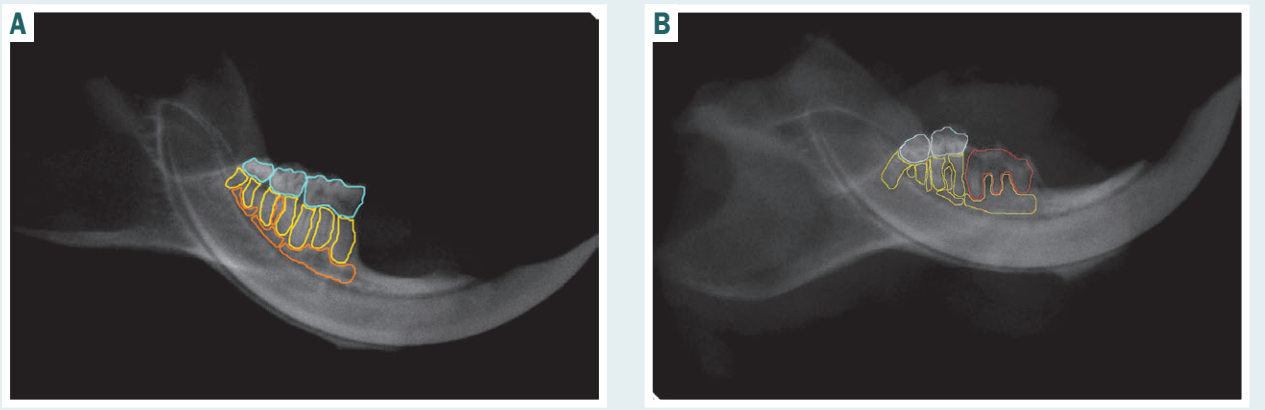

Fig. 1. Radiographic images of semi-mandibles of rats. Without tooth extraction (A). After extraction of the tooth (B).

The colour designations of the "areas of interest" for digital analysis of the radiographic density of the parameters under study (the crown of the tooth – blue, the root of the tooth – yellow, the interalveolar and interradicular septa – orange, the area of alveolar socket – red).

For digital image analysis and determination of the radiographic density of the mandible tissues in the obtained images in an interactive mode the "areas of interest" were distinguished, which corresponds to the alveolar socket of the removed 1st molar, crown of the 1st, 2nd and 3rd molars, their root and dental septum of the alveolar crest (interalveolar and interradicular septa (IIS)) (*Fig. 1*).

The prepared images were calculated using software Axio Vision 4.8.2 (Carl Zeiss, Germany) and Excel 7.0.

Radiographic density (RD) was calculated using the formula:

$$RD = | lg10 (BG / AOI) |,$$

where RD is the radiographic density of the mandible tissues;

AOI – "area of interest";

BG is the radiographic density of the "background area" of the selected area of the mandible soft tissues without bone formations.

Statistical calculations were performed in Microsoft Excel 2016 spreadsheet (Microsoft Corp., USA). For all the indicators the value of the arithmetic mean of the sample (M), its dispersions, and the mean error (m) were calculated. To identify the significance of differences in the results of research in the experimental and control groups of rats, the Student's coefficient (t) was calculated, and after that the probability of the difference in samples (P) and the confidence interval of the average as per the Student's tables of distribution were determined. The differences of values for which Pst < 0.05 were considered valid [9,10].

Results

Extraction of the 1st low molar from the rats of the control group on the 1st day of the post-extraction period led to a significant decrease in RD for more than 2.7 times in the root area of the extracted tooth and 65 % in the IIS area, which is connected not only with the extraction of tooth bone tissue, but also with an active inflammatory process, leading to bone tissue resorption (*Table 1*).

On the 7th day after the extraction, the RD index in the area of the tooth root did not significantly differ from the values of the previous term group, whereas in the IIS area the RD values permitted to suggest a decrease in resorptive processes in the mandible bone tissue and a partial recovery of mineralization processes, that can be confirmed by the increase of RD by 44.1 % comparing to the 1st day of the post-extraction period (*Table 1*).

The 14th day of observation showed, comparing to the previous period, the 7th day, an increase in the RD index in the 1st molar root area by 53.8 % and the absence of significant differences in the IIS area. It should be noted that in this period of complete restoration of bone density to the indicators of the "Control-0" group did not occur, because RD in the area of the root remained less by 1.67 times, and in the area of IIS – by 11 %, which is an important evidence of the ongoing reconstructive processes in the area of the alveolar socket (*Table 1*).

It is known that tooth extraction is accompanied not only by local inflammatory processes in the area of the alveolar socket, the associated changes in nearby teeth, which are characterized by the presence of a pain component, the development of periapical periodontitis, the occurrence of pathological mobility, are proved [11].

The analysis of RD indices located near to the extracted tooth of the 2nd and 3rd molars of the control group rats showed that its extraction could not but affect the state of the bone tissue of IIS. Already on the 1st day there was a decrease in radiological density of the IIS of the 2nd molar by 24.4 %, and on the 3rd by 16.8 %. Moreover, the RD of the crown of the 2nd molar showed its decrease by 21.9 %, which is most likely due to bone tissue resorption due to the activity of the inflammatory process, disruption of local trophism, changes in the pH of the oral fluid [12]. It should be noted that the identified process is reversible because already on the 7th day, a full recovery of the values up to the control indicators was observed, while the RD indicator on the 14th day of the post-extraction period did not have significant differences in the studied areas (*Table 1*).

A comparative analysis of the radiological density of the mandible tissues in the area of the 1st–3rd molars of the rats with experimental streptozotocin diabetes of

Table 1. Radiographic density of the mandible tissues after the tooth extraction of the rats from the control group (M ± m)

Formations under study		Radiographic density, rel.un			
		Without extraction, n = 15	The 1st day after extraction, n = 15	The 7th day after extraction, n = 15	The 14th day after extraction, n = 15
The 1st molar	Tooth crown	0.518 ± 0.011	alveolar socket of the 1st molar		
	tooth root	0.469 ± 0.014	0.172 ± 0.006[1]	0.182 ± 0.006[1]	0.280 ± 0.006[1,2]
	IIS	0.408 ± 0.012	0.247 ± 0.008[1]	0.356 ± 0.012[1,2]	0.367 ± 0.015[1]
The 2nd molar	Tooth crown	0.527 ± 0.018	0.432 ± 0.011[1]	0.508 ± 0.012[2]	0.522 ± 0.011
	Tooth root	0.481 ± 0.017	0.450 ± 0.012	0.463 ± 0.009	0.471 ± 0.013
	IIS	0.392 ± 0.016	0.315 ± 0.007[1]	0.368 ± 0.009[2]	0.370 ± 0.012
The 3rd molar	Tooth crown	0.511 ± 0.016	0.484 ± 0.012	0.499 ± 0.014	0.492 ± 0.014
	Tooth root	0.474 ± 0.014	0.435 ± 0.015	0.455 ± 0.016	0.467 ± 0.009
	IIS	0.384 ± 0.014	0.341 ± 0.012[1]	0.369 ± 0.014	0.397 ± 0.015

[1]: significant differences in the indices of groups after tooth extraction (Pst < 0.05) in relation to the group without extraction; [2]: significant differences in the indices of groups after tooth extraction (Pst < 0.05) in relation to the group of the previous term.

Table 2. Radiological density of the mandible tissues after the tooth extraction of the rats with the experimental diabetes mellitus (M ± m)

Formations under study		Radiographic density, rel.un			
		Without extraction, n = 15	The 1st day after extraction, n = 15	The 7th day after extraction, n = 15	The 14th day after extraction, n = 15
The 1st molar	Tooth crown	0.509 ± 0.008	alveolar socket of the 1st molar		
	Tooth root	0.425 ± 0.009	0.187 ± 0.005[1]	0.198 ± 0.007[1]	0.154 ± 0.008[1,2]
	IIS	0.320 ± 0.006	0.391 ± 0.016	0.387 ± 0.009[1,2]	0.291 ± 0.009[1,2]
The 2nd molar	Tooth crown	0.515 ± 0.009	0.521 ± 0.008	0.496 ± 0.011[1,2]	0.458 ± 0.008[2]
	Tooth root	0.476 ± 0.015	0.485 ± 0.013	0.427 ± 0.012[1,2]	0.356 ± 0.009[1,2]
	IIS	0.325 ± 0.006	0.396 ± 0.007[1]	0.318 ± 0.019	0.269 ± 0.007[1,2]
The 3rd molar	Tooth crown	0.491 ± 0.009	0.472 ± 0.017	0.469 ± 0.013	0.481 ± 0.008
	Tooth root	0.478 ± 0.013	0.453 ± 0.013	0.476 ± 0.011	0.411 ± 0.013[1,2]
	IIS	0.316 ± 0.014	0.374 ± 0.015[1]	0.275 ± 0.011[1,2]	0.269 ± 0.011[1]

[1]: significant differences in the performance of groups after tooth extraction (Pst < 0.05) in relation to the group without extraction; [2]: significant differences in the performance of groups after tooth extraction (Pst < 0.05) in relation to the group of the previous term.

the group without extraction of the tooth showed that the formed hyperglycaemia leads to a significant decrease in RD in the area of IIS of all three molars: by 27.5 % for the 1st, 20.6 % for the 2nd and 21.5 % for the 3rd. Moreover, the RD index of the 1st molar root area was also 10.3 % lower than the values of the corresponding control and this allows suggesting their increased resorptive processes in the bone tissue (*Tables 1, 2*).

Extraction of the 1st molar of the rats with EDM on the 1st day led to the expected decrease in radiological density in the area of its root, but it increased in the IIS area by 22.0 %. A similar pattern was observed in the IIS area of the 2nd and 3rd molars – the RD index was increased by 21.8 % and 18.3 %, respectively, which is a result of the development of the resorptive phase of the inflammatory reaction with tissue infiltration not only in the remote molar area, but also its considerable prevalence on the adjacent teeth (*Table 2*).

On the 7th day of the post-extraction period rats with EDM, in contrast to the indicators of the control rats of the corresponding age, had a decrease in radiographic density in the area of the IIS of the 2nd and 3rd molars by 24.5 % and 36.0 %, respectively, with its decrease in the root area of the 2nd molar by 13.5 % (*Tables 1, 2*). The 14th day's observations showed that in this period there were significant structural changes in the studied areas, i.e. the inflammatory process did not end, but on the contrary, there was a decrease in the RD index in the alveolar socket and IIS of the 1st molar by 28.6 % and 33.0 %, respectively. Obvious resorptive processes were revealed during the study of the radiological density of parts of the 2nd molar, with a decrease in RD in the crown area by 8.2 %, tooth root by 19.9 %, IIS – by 18.2 %. The resorptive processes also affected the 3rd molar, since a decrease in the RD of its root by 15.8 % was noted (*Table 2*).

Discussion

During the realized study it was found that diabetes mellitus makes a significant contribution not only to the course of the wound process after tooth extraction, but also its role was shown in the pathogenesis of the complications formation due to violation of the resorption-reparative relationship in the area of the alveolar socket and adjacent molars.

It is important to note that the features of the course of the wound process on the background of diabetes mellitus have already been repeatedly discussed. Most researchers identify several key factors that are crucial in the formation of postoperative complications in patients with diabetes. Among them it is necessary to single out the pre-existing ones, which change the direction, duration and staging of the inflammatory reaction, and newly formed during tissue trauma associated with an imbalance of enzyme systems and local immune responses [13].

According to the results of numerous clinical observations and experimental studies, pathological changes

in bone tissue, significant microcirculatory disorders, and neurotrophic disorders were identified among the pre-existing adverse factors affecting the course of the post-operative period of patients with DM. At the same time, it is believed that osteopenia and osteoporosis, as the most frequent pathological changes in bone tissue, have the diffuse character, since both cancellous and tubular bones "suffer" [14]. Conducted histomorphometric studies have shown that in case of diabetes mellitus type 1 there is a reduced bone formation with a decrease in metabolic processes in it. In the experiment on rats, it was found out that with simulated streptozotocin diabetes in bone tissue, there is a decrease in the content of non-mineralized matrix and the number of osteoclasts [15].

In the study realized by us the indisputable confirmation of emerging osteoporosis with bone resorption was the decrease in the radiological density of the tooth root of the 1st molar, as the most traumatized and loaded rats' tooth, and IIS in the area of the 1st-3rd molars.

Another important fact that was stated in the work was the confirmation of the DM effect on the inflammatory process after tooth extraction. It was found out that persistent hyperglycaemia, a key pathogenetic factor of disease complication, significantly changes the nature of the wound process, which according to most researchers, is associated with impaired stages of inflammation phases, their duration and effectiveness. In particular in the works of O. E. Lutsevich et al. it was shown that the wound process on the background of diabetes mellitus is characterized by pronounced macro- and microcirculatory disorders, the presence of microthrombus, the formation of a sludge-phenomenon, dystrophic and necrotic processes, the predominance of the alterative component over the reparative, the inhibition of cell proliferation, the suppression of phagocyte activity of leukocytes, incomplete phagocytosis, decrease in general and local immunological reactivity [16].

Studied in the work features of the dynamics of changes in indicators of radiological bone tissues density of the mandible after tooth extraction on the background of DM in different periods of the post-extraction period were indirect confirmation of the above mentioned. Thus, an increase and not the decrease of the RD index on the 1st day in the alveolar socket area and the adjacent 2nd and 3rd molars may be a consequence of significant infiltration associated with the development of marked secondary alteration. The final stage of the resorptive phase of the local inflammatory reaction also had its own characteristics. Thus, in the control on the 7th day of the post-extraction period, that correspond to this phase [17], almost complete recovery of RD is observed, whereas on the background of diabetes mellitus, on the contrary, the radiological density of the studied areas decreased, and this process continued on the 14th day. The established fact indicates the progression of resorptive processes against the background of low proliferative activity. In addition to the identified features of the inflammatory process, the study showed the role of EDM in the formation of long-term complications in the form of increased mobility of adjacent teeth. This was evidenced by the decrease and not the increase of the RD index in the IIS area, which, being part of a tooth support apparatus, normally not only ensures the stability of the tooth position in the bone, their trophic function has also been proven, due to abundant vascularisation and the large number of nerve endings [17].

Conclusions

1. Tooth extraction from rats with normal indices of carbohydrate metabolism is accompanied by dynamic changes in radiological density not only in the extraction area of the 1st molar (it decreases on the 1st day in the area of the root by more than 2.7 times and by 65 % in the area of interalveolar and interradicular septa with its restore to the 14th day). It was established that the pre-existing early resorptive phase of the local inflammatory reaction ends by the 7th day of the post-extraction period, changing to the reparative by the 14th day.

2. The development of experimental diabetes mellitus in rats leads to an increase in resorptive processes in the mandible bone tissue, which is manifested by a decrease in RD in the area of the 1st molar root by 2.27 times along with its increase in the IIS area of all three low molars by 22.0 %, 21.8 % and 18.3 % respectively.

3. Experimental diabetes mellitus contributes to the particular course of the wound process after tooth extraction. At the same time, it is an important pathogenetic link for the formation of complications due to the disturbance of the resorption-reparative relationship in the area of the alveolar socket and the adjacent molars.

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Information about authors:
Abramov A. V., MD, PhD, DSc, Professor of the Department of Pathological Physiology, Zaporizhzhia State Medical University, Ukraine.
Hanchev K. S., Assistant Professor of the Department of Propaedeutical and Surgical Dentistry, Zaporizhzhia State Medical University, Ukraine.
Kadzharian Ye. V., MD, PhD, Senior Lecturer of the Department of Pathological Physiology, Zaporizhzhia State Medical University, Ukraine.

Відомості про авторів:
Абрамов А. В., д-р мед. наук, професор каф. патологічної фізіології, Запорізький державний медичний університет, Україна.
Ганчев К. С., асистент каф. пропедевтичної та хірургічної стоматології, Запорізький державний медичний університет, Україна.
Каджарян Є. В., канд. мед. наук, старший викладач каф. патологічної фізіології, Запорізький державний медичний університет, Україна.

Сведения об авторах:
Абрамов А. В., д-р мед. наук, профессор каф. патологической физиологии, Запорожский государственный медицинский университет, Украина.
Ганчев К. С., ассистент каф. пропедевтической и хирургической стоматологии, Запорожский государственный медицинский университет, Украина.

Каджарян Е. В., канд. мед. наук, старший преподаватель каф. патологической физиологии, Запорожский государственный медицинский университет, Украина.

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