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РЕТРОСПЕКТИВНИЙ АНАЛІЗ СТУПЕНЯ РЕДУКЦІЇ ПЕРИІМПЛАНТАТНОЇ КІСТКОВОЇ ТКАНИНИ ПРИ ПРОТОКОЛАХ НЕГАЙНОЇ ТА ВІДСТРОЧЕНОЇ ДЕНТАЛЬНОЇ ІМПЛАНТАЦІЇ

В статті наведений порівняльний аналіз показника редукції рівня періімплантатної кісткової тканини паралельно із дослідженням рівнів успішності та виживання імплантатів, встановлених за протоколами негайної, ранньої та відстроченої імплантації з пошуком можливих статистичних чи трендових асоціацій між досліджуваними параметрами, описаними у попередньо відібраному пулі наукових робіт. **Мета дослідження.** *Проаналізувати відмінності у зміні показників редукції періімплантатної кісткової тканини за умов реалізації протоколів негайної та відстроченої імплантації, як критеріїв її прогнозу та оцінки успішності в процесі віддаленого моніторингу.* **Матеріали і методи.** *Пошук релевантних наукових публікацій проводився за допомогою пошукової системи Google Академії, забезпечуючи ранжування отриманих результатів за критеріями глибини дослідження, повноти відповідності ключових слів назві та контенту резюме публікацій, а також кількості цитувань у структурі попередньо проведених систематичних оглядів та мета-аналізів. Групування результатів та оцінка рівня та значимості статистичних залежностей між відокремленими параметрами дослідження проводилися у програмному забезпеченні табличного редактора Microsoft Excel 2019 (Microsoft Office 2019).* **Результати досліджень та їх обговорення.** *Рівень редукції кісткової тканини в періімплантатній області є одним з визначальних критеріїв успішності встановлених дентальних імплантатів у безпосередній та віддалені періоди моніторингу, що були попередньо запропоновані багатьма вітчизняними та зарубіжними авторами. Існуючі на сьогодні методи реєстрації зниження вертикальних параметрів кісткового гребня, суміжного з поверхнею встановлених титанових інтраосальних опор, передбачають можливості не лише для чисельного розрахунку різниці показників у різні терміни спостереження, а й для їх квантифікації у формі обрахунку об'ємної втрати кістки, циркулярної її редукції, візуалізації геометрії наявних сауцероподібних дефектів. Цінність показника втрати рівня кісткової тканини в періімплантатній області як критерію успішності імплантації також зростає у випадках комплексної інтерпретації його змін із рядом інших досліджуваних параметрів, на зразок кумулятивного показника виживання та успішності імплантатів, відносного ризику різних форм ускладнень, статистичних асоціацій із потенційно-визначальними факторами впливу. Саме комплексний підхід до трактування зареєстрованих відмінностей між показниками редукції рівня періімплантатної кісткової тканини у випадках реалізації протоколів негайної та відстроченої імплантації з пошуком можливих асоціації між цим критерієм та рядом потенційно-впливових факторів забезпечив проведення деталізованого аналізу попередньо опублікованих даних.* **Висновки.** *В результаті деталізованого аналізу вдалось встановити, що дані попередньо проведених досліджень присвячених порівнянню клінічних критеріїв ефективності реалізації негайного та інших протоколів дентальної імплантації, не дозволяють сформулювали однозначний висновок щодо вираженої різниці досліджуваних показників протягом різних періодів спостереження.*

Ключові слова: *рівень редукції, періімплантатна кісткова тканина, протокол дентальної імплантації, виживання імплантатів.*

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RETROSPECTIVE ANALYSIS OF THE DEGREE OF REDUCTION OF PERI-IMPLANT BONE TISSUE DURING IMMEDIATE AND DELAYED DENTAL IMPLANTATION PROTOCOLS

The article presents a comparative analysis of the periimplant bone tissue level reduction indicator in parallel with the study of the success and survival levels of implants installed according to the protocols of immediate, early and delayed implantation with the search for possible statistical or trend associations between the studied parameters described in the preselected pool of scientific works. **The purpose** *of the study is to analyze the differences in the change in periimplant bone tissue reduction indicators under the conditions of implementation of immediate and delayed implantation protocols, as criteria for its prognosis and assessment of success in the process of remote monitoring.* **Research materials and methods.** *The search for relevant scientific publications was carried out using the Google Academy search engine, ensuring the ranking of the obtained results according to the criteria of research depth, the completeness of the correspondence of keywords to the title and content of the abstracts of publications, as well as the number of citations in the structure of previously conducted systematic reviews and meta-analyses. The grouping of the results and the assessment of the level and significance of statistical dependencies between the separated parameters of the study were carried out in the Microsoft Excel 2019 table editor software (Microsoft Office 2019).* **Research results and their discussion.** *The level of bone tissue reduction in the peri-implant area is one of the determining criteria for the success of installed dental implants in the immediate and remote periods of monitoring, which were previously proposed by many domestic and foreign authors. Existing methods of registering the decrease in the vertical parameters of the bone ridge adjacent to the surface of installed titanium intraosseous supports provide opportunities not only for the numerical calculation of the difference in indicators at different periods of observation, but also for their quantification in the form of calculating the volume loss of bone, its circular reduction, visualization of the geometry of existing saucer-like defects. The value of the index of loss of bone tissue in the periimplant area as a criterion for the success of implantation also increases in cases of complex interpretation of its changes with a number of other studied parameters, such as the cumulative index of survival and success of implants, the relative risk of various forms of complications, statistical associations with potentially determining factors of influence. It is the complex approach to the interpretation of the registered differences between the indicators of the reduction of the level of periimplant bone tissue in the cases of implementation of the protocols of immediate and delayed implantation with the search for possible associations between this criterion and a number of potentially influential factors that ensured the detailed analysis of previously published data.* **Conclusions.** *As a result of a detailed analysis, it was possible to establish that the data of previously conducted studies devoted to the comparison of clinical criteria for the effectiveness of the implementation of immediate and other protocols of dental implantation do not allow formulating an unequivocal conclusion regarding the pronounced difference of the investigated indicators during different periods of observation.*

Key words: *reduction level, periimplant bone tissue, dental implantation protocol, implant survival.*

Introduction. As a result of conducting a significant number of clinical and experimental studies devoted to the issue of dental implantation and evaluating the results of its success in the immediate and remote periods of monitoring, it was possible to justify the feasibility of introducing into clinical practice not only classical, but also modified protocols for the installation of intraosseous titanium implants for the purpose of further rehabilitation of dental patients with symptoms of adentia [1–6; 31; 32].

In the Cochrane systematic review conducted by Esposito M. and colleagues (2010), in relation to the criterion of the time of implant installation in the socket of an extracted tooth, the authors distinguished three possible approaches: the protocol of immediate implantation, which involves the installation of an implant in the socket of an extracted tooth immediately after the extraction procedure (immediate implantation); the immediate-delayed implantation protocol, which provides for the installation of an implant in the socket of the extracted tooth after a period of several weeks to several months after the extraction procedure in order to ensure the healing of soft tissues in the area of surgical intervention (immediate-delayed implantation); and the delayed implantation protocol, which provides for the installation of an implant in the hole of the extracted unit of the tooth row after complete or partial healing of the area of bone tissue at the site of surgical intervention (delayed implantation) [5]. According to the recommendations of the ITI (International Team of Implantologists),

implantation protocols in accordance with the time of installation of dental implants relative to the moment of tooth extraction should be classified as follows: 1) type I – immediate implantation (in the socket of a newly removed tooth without healing of soft or hard tissues in the area intervention); 2) type II – early implantation 4–8 weeks after extraction (in the tooth socket with healed soft tissues, but without significant healing of the bone tissue area); 3) type III – early implantation 12–16 weeks after extraction (in the tooth socket with healed soft tissues and partially healed healed bone tissue); 4) type IV – late implantation at least 6 months after extraction (in the area of a completely healed tooth socket) [5; 6].

However, since the last systematic reviews devoted to the issue of differentiation of the results of immediate and delayed implantation, a number of new data have been obtained, and the previous results have been additionally interpreted from the point of view of modern understanding of the mechanisms of bone remodeling, which in the complex expands the opportunities for discussion and argumentation of the prognosis of various protocols for the installation of intraosseous titanium implants dental implants taking into account the initial conditions of the clinical situation.

The aim of the study. To analyze the differences in the change in indicators of reduction of peri-implant bone tissue under the conditions of implementation of the protocols of immediate and delayed implantation, as criteria for its prognosis and assessment of success in the process of remote monitoring.

Research materials and methods. The search for relevant scientific publications devoted to the issue of studying the change in indicators of peri-implant bone tissue reduction under the conditions of implementation of immediate and delayed implantation protocols was carried out using the Google Academy search engine, ensuring the ranking of the obtained results according to the criteria of the depth of the study, the completeness of the correspondence of keywords to the title and the content of the summary of the publications, as well as the number of citations in the structure of previously conducted systematic reviews and meta-analyses [7; 8].

The analysis of the peri-implant bone tissue level reduction indicator was conducted in parallel with the study of the success and survival levels of implants installed according to the protocols of immediate, early and delayed implantation with the search for possible statistical or trend associations between the studied parameters described in the pre-selected pool of scientific works.

The grouping of results and the assessment of the level and significance of statistical dependencies between the selected parameters of the study were carried out in the Microsoft Excel 2019 table editor software (Microsoft Office 2019, Microsoft).

Research results and their discussion. The level of bone tissue reduction in the peri-implant area is one of the determining criteria for the success of installed dental implants in the immediate and remote periods of monitoring, which were previously proposed by many domestic and foreign authors [3; 9–12]. Existing methods of registering the decrease in the vertical parameters of the bone ridge adjacent to the surface of installed titanium intraosseous supports provide opportunities not only for the numerical calculation of the difference in indicators at different periods of observation, but also for their quantification in the form of calculating the volume loss of bone, its circular reduction, visualization of the geometry of existing saucer-like defects [13–18].

In a study by Barbier and colleagues (2011), in which immediate loading of implants installed immediately in sockets of extracted teeth and in sockets after healing was carried out, it was established that the time of implantation does not affect the level of reduction of peri-implant bone tissue ($p > 0.3$) [19]. The average decrease in the height of the bone crest relative to the reference reference point ranged from 0.25 mm to 0.48 mm 1 year after the loading of the infrastructure, which corresponds to the success criteria proposed by Albrektsson T. and Zarb G. Considering the obtained indicators and the registered 100% survival rate implants, the authors summarized that their proposed and described approach of immediate implantation with subsequent immediate loading can be considered successful based on a 1-year monitoring period [19].

However, one of the latest studies published by Mello C.C. et al. (2017) in the form of a systematic review and conducted meta-analysis indicates that the survival rates of implants installed in the sockets of extracted teeth after healing are statistically higher than similar indicators of implants installed in the sockets of teeth immediately after their removal – 98.38% versus 95.21% ($p = 0.001$) [20]. Thus, the researchers were able to establish that the relative risk of loss of dental implants installed immediately in the sockets of extracted teeth reaches 1.58 with a 95% confidence interval of 1.27–1.95 ($p = 0.0001$) [21]. The last fact can be justified by the effect of splinting installed infraosseous units with a total orthopedic construction, which has a positive effect on a more uniform distribution of active occlusal forces and a reduction of stresses in the area of various interfaces of the biomechanical prosthesis-implant-bone system.

As a result, these aspects during total rehabilitation have a positive effect on the growth of the cumulative implant survival rate. During the research Peñarrocha-Diago M.A. and colleagues (2011) also found that in cases of total prosthetic rehabilitation of patients with installation of 6–8 implants on the upper jaw and 6 on the lower jaw, the protocols of immediate and delayed implantation in terms of the reduction in the level of peri-implant bone tissue do not differ statistically ($p \geq 0.05$) [22]. Conducting a detailed analysis of the results, the authors also summarized that the presence of a gap between the surface of the implant and the wall of the socket of the extracted tooth, according to the data of clinical observation, obviously does not affect the risk of losing the installed intraosseous supports. The authors noted that the level of reduction or growth of bone tissue in the peri-implant area under the conditions of immediate installation of implants in the sockets of extracted teeth is not associated with the criterion of the time of implantation in relation to the extraction procedure, but with such derivatives as the subcrestal position of the implant, the fact of additional augmentation interventions, the design of connection of the implant with the abutment [21].

A systematic review by Lee C.-T. and colleagues (2014), focused on the analysis of changes in bone tissue from the vestibular and lingual sides of implants installed according to the immediate intervention protocol, made it possible to establish that the weighted average indicator of bone tissue reduction from the vestibular side in the horizontal direction was 1.07 mm, and in the vertical direction – 0.78 mm; at the same time, the weighted average rate of reduction of bone tissue from the lingual side in the horizontal direction reached 0.62 mm, and in the vertical direction – 0.50 mm [23].

Comparing the results of immediate and delayed single implantation in the frontal jaws, Tonetti M.S. and colleagues (2016) established that the protocol of immediate installation of implants in the socket of an extracted tooth is characterized by a more pronounced trend of radiologically registered bone tissue loss ($P\text{trend} < 0.01$) [24]. The average difference in the reduction of peri-implant bone tissue levels during immediate and delayed implantation was 0.8±0.4 mm ($p < 0.01$). The authors came to the conclusion that the predictability of the immediate implantation procedure in the frontal areas of the jaws is questionable, and it is advisable to implement it only in individual clinical cases. Although in a previous study conducted by Hof et al. (2014), after 4.5±2.9 years of observation, it was not possible to register a statistical difference between the indicators of vertical loss of peri-implant bone tissue during the implementation of immediate, early and delayed protocols of dental implantation in the frontal areas of the jaws (1,5±0.8 mm, 1.4±0.8 mm, and 1.2±0.8 mm, respectively; the average value is 1.6±0.9 mm) [25]. Stratification meta-analysis conducted by Hartog L.D. et al. (2008) also did not reveal a static difference between the clinical indicators of rehabilitation of patients in the aesthetic area using dental implants installed according to immediate, early or delayed protocols – the average indicators of the evaluation criteria used fluctuated in approximately the same ranges, providing an average implant survival rate of 95, 5% [95% confidence interval: (93.0–97.1)] during 1-year monitoring [26].

In a randomized clinical trial by Schropp L. et al. (2013), it was also possible to find a statistical difference between the indicators of reduction in the level of peri-implant bone tissue in cases of early (on average 10 days after extraction), delayed (on average 3 months after extraction) and late implantation (on average 17 months after extraction), which were, respectively, 1.15±0.77 mm, 1.53±1.06, 1.42±1.07 at the time of control 10 years after the surgical intervention [27]. Soydan S. and colleagues (2013), on the contrary, established that although the protocol of immediate implantation provokes a less pronounced vertical loss of the surrounding bone tissue in comparison with the protocol of early implantation – 0.55 mm (0–6 mm) versus 0.80 mm (0–2,8) after 1 year, however, the average cumulative success rate of implants installed directly in the socket of the extracted tooth reached 76.92%, while early implantation was characterized by an average cumulative success rate of 79.16% [28].

In a study by Mohindra K., it was established that during 6-month monitoring of implants installed according to the immediate protocol, the change in buccal-lingual ridge width is observed in the range of 3.42±0.97 mm, and the change in the interproximal levels of bone tissue in the area of contact with the implant in the range of –0.30±0.04; when providing a delayed implantation protocol, these indicators were 3.57±0.97 mm and –0.38±0.06 mm, respectively. Thus, the authors similarly failed to confirm the hypothesis that the immediate implantation protocol is characterized by a lower success rate than the delayed implant intervention protocol [29].

Schropp L. and Isidor F. categorized the procedures of immediate and early implantation as quite promising alternatives to the classic delayed protocol for the installation of intraosseous titanium supports, which can ensure the achievement of sufficiently high aesthetic and functional rehabilitation results. At the

same time, however, the authors noted the dependence of the promising results of treatment with immediate implantation on the adequacy and completeness of the implementation of the procedure and the previous experience of the doctor, as well as on the initial conditions of the clinical situation [30–34].

Conclusion. As a result of a detailed analysis, it was possible to establish that the data of previously conducted studies devoted to the comparison of clinical criteria for the effectiveness of the implementation of immediate and other protocols of dental implantation do not allow formulating an unequivocal conclusion regarding the pronounced difference of the investigated indicators during different periods of observation. At the same time, however, the obtained results are not controversial, and their interpretation, taking into account the existing limitations related to the design of this analytical study, can be carried out as follows: 1) the survival rate of dental implants under the conditions of the implementation of the immediate implantation protocol is statistically lower compared to the results that can be achieved during the implementation of early and delayed implantation protocols; 2) it was not possible to register a clinically significant difference between the success rates of dental implants installed in accordance with the protocols of immediate, early and delayed intervention; a statistically significant difference in these indicators during the 1-year observation period was noted only in some clinical studies; 3) differences in the change in indicators of reduction of peri-implant bone tissue under the conditions of implementation of the protocols of immediate and delayed implantation as criteria for its prognosis and assessment of success in the process of remote monitoring are not statistically confirmed, and therefore, from the point of view of the parameter of loss of height of the bone crest adjacent to the surface of the implant, the two compared above techniques are equally effective; 4) the procedure of immediate implantation is more manual and technically sensitive for practical implementation, which suggests that the predictability of this manipulation depends on the experience of the operator (implant surgeon) and the validity of the selection of clinical cases for the implementation of this operative approach under favorable anatomical conditions.

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