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APPLICATION OF ALVEOLAR RIDGE SPLIT TECHNIQUE IN COMPLICATED DENTAL IMPLANTATION WITHOUT THE USE OF BONE AUGMENTATION IN PERIODONTAL TISSUE PATHOLOGY

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Twenty-five patients (12 male and 13 female patients) of young and Ist adult age without bad habits were selected, who underwent surgical treatment with horizontal atrophy of the jawbone tissue in periodontal tissue pathology. Patients were divided into two groups with a preliminary prognosis of "crestal" and "subcrestal" placement of dental implants with appropriate vertical soft tissue dimensions, which directly affected the choice of osseointegration of the latter. A total of 47 dental implants were integrated. A significant number of dentists apply the alveolar ridge split technique only using bone material. We used splitting without the use of bone substitutes in our study. We examined the condition of the bone and soft tissue after the load, performing a correlation and completing an integrated analysis from initial assessment to long-term treatment outcomes. Application of the "sequential" alveolar ridge splitting with the piezoelectric periotome without the use of bone substitutes to increase the horizontal dimension of the bone tissue of the jaws demonstrated properties (elasticity, resilience, and flexibility) of bone tissue under difficult conditions of dental implantation.

Key words: generalized periodontal diseases, bone augmentation, alveolar ridge split, dental implantation.

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ЗАСТОСУВАННЯ МЕТОДУ РОЗЩЕПЛЕННЯ АЛЬВЕОЛЯРНОГО ВІДРОСТКА ЗА УСКЛАДНЕНОЇ ДЕНТАЛЬНОЇ ІМПЛАНТАЦІЇ БЕЗ ЗАСТОСУВАННЯ КІСТКОВОЇ АУГМЕНТАЦІЇ ПРИ ПАТОЛОГІЇ ТКАНИН ПАРОДОНТУ

Були відібрані 25 хворих (12 чоловіків та 13 жінок) молодого та I-го зрілого віку без шкідливих звичок, яким було проведено оперативне лікування з горизонтальною атрофією кісткової тканини щелеп при патології тканин пародонту. Хворі були розділені на дві групи з попереднім прогнозуванням «крестальне» та «субкрестальне» розміщення дентальних імплантатів із відповідними вертикальними розмірами м'яких тканин, що безпосередньо впливали на вибір остеоінтеграції останніх. Усього було інтегровано 47 дентальних імплантатів. Значна кількість лікарів-стоматологів використовують методи розщеплення альвеолярного відростка лише зі застосуванням кісткового матеріалу, в нашому дослідженні ми застосовували розщеплення без використання кісткових замінників. Розглядаємо стан кісткової та м'яких тканин після навантаження, проводячи кореляційний та завершуючи інтегрований аналіз від початкової оцінки до віддалених результатів лікування. Використовуючи метод «покрокового» розщеплення альвеолярного відростка п'єзо електричним періотомом без використання кісткових замінників для збільшення горизонтальних розмірів кісткової тканини щелеп, продемонстровані властивості (еластичність, пружність та податливість) кісткової тканини при складних умовах дентальної імплантації.

Ключові слова: генералізовані захворювання тканин пародонту, кісткова аугментація,розщеплення альвеолярного відростка, дентальна імплантація.

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Presently, the issue of horizontal atrophy of the bone tissue of the jaws in generalized periodontal diseases occupies a leading place in modern dentistry. The main causes of horizontal atrophy are premature loss of a permanent tooth without immediate load and disturbed metabolic processes in periodontal tissues [1]. Hence, the preservation of natural teeth is one of the tasks of modern dentistry, but in cases where this is not possible, the structure of hard and soft tissues should be preserved to achieve successful dental implantation. Unfortunately, there is no technique to stop the horizontal atrophy of bone tissue after tooth extraction – this process is inevitable, and urgent dental implantation is not always possible [3–5, 8].

Based on the analysis of biomechanical characteristics of natural teeth and jawbone in the post-extraction period, it is necessary to conduct dental implantation, which could serve the basic dental functions due to its parameters and not destroy the jawbone in the presence of periodontal pathology [4–6]. Therefore, it is necessary to solve the problem of osseointegration of implants and find a possibility to increase the functional load on the implant in horizontal atrophy of the alveolar ridge by stimulating osteogenesis and creating a larger contact area of the intraosseous part of the implant without increasing its volume. To achieve this result, alveolar ridge split techniques are applied using bone augmentation with various osteoplastic materials with the direct or indirect remodeling of the maxillary or mandibular bone tissue, taking into account periodontal diseases. Two techniques are now known to increase the area of intervention: split-control and intercortical osteotomy with the block's displacement. However, the above methods require the restoration of bone volume, which is a complex and expensive procedure for fully rehabilitating patients with generalized periodontal disease. After all, the ratio of the height of the intraosseous and extraosseous part of the implant and the proportionality of the size of the supporting surface of the implant and the occlusal surface of the tooth are important for full dental implantation [6–7, 9].

The purpose of the study was to determine the effectiveness of the maxillary or mandibular alveolar ridge split techniques in patients with horizontal atrophy of the alveolar ridge and periodontal pathology in difficult conditions and to demonstrate the interdependence of this technique with positioning dental implants in bone tissue and vertical dimensions of soft tissues with a delayed assessment of the condition of these components after orthopaedic rehabilitation.

Materials and methods. On the basis of the Dental Medical Center of Danylo Halytsky Lviv National Medical University, 25 patients (12 male and 13 female) of young and Ist adult age without bad habits were selected. They underwent surgical treatment of horizontal atrophy of the alveolar ridge in generalized periodontal diseases by alveolar ridge split technique without using bone augmentation with immediate dental implantation using Connect Implant System (Ukraine). A total of 47 dental implants with subcrestal and crestal placement were integrated. A significant number of dentists apply the alveolar ridge split technique using only bone material. In our study, we used splitting without using bone substitutes, enabling the patient's body to self-organize bone tissue around dental implants with the concept of bone preservation. Using any bone material, we face the processes of uncontrolled resorption because the bone material only helps to replace the implanted substitute with the proper bone and therefore rarely achieves a result of 1:1. With the help of computed tomography with 3D reproduction on the Morita veraviewepas 3D Model X-550 device (Japan) the condition of bone tissue was assessed before alveolar ridge splitting and dental implantation, after alveolar ridge splitting with one-stage dental implantation before rational prosthetics and 12 months after splitting and dental implantation with rational prosthetics. The vertical dimensions of soft tissues before and after the above-mentioned manipulations were also assessed. A computer database in Microsoft Excel has been created to perform the calculations. Statistical processing of the results was performed using the Statistica 6.0 software.

Results of the study and their discussion. During the alveolar ridge splitting with the ARTeotomy OP1 LED piezoelectric periotome (Bonart, China (Taiwan)) using saline cooling, we activate osteoblasts, osteoclasts and growth factors, causing bone neogenesis. After all, bone structure is the only system in the body that can regenerate without forming scar tissue. Fibroblasts migrate to the wound surface with the growth of blood vessels, delimit the leukocyte shaft and form fibroblastic syncytia. Newly formed vessels grow into fibroblastic layers simultaneously with their formation. This is the formation of granulation tissue, which gradually fills the wound defect around the implant, which promotes adhesion to the surface of the dental implant. The newly formed peri-implant tissue has the properties of the periodontium, which demonstrates the processes of normative osseointegration.

According to the data in table 1, subsection 1 “Before alveolar ridge splitting and dental implantation”, 25 patients with horizontal atrophy of the jawbone tissue in periodontal pathology were divided into two groups with the preliminary prognosis of “crestal” and “subcrestal” placement of dental implants with vertical dimensions of soft tissues that directly affected the choice of osseointegration of the latter. In parallel, we separated patients with this pathology from the width of the alveolar ridge.

Thus, with an alveolar ridge width of 2–2.5 mm, the subcrestal prognosis of implant placement in 2 male patients was 8 % ($p<0.05$) of the total number of all patients and one female, which corresponds to 4 % ($p<0.05$) of all patients. Together, this figure was obtained in 3 subjects, which is 12 % ($p<0.05$) of all surveyed patients with this pathology. With an alveolar ridge width of 2.5–3 mm, one male had a subcrestal prognosis of dental implant placement, which is 4 % ($p<0.05$) of all patients and 2 female patients, which corresponds to 8 % ($p<0.05$) of the total number of all patients. Together, this figure was obtained in 3 subjects, which is 12 % ($p<0.05$) of all subjects with periodontal tissue pathology and horizontal atrophy of the alveolar ridge.

With an alveolar ridge width of 3–3.5 mm, 2 male patients had a subcrestal prognosis of dental implant placement, which accounts for 8 % ($p<0.05$) of all patients and a female, which corresponds to 4 % ($p<0.05$) of the total number of all patients. Together, this figure is similar to the previous two subgroups and accounts for 12 % ($p<0.05$) of all subjects with periodontal tissue pathology and horizontal atrophy of the alveolar ridge.

In the study of soft tissues in subcrestal prognosis of placement of dental implants, a decrease in the vertical dimension (hypotrophy) was observed in 4 male patients, which is 16 % ($p<0.05$) and in 3 female patients, which corresponds to 12 % ($p<0.05$) of all examined subjects in horizontal atrophy with periodontal tissue pathology. In total, this figure was found in 7 subjects, which is 28 % of all examined with this pathology. Normative indicators (normotrophy) were found in one male and female and correspond to the result of 4 % (p<0.05) of all examined subjects and together the indicator is 8 % (p<0.05) of all patients with this pathology. No soft tissue hypertrophy was detected.

Table 1

Condition of bone and soft tissues before and after splitting with osseointegration of implants and rational prosthetics in generalized periodontal diseases

<table>
<tr><td colspan="2">Subsection 1</td><td colspan="9">Before alveolar ridge splitting and dental implantation</td></tr>
<tr><td rowspan="4">Preliminary prognosis of dental implant position</td><td rowspan="4">Gender</td><td colspan="5" rowspan="2">L; B dimensions of the alveolar ridge (mm) and number (n) of patients (%)</td><td colspan="4">Vertical dimensions</td></tr>
<tr><td colspan="4" rowspan="2">Soft tissues (XM); (n); (%) (N = 2mm)</td></tr>
<tr><td colspan="5">>10</td></tr>
<tr><td colspan="2">2–2.5</td><td colspan="2">2.5–3</td><td>3–3.5</td><td colspan="2"><</td><td>=</td><td>></td></tr>
<tr><td rowspan="3">subcrestal</td><td>male</td><td colspan="2">2 (8)</td><td colspan="2">1 (4)</td><td>2 (8)</td><td colspan="2">4 (16)</td><td>1 (4)</td><td>-</td></tr>
<tr><td>female</td><td colspan="2">1 (4)</td><td colspan="2">2 (8)</td><td>1 (4)</td><td colspan="2">3 (12)</td><td>1 (4)</td><td>-</td></tr>
<tr><td>total</td><td colspan="2">3 (12)</td><td colspan="2">3 (12)</td><td>3 (12)</td><td colspan="2">7 (28)</td><td>2 (8)</td><td>-</td></tr>
<tr><td rowspan="3">crestal</td><td>male</td><td colspan="2">2 (8)</td><td colspan="2">2 (8)</td><td>3 (12)</td><td colspan="2">-</td><td>4 (16)</td><td>3 (12)</td></tr>
<tr><td>female</td><td colspan="2">3 (12)</td><td colspan="2">5 (20)</td><td>1 (4)</td><td colspan="2">-</td><td>7 (28)</td><td>2 (8)</td></tr>
<tr><td>total</td><td colspan="2">5 (20)</td><td colspan="2">7 (28)</td><td>4 (16)</td><td colspan="2">-</td><td>11 (44)</td><td>5 (20)</td></tr>
<tr><td colspan="2">Subsection 2</td><td colspan="9">After alveolar ridge splitting with one-stage dental implantation before rational prosthetics</td></tr>
<tr><td rowspan="2">Dental implant position</td><td rowspan="2">Gender</td><td colspan="5">Ø dimensions and number of dental implants (mm) (n) (%)</td><td colspan="4">Soft tissues (XM) (mm) (n) (%)</td></tr>
<tr><td colspan="2">3.5</td><td colspan="2">4</td><td>4.5</td><td colspan="2"><</td><td>=</td><td>></td></tr>
<tr><td rowspan="3">subcrestal</td><td>male</td><td colspan="2">3 (6.4)</td><td colspan="2">4 (8.5)</td><td>3 (6.4)</td><td colspan="2">-</td><td>7 (14.9)</td><td>3 (6.4)</td></tr>
<tr><td>female</td><td colspan="2">2 (4.3)</td><td colspan="2">2 (4.3)</td><td>4 (8.5)</td><td colspan="2">-</td><td>6 (12.8)</td><td>2 (4.3)</td></tr>
<tr><td>total</td><td colspan="2">5 (10.6)</td><td colspan="2">6 (12.8)</td><td>7 (14.9)</td><td colspan="2">-</td><td>13 (27.7)</td><td>5 (10.6)</td></tr>
<tr><td rowspan="3">crestal</td><td>male</td><td colspan="2">5 (10.6)</td><td colspan="2">4 (8.5)</td><td>4 (8.5)</td><td colspan="2">-</td><td>12 (25.53)</td><td>-</td></tr>
<tr><td>female</td><td colspan="2">4 (8.5)</td><td colspan="2">5 (10.6)</td><td>7 (14.9)</td><td colspan="2">-</td><td>15 (31.91)</td><td>2 (4.3)</td></tr>
<tr><td>total</td><td colspan="2">9 (19.1)</td><td colspan="2">9 (19.1)</td><td>11 (23.4)</td><td colspan="2">-</td><td>27 (57.44)</td><td>2 (4.3)</td></tr>
<tr><td colspan="2">Subsection 3</td><td colspan="9">12 months after splitting and dental implantation with rational prosthetics</td></tr>
<tr><td rowspan="2">Dental implant position</td><td rowspan="2">Gender</td><td colspan="6">Bone tissue (XB) (mm) (n)</td><td colspan="3">Soft tissues (XM) (mm) (n) (%)</td></tr>
<tr><td>0</td><td>0.5–1</td><td>0</td><td>0.5–1</td><td>0</td><td>0.5–1</td><td><</td><td>=</td><td>></td></tr>
<tr><td rowspan="3">subcrestal</td><td>male</td><td>-</td><td>3</td><td>-</td><td>4</td><td>1</td><td>2</td><td>-</td><td>8 (17.0)</td><td>2 (4.3)</td></tr>
<tr><td>female</td><td>1</td><td>1</td><td>-</td><td>2</td><td>3</td><td>1</td><td>-</td><td>8 (17.0)</td><td>-</td></tr>
<tr><td>total</td><td>1</td><td>4</td><td>-</td><td>6</td><td>4</td><td>3</td><td>-</td><td>16 (34.0)</td><td>2 (4.3)</td></tr>
<tr><td rowspan="3">crestal</td><td>male</td><td>4</td><td>1</td><td>4</td><td>-</td><td>3</td><td>1</td><td>2 (4.3)</td><td>11 (23.4)</td><td>-</td></tr>
<tr><td>female</td><td>4</td><td>-</td><td>5</td><td>-</td><td>6</td><td>1</td><td>3 (6.4)</td><td>13 (27.7)</td><td>-</td></tr>
<tr><td>total</td><td>8</td><td>1</td><td>9</td><td>-</td><td>9</td><td>2</td><td>5 (10.6)</td><td>24 (51.1)</td><td>-</td></tr>
</table>

Note: (p<0.05): XB – loss of crestal bone tissue around dental implants. XM – condition (< (hypotrophy); = (normotrophy); > (hypertrophy)) of soft tissues around dental implants. L – length of the alveolar ridge. B – width of the alveolar ridge. n – number. Ø – diameter of dental implants.

With an alveolar ridge width of 2–2.5 mm, the crestal prognosis of implant placement in 2 male patients was 8 % (p<0.05) of the total number of all patients and in 3 female patients, which corresponds to 12 % (p<0.05) of all patients. In total, this indicator was obtained in 5 subjects, which is 20 % (p<0.05) of all examined persons with periodontal tissue pathology and horizontal atrophy of the alveolar ridge. With an alveolar ridge width of 2.5–3 mm, two male patients had a crestal prognosis of placement of dental implants, which is 8 % (p<0.05) of all patients and 5 female patients, which corresponds to 20 % (p<0.05) of the total number of all patients. In total, this indicator was obtained in 7 patients, which is 28 % (p<0.05) of all examined subjects with periodontal tissue pathology and horizontal atrophy of the alveolar ridge. With an alveolar ridge width of 3–3.5 mm, 3 male patients had a crestal prognosis of placement of dental implants, which is 12 % (p<0.05) of all patients and one female, which corresponds to 4 % (p<0.05) of the total number of all patients. Together, this figure is 16 % (p<0.05) of all subjects with periodontal tissue pathology and horizontal atrophy of the alveolar ridge.

In the study of soft tissues in the crestal prognosis of the placement of dental implants, hypotrophy was not observed in either males or females. Normotrophy was observed in 4 male patients, which is 16 % (p<0.05) and in 7 female patients, which corresponds to the result of 28 % (p<0.05) of all examined patients with this pathology. Together, this figure is 44 % (p<0.05) of all surveyed. Hypertrophy was detected in 3 male patients, corresponding to 12 % (p<0.05) and in 2 female patients, accounting for 8 % (p<0.05) of all patients. Together, this figure was obtained in 5 subjects, which corresponds to 20 % (p<0.05).

According to the data analysis in subsection 1 of the table, it can be seen that subcrestal prediction of the placement of dental implants was carried out in patients with the insufficient size of the soft tissues of the mandibular and maxillary alveolar mucosa or signs of impaired trophism, even with vertical dimensions of 2 mm. At the same time, crestal prediction of the placement of dental implants was carried out in patients with normal dimensions and clear signs of hypertrophy of the vertical dimensions of the soft tissues of the mandibular and maxillary alveolar mucosa.

In subsection 2 "After the alveolar ridge splitting with one-stage dental implantation to rational prosthetics", we highlight only the number of integrated dental implants, omitting the preliminary division only into patients with horizontal atrophy of jawbone and generalized periodontal disease. However, we maintain consistency in the study, demonstrating patterns from the alveolar ridge and soft tissue dimensions (subsection 1) to integrated dental implant dimensions with available soft tissue dimensions 6 months after the implantation (subsection 2).

Hence, 3 dental implants with a diameter of 3.5 mm, which were integrated into the subcrestal position in males, accounted for 6.4 % ($p<0.05$) and 2 dental implants of the same diameter, corresponding to 4.3 % ($p<0.05$), were set in females. In total, this figure was 5 implants with a result of 10.6 % ($p<0.05$) of all dental implants integrated into patients with periodontal tissue pathology and horizontal atrophy of the alveolar ridge. Four dental implants with a diameter of 4 mm were placed in males with a result of 8.5 % ($p<0.05$) and 2 dental implants with this diameter – in females, which accounted for 4.3 % ($p<0.05$) of all patients with periodontal tissue pathology and horizontal atrophy of the alveolar ridge, which were integrated into the subcrestal position. Together, this indicator shows the result with the number of 6 dental implants and corresponds to 12.8 % ($p<0.05$) of all dental implants integrated into patients with this pathology. Three dental implants with a diameter of 4.5 mm were placed in males with a result of 6.4 % ($p<0.05$) and 4 dental implants of this diameter – in females accounting for 8.5 % ($p<0.05$) of all dental implants in patients with periodontal disease and horizontal atrophy of the alveolar ridge, which were integrated into the subcrestal position. Together, this indicator shows the result with the number of 7 dental implants and corresponds to 14.9 % ($p<0.05$) of all dental implants integrated into patients with this pathology.

Considering the crestal placement of dental implants, it can be seen that 5 units were integrated with a diameter of 3.5 mm, which is 10.6 % ($p<0.05$) in males and 4 dental implants in females, which corresponds to 8.5 % ($p<0.05$). Together, this figure equals 9 dental implants with a result of 19.1 % ($p<0.05$) of all implants integrated into patients with periodontal tissue pathology and horizontal atrophy of the alveolar ridge. Four dental implants with a diameter of 4 mm were placed in males with a result of 8.5 % ($p<0.05$) and 5 dental implants of the same diameter – in females, which accounted for 10.6 % ($p<0.05$) of all dental implants that were integrated into the crestal position in patients with pathology of periodontal tissues and horizontal atrophy of the alveolar ridge. Together, this figure equals 9 dental implants with a result of 19.1 % ($p<0.05$) of all implants integrated into patients with this pathology. Four dental implants with a diameter of 4.5 mm were placed in males with a result of 8.5 % ($p<0.05$) and 7 dental implants of the same diameter – in females, which accounted for 14.9 % ($p<0.05$) of all dental implants that were integrated into the crestal position. Together, this figure equals 11 dental implants with a result of 23.4 % ($p<0.05$) of all implants integrated into patients with periodontal tissue pathology and horizontal atrophy of the alveolar ridge.

Assessing the condition of soft tissues 6 months after osseointegration of dental implants shows that hypotrophy of vertical dimensions of soft tissues is not observed in the subcrestal position in either males or females. Normotrophy has been detected in males over 7 dental implants, which is 14.9 % ($p<0.05$) of the total number of implants and in females over 6 dental implants, which corresponds to 12.8 % ($p<0.05$) of all integrated dental implants. In total, this figure is 13 dental implants with a result of 27.7 % ($p<0.05$). Hypertrophy of vertical soft tissue dimensions in the subcrestal position of dental implants is observed over 3 dental implants, which is 6.4 % ($p<0.05$) in males of the total number of implants and over 2 dental implants, which is 4.3 % ($p<0.05$) in females of all dental implants. Together, this figure is 5 dental implants with a result of 10.6 % ($p<0.05$).

Vertical soft tissue hypotrophy was not observed in the crestal placement of dental implants. Normotrophy was detected over 12 dental implants in males, which is 25.5 % ($p<0.05$) of the total number of implants and over 15 dental implants in females, which corresponds to 31.9 % ($p<0.05$) of all integrated dental implants. In total, this figure is 27 dental implants with a result of 57.4 % ($p<0.05$). Soft tissue hypertrophy was observed over two implants in females only and corresponds to 4.3 % ($p<0.05$).

In the analysis of subsection 2, it was demonstrated that with the subcrestal placement of dental implants, the vertical dimensions of the soft tissues of the mandibular and maxillary alveolar mucosa around the dental implants were normalized, and signs of hypertrophy of the vertical dimensions of the soft tissues were revealed, as mentioned above in the subsection 2. We found the preservation of the vertical dimensions of soft tissues in crestal placement of dental implants, comparing them with the dimensions at the prognosis stage.

In subsection 3 "12 months after the splitting and dental implantation with rational prosthetics", we study the condition of the bone and soft tissue after the load, correlating and completing the integrated analysis from initial assessment to long-term treatment outcomes. We maintain the division into "subcrestal and crestal" placement of dental implants in patients with periodontal tissue pathology and horizontal atrophy of the alveolar ridge and emphasize the degree of atrophy of bone tissue around osseointegrated dental implants with orthopaedic suprastructures, taking into account the vertical dimensions of soft tissues.

According to the table data in subsection 3, bone atrophy of 0.5–1 mm in the subcrestal placement of 3 dental implants with a diameter of 3.5 mm was detected only in males and accounts for 6.4 % ($p<0.05$) of all implants. The preservation of bone tissue is observed in females, which accompanies one dental implant and bone atrophy around one dental implant and corresponds to 2.1 % ($p<0.05$) of all implants. Together, the rate of bone atrophy shows a total of 4 dental implants with a value of 8.5 % ($p<0.05$). Bone atrophy of 0.5–1 mm in the subcrestal placement of 4 dental implants with a diameter of 4.0 mm was detected in males accounting for 8.5 % ($p<0.05$) of all implants. In females, bone atrophy is observed in the subcrestal placement around 2 dental implants and corresponds to 4.3 % ($p<0.05$) of all integrated implants. Together, the rate of bone atrophy was found around 6 dental implants corresponding to 12.8 % ($p<0.05$). In the case of osseointegration of dental implants with a diameter of 4.5 mm, bone preservation was observed around one implant in males (2.1 % ($p<0.05$)) and around 3 dental implants in females (6.4 % ($p<0.05$)). Bone atrophy in these dimensions in male patients was detected around 2 dental implants, which is 4.3 % ($p<0.05$), in female patients – around one dental implant and corresponds to 2.1 % ($p<0.05$). Together, this value is 3 dental implants with a result of 6.4 % ($p<0.05$).

In the crestal placement of dental implants with a diameter of 3.5 mm, the preservation of bone tissue was found in males and females in the number of 4 dental implants, which is 8.5 % ($p<0.05$) each. Bone atrophy was observed only around one male implant at 2.1 % ($p<0.05$). The preservation of bone tissue in male patients with dental implants with a diameter of 4 mm corresponds to 4 implants and 8.5 % ($p<0.05$), and 5 dental implants in female patients – 10.6 % ($p<0.05$). In total, the rate of bone preservation was found around 9 dental implants corresponding to 19.1 % ($p<0.05$). Bone atrophy was not detected in patients of both sexes. The preservation of bone tissue in male patients with a diameter of dental implants of 4.5 mm, corresponds to 3 implants with a result of 6.4 % ($p<0.05$), in female patients – to 6 dental implants, which is 12.8 % ($p<0.05$). In total, the rate of bone preservation around 9 dental implants is 19.1 % ($p<0.05$). Bone atrophy is detected in one dental implant in both sexes, which is 2.1 % each ($p<0.05$), the total value corresponds to 4.3 % ($p<0.05$).

Twelve months after the splitting and dental implantation with subcrestal placement, the condition of soft tissues is as follows: hypotrophy is not detected; normotrophy is observed around 8 dental implants accounting for 17.0 % ($p<0.05$) of all dental implants; the total value corresponds to 16 implants i.e. 16.3 % ($p<0.05$); hypertrophy is found only around 2 dental implants – 4.3 % ($p<0.05$) and only in males.

In the crestal placement of dental implants 12 months after the splitting, hypotrophy was detected over 2 dental implants in male patients and corresponds to 4.3 % ($p<0.05$), in female patients it was observed over 3 dental implants i.e. 6.4 % ($p<0.05$). In total, this value corresponds to 5 implants and equals 10.6 % ($p<0.05$). Normotrophy was found over 11 dental implants in males, which is 23.4 % ($p<0.05$), in females the normative indicators were found over 13 implants and correspond to 27.7 % ($p<0.05$). The total value is 24 dental implants which equal 51.1 % ($p<0.05$). Hypertrophy was not detected in both sexes.

After a comparative analysis of subsections 1, 2, and 3, we observe the absence of signs of hypotrophy, which indicates signs of normative osseointegration with the absence of postoperative atrophy of bone tissue around dental implants after splitting the alveolar process and rational prosthetics, which provides a significant aesthetic effect due to the preservation and restoration of soft tissues of the mandibular and maxillary alveolar mucosa.

In the case of horizontal atrophy of bone tissue, osteoplasty is possible only using external attachment of bone blocks or bone chips outside the cortical plastics of the alveolar ridge, applying targeted regeneration, which is a complex and costly process. Moreover, the outer cortical layer of bone is very dense, and there is almost no vascular bed. Accordingly, the bone material will germinate with vessels for a long time, and the organization of the bone will be slow. Therefore, the alveolar ridge split was performed during the study. In this procedure, the jawbone is split and filled with artificial material, autobone and other biocompatible material, into which dental implants are then placed with positioning. The researchers also note that the thickness of the mucosa on the mandibular alveolar ridge in patients with dentition defects increased in the direction of the teeth that restricted this defect. This fact demonstrates a clear dependence of the vertical dimensions of the soft tissues of the alveolar mucosa on the presence of preserved teeth [5–8]. Therefore, we proved that after splitting, the normative vertical dimensions of the soft tissues of the mucosa are restored when dental implants are integrated into the edentulous alveolar process [10, 11].

In our study, we decided to perform our technique of "sequential splitting" of the alveolar ridge with the piezoelectric periotome in this area without using bone substitutes with subcrestal and crestal placement of dental implants, taking into account the condition of soft tissues. We called this technique "step-splitting", using several sizes of chisels (from larger to smaller sizes). After all, due to the ratio of phosphorus and calcium in bone tissue, not only strength is preserved, but also elasticity and resilience, which enables to use of a bone as a shock absorber, stretching the alveolar ridge in the transverse direction almost twice as much. This alleviates the stress of osseointegration of dental implants in difficult conditions.

Conclusions

1. Application of the "sequential" alveolar ridge split technique with the piezoelectric periotome without the use of bone substitutes to increase the horizontal dimension of the bone tissue of the jaws, demonstrated properties (elasticity, resilience and flexibility) of bone tissue under difficult conditions of dental implantation.

2. When determining the position of dental implants after the alveolar ridge splitting of the bone tissue of the jaws with delayed load, the interdependence between their position in the bone tissue and the vertical dimensions of the soft tissues is clearly observed. Hence, the subcrestal placement of dental implants contributes to post-traumatic atrophy of bone tissue around dental implants, which is more pronounced in males than females. At the same time, it affects trophic processes that increase the vertical dimensions of soft tissues, considering periodontal tissue pathology.

3. Crestal placement of dental implants after the alveolar ridge splitting, according to the results, does not contribute to post-traumatic atrophy of bone tissue around dental implants and ensures the stability of the results in both initial and final assessment of periodontal tissue. It should also be noted that the vertical dimensions of soft tissues remain, in most cases, stable with minor cases of hypotrophy.

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