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RADIOGRAPHIC CHANGES IN THE BONE GRAFTS DURING GUIDED BONE REGENERATION WITH THE USE OF TITANIUM MESH ON CLASSICAL AND AUTHORS' OWN METHODS FOR THE MUCOSAL FLAPS DETACHMENT

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One of the major problems in rehabilitation of bone volume loss in preparing patients for dental implantation is the bone graft exposure and its infection in the result of ischemic processes in the mucousal flap that covers it. We performed 27 surgical interventions for guided bone regeneration using titanium mesh according to the classical method of detachment of trapezoidal mucousal flap and 30 surgical interventions on authors' own method of detachment and mobilization of the mucousal flap. The augmentation was performed in the mandibular distal segments. Our studies have shown that the optimization of the limits of detachment and mobilization of mucousal and mucoperiosteal flaps, compared with the classical method of trapezoidal flaps, leads to a decrease in bone graft volume loss by 1.9%. The data indicate the possibility of improving the flap surgery efficiency during bone augmentation in patients with acquired edentulism.

Keywords: dental augmentation, CBCT, mucosal flaps

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The method of dental implantation is increasingly used in the dental practice for the treatment of congenital and acquired edentulism, which in many clinical cases allows to achieve a stable and long-term treatment outcome [1, 9].

Partial or complete edentulism is always accompanied by the signs of jawbone atrophy. Therefore, in 30% of clinical cases, there are indications for the correction of alveolar bone loss before dental implant placement. In such situations, either a previous bone rehabilitation or a simultaneous (with implant placement) grafting of the alveolar process by auto-, allo-, or xenograft material (bone augmentation) is required [6]. Bone graft is the volume of bone mass for artificial enlargement, gaining the organ size, in this case – the mandible. However, often due to the technical complexity of the bone augmentation surgery and the high incidence of ischemia-related complications after mucosal flaps tension, these interventions are not practiced. In this case, as a rule, small dental implants are used, which are installed with their incorrect positioning, or patients are refused treatment [10]. This is due to the absence of conventional surgical protocols for bone rehabilitation at different degrees and forms of atrophy. The part of specialists whose professional level allows performing the reconstruction of bone tissue of the alveolar process by various methods, is characterized by unnecessary subjectivity, based on the use of them only separate, proven methods of the bone reconstruction, which is dissonant with the choice of the most effective treatment tactics. The result of such treatment is often poor clinical outcomes regarding short-term prognosis and/or poor aesthetics [4, 6].

The purpose of the study was to increase the effectiveness of flap surgery during bone augmentation in patients with acquired edentulism and reduce the risk of postoperative ischemia-related complications after mucosal flaps tension, by optimizing the boundaries of detachment and mobilization of the mucousal and mucoperiosteal flaps.

Materials and methods. The study involved patients with acquired edentulism of the mandibular distal segments of both sexes aged 38 to 57 years with vertical atrophy of no more than 4 mm. The augmentation dimension did not exceed 25 mm. We performed 27 surgical interventions for guided bone regeneration using titanium mesh according to the classical method of detachment of trapezoidal mucousal flap (control group) and 30 surgical interventions on authors' own method of detachment and mobilization of the mucousal flap (experimental group). The radiographic examination was performed using "Veraviewepocs 3De" (J. Morita Manufacturing Corporation, Japan) Cone-Beam Computed Tomography (CPCT) before surgery, on the 1st day after surgery, 60 days and 180 days after surgery. The height (X), width and thickness of bone graft (Y) were measured using the software provided with the study results (One Volume Viewer Program). The area (Z) of bone graft was also determined using One Volume Viewer. The area was calculated automatically in mm^2. Bone density was measured in the augmentation area and intact areas and determined by CBCT using the One Volume Viewer software provided with the study results. The unit of measurement was the Hunsfield (HU) ionizing radiation attenuation.

The obtained data were processed by the method of variation statistics. To achieve the above, the variational series were calculated taking into account arithmetic mean (M), standard deviation, mean square error (m).

Results of the study and their discussion. Radiographic results of the control group.

We analyzed the CBCT of patients before and after the mandibular bone augmentation. The augmentation height from the native bone, the jaw segment area in the cross section, the parameters of the bone graft volume reduction in a result of osteogenesis, density of the newly formed bone, the osteogenesis rate were taken into account.

For further comparison after the surgery, the bone graft volume obtained on cone-beam computer tomographic images was recorded immediately after guided bone regeneration using the classical method of mucousal flap detachment.

The bone graft was a homogeneous area without cavities and condensation with the same radiographic pattern, to which a sharply contrasting flat perforated titanium mesh with locking screws around the periphery fits. The jaw bone and the bone graft are clearly separated. The greatest thickness of the inserted bone material is marked in the middle zone of the mesh and gradually becomes thinner in the direction of the mesh edges. On average, the cross-sectional area of the sagittal section, that is, the bone graft proportion, was increased by 21.24% (Table 1). Density indicators in the bone graft center averaged 389 HU. In comparison, cortical layer of the jaw bone was 1400-1900 HU, the cancellous layer ranged from 240 to 700 HU. Low graft density may indicate the onset of rehabilitation, vascular invasion, osteoclast activation, and macrophage inflammation phase.

At the sixth month of observations, the bone graft was a homogeneous area without cavities and condensation with the same radiographic pattern. There is a decrease in the bone graft volume. There was a clear boundary zone of non-contrasting space between the titanium mesh and the graft. The radiographic contrast of the graft increased. The transition zone of jaw bone and graft is not determined. The locking screws on the periphery did not change their location. Density indicators in the bone graft center averaged 913 HU (Table 2). The above may indicate the completion of artificial bone remodeling, condensation of the bone graft, its integration into the patient's own jaw bone, osteoblast proliferation, and osteon formation.

As a result of the CBCT analysis, it was found that in 2 patients of the control group the bone graft volume at the moment of the titanium mesh removal (after 6 months) was decreased by 24%, in 2 patients – by 18% in the rest the bone graft volume at the moment of the titanium mesh removal was decreased from 12 to 15%.

At the twelfth month, the graft borders at the CBCT are not marked, the formation of cortical and cancellous layers is observed in the augmentation area. The radiographic contrast of the graft has increased compared to the previous observation, which indicates the continuation of bone compaction in this area. Density indicators in the augmentation center averaged 1350-1450 HU. The bone tissue around the installed implants was no different from that in the peripheral areas.

On average, the cross-sectional area of sagittal section during this period, i.e., the graft proportion, decreased by another 6.9% (Table 1), relative to the previous observation period.

Therefore, analyzing the data on changes in the of bone graft volume and increasing in its radiographic density, we can make an assumption about the osteogenesis rate. After guided bone regeneration using the classical method of the mucousal flap detachment, we have found that the bone mass after surgery and for up to six months loses in the volume but increases in density. So, we can assume the phase of blood flow organization in the bone graft and the osteoclasts activation, the bone matrix construction and the phase of bone remodeling. But later, as a result of osteogenesis, density gradually approaches the indices in the adjacent intact zones, but does not reach them.

The bone graft density on the Hounsfield scale in 94% of cases ranged from 381 to 401 HU right after surgery. And for the newly formed bone, in different periods it was equal to the following indicators: after 6 months – increased by 232.3% and averaged 904 HU, after 12 months – increased by 156% from the previous period, and amounted to 1411 HU (Table 2). Volume indicators showed the opposite dynamics: on average, after 6 months of observations, the bone graft volume decreased by 14,83%, and in the period from 6 to 12 months it decreased by another 6,9%.

Clinical results of the experimental group.

We analyzed the CBCT of patients before and after the mandibular bone augmentation. For further comparison, the volume of bone graft obtained at the CBCT was recorded immediately after guided bone regeneration using the author's own method of the mucousal flap detachment. The bone graft was a homogeneous area without cavities and condensation with the same radiographic pattern, to which a sharply contrasting flat perforated titanium mesh with locking screws around the periphery fits. The jaw bone and the bone graft are clearly separated. The greatest thickness of the inserted bone material is marked in the middle zone of the mesh and gradually becomes thinner in the direction of the mesh edges. On average, the cross-sectional area of the sagittal section, that is, the bone graft proportion was increased by 19,17% (Table 3).

Density indicators in the bone graft center averaged 392 HU. In comparison, cortical layer of the jaw bone was 1400-1900 HU, the cancellous layer ranged from 240 to 700 HU. Low graft density may indicate the onset of rehabilitation, vascular invasion, osteoclast activation, and macrophage inflammation phase.

Table 1

Changes in bone graft volume during twelve months of observation

	Before surgery	After surgery, mm^2	After 6 months, mm^2	After 12 months, mm^2
Patient No. 1	236.21	279.78	273.98	271.41
Patient No. 2	255.95	317.66	308.85	306.34
Patient No. 3	245.22	299.41	290.8	288.73
Patient No. 4	236.96	286.74	277.54	276.77
Patient No. 5	206.05	249.36	246.46	245.63
Patient No. 6	262.09	310.86	303.74	301.46
Patient No. 7	243.44	292.35	285.44	281.44
Patient No. 8	234.99	281.28	274.94	272.47
Patient No. 9	219.77	261.22	254.38	251.93
Patient No.10	258.57	309.51	302.53	301.01
Patient No. 11	201.2	239.64	233.64	230.42
Patient No. 12	227.86	273.64	268.08	265.17
Patient No. 13	200.3	237.58	231.61	229.39
Patient No. 14	181.18	218.35	211.72	209.17
Patient No. 15	270.14	325.09	319.69	317.36
Patient No. 16	198.95	240.83	236.65	234.25
Patient No. 17	205.96	249.29	241.12	235.9
Patient No. 18	184.46	242.85	218.23	215.87
Patient No. 19	201.57	243.94	241.1	240.29
Patient No. 20	213.33	251.36	249.6	247.17
Patient No. 21	195.05	241.35	234.56	223.35
Patient No. 22	236.93	286.8	281.83	280.35
Patient No. 23	173.67	220.93	216.58	214.23
Patient No. 24	242.04	289.54	281.96	279.18
Patient No. 25	234.45	283.73	279.47	276.4
Patient No. 26	231.94	286.32	276.42	275.5
Patient No. 27	217.72	266.95	259.58	256.15
On average, %	-	18.92	16.75	16.73

Table 2

Changes in bone graft density on the Hounsfield scale over twelve months of observations

	After surgery, HU	After 6 months, HU	After 12 months, HU
Patient No. 1	388	900.1	1404.2
Patient No. 2	390	904.8	1411.4
Patient No. 3	395	916.4	1429.5
Patient No. 4	398	923.3	1440.4
Patient No. 5	379	879.2	1371.6
Patient No. 6	392	909.4	1418.7
Patient No. 7	381	883.9	1378.9
Patient No. 8	386	895.5	1397
Patient No. 9	384	890.8	1389.7
Patient No. 10	378	876.9	1368
Patient No. 11	387	897.8	1400.6
Patient No. 12	380	881.6	1375.2
Patient No. 13	401	930.3	1451.2
Patient No. 14	377	874.6	1364.4
Patient No. 15	382	886.2	1382.5
Patient No. 16	390	904.8	1411.4
Patient No. 17	383	888.5	1386.1
Patient No. 18	396	918.7	1433.2
Patient No. 19	389	902.4	1407.8
Patient No. 20	393	911.7	1422.3
Patient No. 21	399	925.6	1444.0
Patient No. 22	397	921	1436.8
Patient No. 23	389	902.4	1407.8
Patient No. 24	391	907.1	1415.1
Patient No. 25	394	914	1425.9
Patient No. 26	400	928	1447.6
Patient No. 27	385	893.2	1393.3

At the sixth month of observations, the bone graft was a homogeneous area without cavities and condensation with the same radiographic pattern. There is a decrease in the bone graft volume. There was a clear boundary zone of non-contrasting space between the titanium mesh and the graft. The radiographic contrast of the graft increased. The transition zone of jaw bone and graft is not determined. The locking screws on the periphery did not change their location. Density indicators in the bone graft center averaged 910.6 HU (Table 4). The above may indicate the completion of artificial bone remodeling, condensation of the bone graft, its integration into the patient's jaw bone, osteoblast proliferation, and osteon formation.

As a result of the CBCT analysis, it was found that the bone graft volume at the time of titanium mesh removal (after 6 months) was decreased by 21% in 1 patient of the experimental group (Table 3), in the rest of patients the bone graft volume decreased by 11.78%.

At the twelfth month, the graft borders at the CBCT are not marked, the formation of cortical and cancellous layers is observed in the augmentation area. The radiographic contrast of the graft has increased compared to the previous observation, which indicates the continuation of bone compaction in this area. Density indicators in the augmentation center averaged 1350-1500 HU. The bone tissue around the installed implants was no different from that in the peripheral areas. On average, the cross-sectional area of sagittal section during this period, i.e., the graft proportion, decreased by another 5.67% (Table 3), relative to the previous observation period.

Table 3

Changes in bone graft volume during twelve months of observation

	Before surgery	After surgery, mm^2	After 6 months, mm^2	After 12 months, mm^2
Patient No. 1	234,56	280,46	275,18	273,14
Patient No. 2	230,71	271,15	266,5	264,46
Patient No. 3	236,93	284,34	278,89	277,85
Patient No. 4	240,95	283,72	278,8	276,76
Patient No. 5	173,87	204,92	201,35	200,32
Patient No. 6	237,29	279,98	275,07	274,03
Patient No. 7	237,77	286,61	280,99	278,95
Patient No. 8	207,7	249,95	245,09	241,05
Patient No. 9	201,85	238,85	233,71	230,67
Patient No. 10	184,68	218,73	214,81	214,78
Patient No. 11	206,24	244,5	240,1	238,06
Patient No. 12	198,43	235,46	231,2	230,17
Patient No. 13	270,22	320,94	315,11	311,06
Patient No. 14	181,39	215,64	211,7	210,67
Patient No. 15	200,3	238,38	234	231,96
Patient No. 16	227,42	270,9	265,9	261,86
Patient No. 17	201,12	239,8	235,35	234,31
Patient No. 18	234,79	276,21	271,45	268,41
Patient No. 19	224,14	267,76	262,74	260,7
Patient No. 20	213,62	252,52	248,05	245,01
Patient No. 21	244,04	293,07	286,55	287,51
Patient No. 22	253,73	303,94	296,4	294,34
Patient No. 23	212,57	254,87	253,55	251,54
Patient No. 24	217,56	255,46	251,1	250,07
Patient No. 25	244,18	291,4	285,97	282,93
Patient No. 26	263,59	316,91	310,78	310,73
Patient No. 27	194,54	229,75	225,7	221,67
Patient No. 28	235,58	282,91	273,76	267,69
Patient No. 29	247,77	299,85	292,5	290,51
Patient No. 30	229,08	282,28	277	274,09
On average, %	-	19,17	16,91	15,95

The bone graft density on the Hounsfield scale in 94% of cases ranged from 240 to 700 HU. And for the newly formed bone, in different periods it was equal to the following indicators: after 6 months – increased by 197% and averaged 910.6 HU (Table 4), after 12 months – increased by 155% from the previous period, and amounted to 1420.8 HU.

The bone graft density on the Hounsfield scale in 95% of cases ranged from 383 to 400 HU right after surgery. And for the newly formed bone, in different periods it was equal to the following

indicators: after 6 months – increased by 231.2% and averaged 912 HU, after 12 months – increased by 157% from the previous period, and amounted to 1441 HU (Table 4). Volume indicators showed the opposite dynamics: on average, after 6 months of observations, the bone graft volume decreased by 11.78%, and in the period from 6 to 12 months it decreased by another 5.67%.

Table 4

Changes in bone graft density on the Hounsfield scale over twelve months of observations

	After surgery, HU	After 6 months, HU	After 12 months, HU
Patient No. 1	402.7	934.3	1457.6
Patient No. 2	396.6	920.2	1435.4
Patient No. 3	388.3	900.8	1405.2
Patient No. 4	404.8	939	1464.9
Patient No. 5	385.4	894.1	1394.9
Patient No. 6	398.7	924.9	1442.8
Patient No. 7	405.8	941.3	1468.5
Patient No. 8	383.4	889.4	1387.4
Patient No. 9	390.5	905.9	1413.3
Patient No. 10	384.4	891.8	1391.3
Patient No. 11	393.6	913.1	1424.4
Patient No. 12	373.5	866.6	1351.8
Patient No. 13	407.8	946.1	1475.9
Patient No. 14	383.4	889.5	1387.6
Patient No. 15	388.5	901.3	1406
Patient No. 16	396.6	920.2	1435.4
Patient No. 17	376.5	873.4	1362.5
Patient No. 18	392.6	910.7	1420.7
Patient No. 19	395.6	917.7	1431.7
Patient No. 20	399.7	927.2	1446.5
Patient No. 21	394.6	915.4	1428.1
Patient No. 22	403.7	936.7	1461.2
Patient No. 23	388.3	889.4	1392.3
Patient No. 24	397.6	922.5	1439.2
Patient No. 25	400.7	929.5	1450.1
Patient No. 26	393.2	912.2	1423
Patient No. 27	391.5	908.4	1417
Patient No. 28	387.5	898.9	1402.3
Patient No. 29	382.4	887.1	1383.9
Patient No. 30	393.2	912.2	1423

Therefore, based on the data obtained on changes in the bone graft volume and increasing its radiological density, we can make an assumption about the osteogenesis rate, which correlates with similar indicators of other authors [7, 8]. The results of clinical and radiographic studies of other authors have shown that the adverse marginal bone resorption around the installed dental implants during alveolar ridge splitting is most pronounced when cutting full-thickness flaps [9], which is fully confirmed by our study. After guided bone regeneration using the author's own method of the mucousal flap detachment, we have found that the bone mass after surgery and for up to six months loses in the volume but increases in density. So, it is possible to assume a phase of the blood flow organization in the bone graft and osteoclasts activation, bone matrix formation and bone remodeling phase, but subsequently, as a result of osteogenesis, the density gradually approaches the indices of the intact zones,but does not reach them, which coincides with the data obtained by other scientists [7,8]. Clinical and radiographic results [3] confirm the possibility of using this method in dentistry to repair defects of the jawbone alveolar ridge.

Conclusion

Our studies have shown that the optimization of the limits of detachment and mobilization of mucousal and mucoperiosteal flaps, compared with the classical method of trapezoidal flaps, leads to a decrease in bone graft volume loss by 1.23%. The data indicate the possibility of improving the flap surgery efficiency during bone augmentation in patients with acquired edentulism with greater efficiency. The results obtained are useful for practicing dental surgeons when planning a bone augmentation surgery on the mandible.

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Реферати

РЕНТГЕНОЛОГІЧНІ ЗМІНИ У КІСТКОВИХ АУГМЕНТАТАХ ПРИ ПРОВЕДЕННІ НАПРАВЛЕНОЇ КІСТКОВОЇ РЕГЕНЕРАЦІЇ З ВИКОРИСТАННЯМ ТИТАНОВОЇ СІТКИ ЗА КЛАСИЧНОЮ ТА АВТОРСЬКОЮ МЕТОДИКАМИ ВІДШАРУВАННЯ СЛИЗОВИХ КЛАПТІВ

Каплун Д.В., Аветіков Д.С., Іваницька О.С., Бойко І.В., Гаврильєв В.М.

Однією з основних проблем відновлення втраченого об'єму кісткової маси під час підготовки пацієнтів до дентальної імплантації, є оголення кісткового аугментату і його інфікування в результаті ішемічних процесів в слизовому клапті, що його прикриває. Нами було проведено 27 хірургічних втручань направленої кісткової регенерації з використанням титанової сітки за класичною методикою відшарування трапецієподібного слизового клаптя та 30 хірургічних втручань за авторською методикою відшарування та мобілізації слизового клаптя. Аугментація проводилась у дистальних відділах нижньої щелепи. Проведені нами дослідження показали, що оптимізація меж відшарування та мобілізації слизових та слизово-окістних клаптів в порівнянні з класичною методикою трапецієподібних клаптів, веде до зменшення втрати об'єму кісткового аугментату на 1.9%. Дані свідчать про можливості підвищення ефективності проведення клаптевих операцій під час кісткової аугментації у хворих на вторинну адентію.

Ключові слова: дентальна аугментація, КПКТ, слизові клапті

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РЕНТГЕНОЛОГИЧЕСКИЕ ИЗМЕНЕНИЯ В КОСТНЫХ АУГМЕНТАТАХ ПРИ ПРОВЕДЕНИИ НАПРАВЛЕННОЙ КОСТНОЙ РЕГЕНЕРАЦИИ С ИСПОЛЬЗОВАНИЕМ ТИТАНОВОЙ СЕТКИ ПО КЛАССИЧЕСКОЙ И АВТОРСКОЙ МЕТОДИКАМ ОТСЛОЕНИЯ СЛИЗИСТЫХ ЛОСКУТОВ

Каплун Д.В., Аветиков Д.С., Иваницькая О.С., Бойко І.В., Гаврильев В.М.

Одной из основных проблем восстановления утраченного объема костной массы при подготовке пациентов к дентальной имплантации, является обнажение костного аугментата и его инфицирование в результате ишемических процессов в слизистом лоскуте, который его прикрывает. Нами было проведено 27 хирургических вмешательств направленной костной регенерации с использованием титановой сетки по классической методике отслойки трапециевидного слизистого лоскута и 30 хирургических вмешательств по авторской методике отслойки и мобилизации слизистого лоскута. Аугментация проводилась в дистальных отделах нижней челюсти. Проведенные нами исследования показали, что оптимизация границ отслоения и мобилизации слизистых и слизисто-надкостничных лоскутов по сравнению с классической методикой трапециевидных лоскутов, ведет к уменьшению потери объема костного аугментата на 1.9%. Данные свидетельствуют о возможности повышения эффективности проведения лоскутных операций при костной аугментации у больных вторичной адентией.

Ключевые слова: дентальная аугментация, КЛКТ, слизистый лоскут.

Рецензент Єрошенко Г.А.