ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/dentalsci.2021-87707

Volumetric Evaluation of Sinus Floor Augmentation Using Platelet-Rich Fibrin and Allogenic Bone Graft Mixture with Simultaneous Dental Implant Placement in Severely Atrophic Posterior Maxillae in a Geriatric Patient Population Cohort Research (Retrospective)

Geriatrik Hasta Popülasyonunda Ciddi Atrofik Posterior Maksillaya Dental İmplant Yerleştirmesini Takiben Trombositten Zengin Fibrin ve Allojenik Kemik Grefti Karışımı Kullanılarak Yapılan Sinüs Tabanı Ögmentasyonunun Hacimsel Değerlendirmesi Kohort Araştırması (Retrospektif)

Ömür DERECİ[a], Nesrin SARUHAN[a], Görkem TEKİN[a], Yasin Çağlar KOŞAR[a]

[a]Department of Oral and Maxillofacial Surgery, Eskişehir Osmangazi University Faculty of Dentistry, Eskişehir, Türkiye

ABSTRACT Objective: We aimed to retrospectively evaluate the volume of new bone formed following sinus floor augmentation with simultaneous dental implant placement in severely atrophied residual alveolar ridges using a combination of platelet-rich fibrin and demineralized cortico-cancellous bone allograft in a geriatric population. **Material and Methods:** The clinical and radiological data of patients who underwent sinus floor augmentation using a combination of platelet-rich fibrin and demineralized cortico-cancellous bone allograft with simultaneous dental implant placement between 01 April 2013 and 01 August 2020 were retrieved from the archives. The main inclusion criteria for the study were age >60 years and a residual ridge height <2 mm. For each patient, cone-beam computed tomography (CBCT) scans were performed preoperatively, and 6 months after surgery. The volume of the maxillary sinus cavity preoperatively and postoperatively was measured using CBCT. The volume of the newly regenerated bone was calculated by subtracting the post-operative total sinus volume from the pre-operative total sinus volume. Residual and postoperative ridge heights were measured on the mid-coronal and mid-sagittal sections of preoperative and postoperative cone beam computed tomography images, respectively. **Results:** Fourteen patients with 19 sinus augmentations were included in the study. Thirty-two dental implants were placed with simultaneous sinus floor augmentation. All cases showed new bone formation on axial, coronal, and sagittal sections of postoperative CBCT scans. **Conclusion: T**he combination of platelet-rich fibrin and demineralized cortico-cancellous bone allograft used in sinus floor augmentation may promote the formation of healthy new bone that supports the simultaneous placement of dental implants in the elderly population with severely atrophic alveolar ridges.

Keywords: Allografts; cone-beam computed tomography; dental implants; geriatrics; sinus floor augmentation

ÖZET Amaç: Bu çalışmada, geriatrik popülasyonda trombositten zengin fibrin ve demineralize kortikokansellöz kemik allogreftinin bir kombinasyonunu kullanarak ciddi derecede atrofik rezidüel alveolar kretlere eş zamanlı dental implant yerleştirme ile sinüs tabanı ögmentasyonunu takiben oluşan yeni kemik hacmini retrospektif olarak değerlendirmeyi amaçladık. **Gereç ve Yöntemler:** 01 Nisan 2013-01 Ağustos 2020 tarihleri arasında trombositten zengin fibrin ve demineralize kortikokansellöz kemik allogrefti ile sinüs ögmentasyonu ve eş zamanlı dental implant uygulaması yapılan hastaların klinik ve radyolojik verileri arşivlerden alınmıştır. Çalışmaya dâhil etme kriterleri 60 yaşından büyük hastalar ve 2 mm'den küçük rezidüel kemik yüksekliğidir. Her hasta için ameliyat öncesi ve ameliyattan 6 ay sonra konik ışınlı bilgisayarlı tomografi (KIBT) taraması yapıldı. Preoperatif ve postoperatif maksiller sinüs boşluğunun hacmi, KIBT kullanılarak ölçüldü. Yeni oluşan kemiğin hacmi, ameliyat öncesi toplam sinüs hacminden ameliyat sonrası toplam sinüs hacminin çıkarılmasıyla hesaplandı. Rezidüel ve postoperatif kret yükseklikleri preoperatif ve postoperatif KIBT görüntülerinin koronal ve sagittal kesitlerinde ölçüldü. **Bulgular:** Çalışmaya 19 sinüs ögmentasyonu olan 14 hasta dâhil edildi. Eş zamanlı sinüs tabanı ögmentasyonu ile 32 dental implant yerleştirildi. Tüm olgularda postoperatif KIBT görüntülerinin aksiyal, koronal ve sagittal kesitlerinde yeni kemik oluşumu görüldü. **Sonuç:** Sinüs tabanı ögmentasyonunda kullanılan trombositten zengin fibrin ve demineralize kortikokansellöz kemik allogreftinin kombinasyonu, ileri derecede atrofik alveolar kretleri olan geriatrik popülasyonda dental implantların aynı anda yerleştirilmesine olanak sağlayarak sağlıklı yeni kemik oluşumunu teşvik edebilir.

Anahtar Kelimeler: Allogreftler; konik ışınlı bilgisayarlı tomografi; dental implantlar; geriatri; sinüs tabanı ögmentayonu

Correspondence: Görkem TEKİN
Department of Oral and Maxillofacial Surgery, Eskişehir Osmangazi University Faculty of Dentistry, Eskişehir, Türkiye
E-mail: dt.gorkemtekin@gmail.com

Peer review under responsibility of Turkiye Klinikleri Journal of Dental Sciences.

Received: 23 Dec 2021 ***Received in revised form:*** 22 Feb 2022 ***Accepted:*** 23 Feb 2022 ***Available online:*** 03 Mar 2022

Edentulism due to the loss of permanent teeth is a common condition in the elderly population.[1] Tooth loss and alveolar crestal bone atrophy are positively correlated with age.[2] Further, tooth loss is followed by pneumatization around dental apices, with crestal bone atrophy being a contributing factor.[3] Sinus floor augmentation (SFA) is a bone regeneration technique performed by creating a void between the Schneiderian membrane and the native bone and filling this empty cavity with block or particulate bone grafts of various origins. In general, SFA is used for the treatment of posterior maxillary bone deficiency due to crestal bone atrophy and sinus pneumatization.

Different types of bone grafts such as autogenous, alloplastic, allogenic, or xenografts have been used with varying success levels in SFA procedures. An autogenous bone graft is the harvested native bone that is transferred to the surgical site with bone insufficiency. This graft is considered the gold standard material in SFA procedures owing to its osteoinductive and osteogenic properties. However, autogenous bone harvesting is associated with donor site morbidity and an increase in surgical sites. On the other hand, the use of allogeneic bone grafts does not cause donor site morbidity, and these bone grafts are reported to exhibit osteoconductive and osteoinductive properties.[4] The use of a combination of bone allografts with xenogenic or alloplastic materials is the preferred technique, as it shows satisfactory results with regard to new bone formation in SFA.[5,6]

The timing of dental implant placement in the augmented sinus is controversial. Simultaneous implant placement with SFA is generally recommended if the residual crestal height is ≥4 mm.[7] A two-stage procedure of dental implant placement is recommended owing to the difficulty in obtaining primary stability and the need for osseous regeneration in the bone graft, in cases where the residual ridge height is <4 mm.[8] However, it was reported that simultaneous dental implant placement can be successfully performed in patients with residual ridge heights between 1 mm and 3 mm.[7]

The combination of biological mediators with non-autogenous bone grafts has been proposed to increase the osteogenic and osteoinductive capacity of bone grafts.[9] Platelet-rich fibrin (PRF) is a blood derivative that contains several growth factors and cytokines, such as transforming growth factor-beta-1, vascular endothelial growth factor, platelet-derived growth factor, and bone morphogenic protein-1, which act as biological mediators in wound healing.[10] PRF also forms a solid fibrin network that enables cell migration and proliferation.[11] It was reported that PRF is effective in promoting new bone regeneration when combined with either a demineralized bovine bone matrix or allogenic bone graft in SFA.[12]

There has been an increased demand for oral rehabilitation with an increase in the elderly population globally.[13] Recent advances in dental implantology and SFA have provided a safe and predictable foundation for the dental rehabilitation of geriatric patients. However, to our knowledge, there are no studies regarding the efficiency of SFA in the elderly population with severely atrophic posterior maxilla. The aim of this study was to evaluate the efficacy of the combination of PRF and demineralized bone allograft with regard to the volume of the new bone formation following SFA with simultaneous dental implant placement in severely atrophic residual alveolar ridges in a geriatric population.

MATERIAL AND METHODS

PATIENTS

The study was planned in a retrospective manner with the approval of Eskişehir Osmangazi University Noninvasive Clinical Research Ethics Committee (date: December 15, 2020, no: 2020-469-12) and performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The clinical and radiological data of patients with posterior alveolar ridge height <2 mm treated with SFA with simultaneous dental implant placement and maxillary posterior implant-supported fixed dentures between 01 April 2013 and 01 August 2020 were retrieved from the archives. The inclusion criteria of the study were as follows:

1. Patients older than 60 years who underwent SFA using a mixture of demineralized cortico-cancellous bone allograft and PRF
2. Availability of complete clinical data

3. Availability of unharmed digitalized volumetric computed tomography data in Digital Imaging and Communications in Medicine (DICOM) format obtained at pre-and post-operative control evaluations

Exclusion criteria were as follows:

1- Chronic metabolic diseases such as diabetes and hypertension

2- Smoking and poor oral hygiene

PRF PREPARATION

Venous access was established using a vascular cannula, and blood was collected with a 20 mL syringe pre-operatively. The blood was then transferred immediately into dry glass tubes without an anticoagulant and centrifuged at 2,700 rpm for 10 min. The whitish-yellowish PRF clot was separated from the basal red cell accumulation layer using a tissue scissor and cut into small fragments. These fragments were mixed with 2 mL of demineralized cortico-cancellous bone allograft (Maxxeus, Community Tissue Services, Ohio, USA). Two PRF clots were used for each sinus augmentation procedure. One of them was used for the bone allograft and PRF mixture. The other PRF clot was used as the membrane on the lateral sinus osteotomy site.

SINUS AUGMENTATION AND IMPLANT PLACEMENT

SFA surgery was performed by the same researcher (N.S.) using the lateral osteotomy technique. A rectangular osteotomy was performed in the lateral sinus wall after full-thickness mucoperiosteal flap reflection under local anaesthesia (Fullcain Fort 2 mL, Onfarma Pharmaceutical Ltd. Company, Samsun, Türkiye) using a piezosurgery device (Piezosurgery® Touch Unit, Mectron, Carasco, Italy) under constant irrigation. The rectangular bony window was gently removed to expose the osteotomy site, and the Schneiderian membrane was elevated with sinus elevators until it was completely freed from the sinus floor. The prepared mixture of demineralized corticocancellous bone allograft and PRF was inserted into the prepared cavity. OsseoSpeed™ TX dental implants with a TiO_2-blasted fluoride-modified surface were placed simultaneously under constant physiological saline irrigation. The bony window was replaced at the osteotomy site and was covered with a PRF membrane. Flaps were sutured using 3-0 vicryl sutures. Patients were administered antibiotics (1,000 mg amoxicillin-clavulanate, BD for 1 days), non-steroid anti-inflammatory drugs (550 mg naproxen sodium, TD for 1 days), and oral antiseptics (0.12% chlorhexidine digluconate, TD for 1 days) for post-operative prophylaxis. The sutures were removed on post-operative day 10.

Healing caps were mounted under local anaesthesia with full-thickness flap elevation under local anaesthesia (Fullcain Fort 2 mL, Onfarma Pharmaceutical Ltd. Company, Samsun, Türkiye) 6 months post-surgery. Fixed partial prostheses were fabricated 1 week following healing cap placement by an independent clinician.

VOLUME AND RIDGE HEIGHT MEASUREMENT

For each patient, cone-beam computed tomography (CBCT) imaging was performed preoperatively, and 6 months after surgery using a CBCT machine. CBCT images were obtained in a standing position using a CBCT scanner (Planmeca Promax 3D mid, Helsinki, Finland) using the following exposure parameters: 94 kVp tube voltage, 14 mA tube current, and 27 s time. The CBCT data were transferred to a software program (SYNAPSE version 4.4.000, Fujifilm, Tokyo, Japan) in DICOM format. The tomographic data were evaluated with 0.4 mm slice thickness and 2 mm slide sections. During the first stage of the segmentation process, the borders of the sinus cavity were traced with a border marker tool, and the volume of the sinus cavity was determined on the axial section. Next, the deficient and distorted areas were modified and corrected with the same border marker tool in the sagitta and coronal sections. The volume of the marked air-filled cavity was highlighted automatically using the reconstruction feature of the software program following the segmentation procedure (Figure 1). A subtraction method was employed to measure the total graft volume. In this method, the graft volume was determined by subtracting the volume of the complete sinus cavity which was measured by the computer program using preoperative and postoperative follow-up CBCT data.

The same tracing software was used to measure the ridge heights of the posterior maxilla. The residual ridge heights were measured with a measurement marker tool on the mid-sagittal and mid-coronal sections in the central region of SFA (Figure 2A, Figure 2B). Postoperative ridge heights were measured using the marker tool adjacent to the dental implant on sagittal and coronal sections (Figure 2C, Figure 2D).

Measurements were performed by a single researcher (G.T.). For intra-observer agreement, the examiner performed tomographic measurements in 10 patients with SFA, who were not included in the current study prior to the initiation of actual measurements for the study.

STATISTICAL ANALYSIS

An independent statistician reviewed the methodology and results of the study. SPSS version 21.0 (IBM, Chicago, USA) was used for statistical analysis of the results. Bone regeneration in the maxillary sinus is

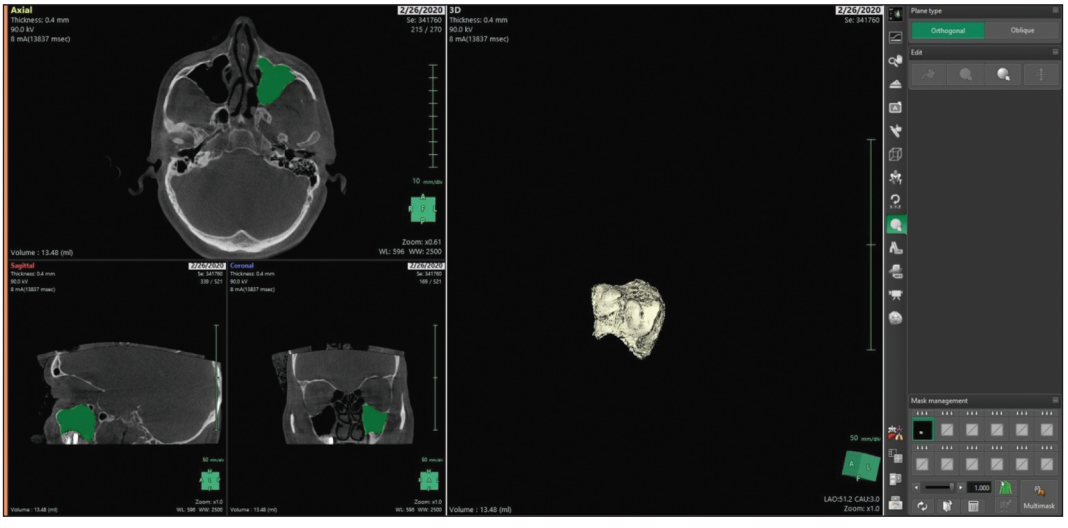

FIGURE 1: The final volume of the sinus cavity was determined with the reconstruction feature after all corrections were made in sagittal and coronal sections.

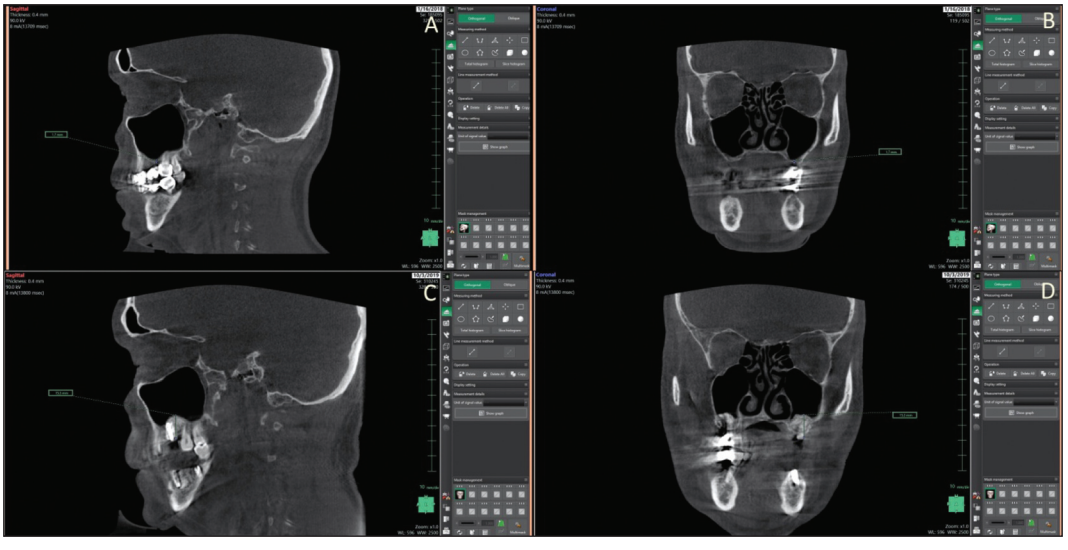

FIGURE 2: The residual ridge height was measured on the mid-crestal region of mid-sagittal **(A)** and mid-coronal **(B)** planes with a measurement tool that automatically shows the diameter in mm. The post-operative ridge height was measured on mid-sagittal **(C)** and mid-coronal **(D)** planes in close proximity to dental implants placed simultaneously with sinus floor augmentation.

displayed as a percentage value. The Kolmogorov-Smirnov and Shapiro-Wilk tests (p>0.05) indicated that the measurement scores were normally distributed. The differences in the alveolar ridge heights and sinus volumes between preoperative and postoperative control evaluations were analysed using a paired t-test. The Pearson's correlation coefficient was used to evaluate the relationships between residual and postoperative ridge heights and sinus volumes.

RESULTS

Fourteen patients with 19 SFAs were included in the study. Of the included patients, 11 were men and three were women. The mean age was 63.2±2.57 years. Thirty-two dental implants were placed simultaneously with SFA. The follow-up period varied from 19 to 29 months.

We encountered an incidence of a perforation of the sinus membrane during membrane elevation in one patient. In this case, the perforation was gently repaired using a PRF membrane. There were no further complications related to the perforation in this particular case, during the treatment and the postoperative follow-up period. All implants were functional without any signs of peri-implantitis at the time of control evaluation.

The measured and mean values of the preoperative and postoperative sinus cavities and newly regenerated bone are summarised in Table 1. There was a statistically significant difference between the mean preoperative and postoperative volumes of the sinus cavities (p>0.05) (Table 2). The postoperative ridge height was significantly more than the residual ridge height (p<0.05) (Table 2). There was no correlation between residual and postoperative ridge heights (p>0.05). However, preoperative sinus volume was positively correlated with postoperative sinus volume (p<0.05, r=0.972) (Table 3).

DISCUSSION

A residual alveolar ridge height <3 mm is suitable for a two-stage dental implant surgery to prevent complications following SFA and achieve long-term success.[14] However, SFA with simultaneous implant

TABLE 1: Determination of the volume of newly regenerated bone.

N (Cases)	Pre-operative sinus volume (mL)	Post-operative sinus volume (mL)	Newly regenerated bone volume (mL)
1	12.43	10.34	2.09
2	21.23	19.53	1.7
3	22.81	20.28	2.53
4	20.1	18.63	1.47
5	21.44	19.85	1.59
6	19.92	17.87	2.05
7	19.29	17.3	1.99
8	8.54	8.01	0.53
9	17.6	14.68	2.92
10	19.26	13.48	5.78
11	9.35	8.23	1.12
12	21.57	19.03	2.54
13	15.07	12.4	2.67
14	20.93	18.55	2.38
15	17.55	16.16	1.39
16	19.87	17.86	2.01
17	23.17	21.73	1.44
18	21.29	19.45	1.84
19	25.6	23.68	1.92
Mean±standard deviation	18.79±4.52	16.68±4.40	2.1±1.06

TABLE 2: Differences between residual and post-operative ridge heights and sinus volumes.

	Pre-operative	Post-operative	t value	Degree of freedom	p (Paired t-test)
Ridge height (mm) (mean±SD)	1.54±0.5	14.47±1.96	-27.908	18	**0.000**
Sinus volume (mL) (mean±SD)	18.79±4.52	16.68±4.40	8.632	18	**0.000**

p<0.05 was considered statistically significant; SD: Standart deviation.

TABLE 3: Correlation between residual and post-operative ridge heights and between pre-operative and post-operative sinus volumes.

	Pre-operative	Post-operative	p (Pearson correlation analysis)	Correlation coefficient (r)
Ridge height (mm) (mean±SD)	1.54±0.5	14.47±1.96	**0.255**	0.231
Sinus volume (mL) (mean±SD)	18.79±4.52	16.68±4.40	**0.000**	0.972

p<0.05 was statistically significant; SD: Standard deviation.

placement in severely atrophic residual ridges with a residual ridge height under 3 or 4 mm can be successful if the native bone is of high quality. In a study conducted by Peleg et al., 20 patients with a posterior alveolar ridge height of 1-2 mm were treated with SFA and simultaneous implant placement using a mixture of autogenous bone and demineralized freeze-dried bone allograft.[15] It was concluded that the inserted dental implants were in good condition without any marginal bone loss, with satisfactory bone consolidation around them after an average follow-up period of 26.5 months. Mardinger et al. reported that dental implants placed simultaneously with SFA in the residual alveolar bone with 1-3 mm vertical height showed a 92% success rate after a mean follow-up of 36.8 months.[16] Tilaveridis et al. reported that mineralized cancellous bone allografts could be successfully used alongside SFA with simultaneous dental implant placement in severely atrophic posterior ridges, in cases where alveolar bone heights ranged between 1 mm and 3 mm.[7] In the current study, a significant bone regeneration was observed around dental implants placed simultaneously with SFA in the severely atrophic posterior maxilla with a residual ridge height <2 mm. Additionally, there was a marked increase in the postoperative ridge height in the control evaluation. However, there was no correlation between residual ridge height and postoperative ridge height. Altogether, these findings indicate that the combination of PRF and demineralized bone allograft produced high levels of new bone regardless of the quantity of residual alveolar bone.

The need for dental rehabilitation increases with age because of the increased prevalence of tooth loss in the elderly population. SFA is a well-known and major treatment modality used in the rehabilitation of posterior maxillary atrophy and edentulism. However, adequate data regarding the success of SFA in the geriatric population are not available. Wolf et al. analysed 20 biopsy specimens collected following SFA with a nanocrystalline bone graft. They reported that SFA can be performed in patients between 41 and 70 years of age with a sub-antral residual bone between 3 mm and 7 mm.[17] In this study, dental implant therapy was successfully performed simultaneously with SFA, even in cases with a residual bone height of <2 mm.

Simultaneous implant placement with SFA in cases with residual ridge heights <3-4 mm is unfavourable owing to the decreased implant support and difficulty in achieving primary stability, which are prerequisites for healthy osseointegration. Dental implants placed in severely atrophic and fragile alveolar ridges may undergo positional changes during the placement process due to the screwing handpiece or following the surgery due to traumatic forces. It has been reported that the manoeuvre of unscrewing the cover screws may also mobilise the dental implant and affect angulation.[16] In this study, the osteotomy was performed and finished with a diameter lower than the diameter of the drill that was designated as the final drill for the diameter of the selected dental implant by the manufacturer. This in turn would facilitate a solid feeling of pressure during the insertion

of the implant and increase primary stability. The control of the angulation of the dental implant was established during the placement of the cover screw. Moreover, meticulous graft placement into the sinus cavity supports dental implants that are simultaneously placed with sinus augmentation and contributes to primary stability, which is one of the primary necessities in the successful reconstruction of the severely atrophic maxilla.[7]

The use of panoramic radiography for evaluating new bone formation following the SFA is not recommended due to its limitations, which include inadequate display of the graft area due to the two-dimensional nature of the radiography and difficulty in establishing outlines of the matured graft due to superpositions and artefacts associated with radiography.[18] Volumetric measurement of bone regeneration in SFA is relatively new and aids clinicians in accurate determination of success in the postoperative period. Bornstein et al. reported that the use of additional CBCT imaging for implant treatment planning is influenced by the patient's age.[19] In light of these findings, CBCT was used to determine the exact volume of newly regenerated bone following SFA in this study. The segmentation method is an indirect method of measuring graft maturation. In this method, the outline of the air-filled sinus cavity is marked with a measurement tool on axial, sagittal, and coronal tomographic sections. Further, the volume of the sinus cavity is automatically calculated by the software program. The graft volume is determined indirectly by subtracting the postoperative sinus volume from the preoperative and sinus volume. Several studies have reported direct measurement of the sinus bone graft by manually reconstructing the grafted area based on threshold values selected according to the grey values of adjacent structures, such as native bone or soft tissue.[20,21] The matured bone graft is usually irregular and not well-defined. In tomographic sections, the identification and measurement of air-filled areas may be easier when compared with dense bone-like regions, since the Hounsfield unit value of air-filled cavities is always below zero.[22] However, the radiopacity of the maturing graft may vary, and it could be difficult to manually delineate the borders of the bone graft.

The combination of a bone grafting material with PRF is an emerging technique in sinus augmentation surgery. The addition of PRF fragments into the bone grafts not only provides a binding medium for the bone graft particles but also facilitates bacterial defence mechanisms and prevents bacterial infection after SFA.[23] Bolukbasi et al. reported that the effectiveness of PRF is mainly based on the characteristics of the graft combined with PRF and is effective in the early phases of the bone regeneration process.[24] There is no consensus on the terms and algorithms for the use of PRF in combination with other grafting materials. However, several authors have reported that new bone regeneration was observed following SFA with a combination of PRF and bovine bone graft.[12,24] It is suggested that PRF should be combined with additional bone grafting materials if the buccopalatal dimension of the sinus exceeds 15 mm.[25] In this study, all included cases had increased buccopalatal dimensions due to extensive pneumatization and atrophy in the posterior maxilla.

CONCLUSION

SFA may be predictably and successfully used in geriatric patients with a residual bone height <2 mm. The use of PRF in combination with demineralized cortico-cancellous bone allografts may be a working option in SFA with simultaneous dental implant placement in the elderly population. The success of dental implants and bone grafting is associated with good primary stability in the severely atrophic posterior maxilla. The primer stability of simultaneously placed dental implants may be secured by using a dental implant wider than the osteotomy width.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Ömür Dereci;* ***Design:*** *Ömür Dereci;* ***Control/Supervision:*** *Nesrin Saruhan, Yasin Çağlar Koşar;* ***Data Collection and/or Processing:*** *Nesrin Saruhan, Görkem Tekin;* ***Analysis and/or Interpretation:*** *Ömür Dereci, Nesrin Saruhan;* ***Literature Review:*** *Görkem Tekin;* ***Writing the Article:*** *Ömür Dereci;* ***Critical Review:*** *Ömür Dereci, Nesrin Saruhan, Yasin Çağlar Koşar, Görkem Tekin;* ***References and Fundings:*** *Ömür Dereci, Nesrin Saruhan, Yasin Çağlar Koşar;* ***Materials:*** *Nesrin Saruhan, Ömür Dereci.*

REFERENCES

1. Atwood DA. Reduction of residual ridges: a major oral disease entity. J Prosthet Dent. 1971;26(3):266-79. [Crossref] [PubMed]
2. Wagner F, Dvorak G, Nemec S, Pietschmann P, Figl M, Seemann R. A principal components analysis: how pneumatization and edentulism contribute to maxillary atrophy. Oral Dis. 2017;23(1):55-61. [Crossref] [PubMed]
3. Tan WL, Wong TL, Wong MC, Lang NP. A systematic review of post-extractional alveolar hard and soft tissue dimensional changes in humans. Clin Oral Implants Res. 2012;23 Suppl 5:1-21. [Crossref] [PubMed]
4. Kolerman R, Nissan J, Rahmanov M, Vered H, Cohen O, Tal H. Comparison between mineralized cancellous bone allograft and an alloplast material for sinus augmentation: A split mouth histomorphometric study. Clin Implant Dent Relat Res. 2017;19(5):812-20. [Crossref] [PubMed]
5. Boëck-Neto RJ, Gabrielli M, Lia R, Marcantonio E, Shibli JA, Marcantonio E Jr. Histomorphometrical analysis of bone formed after maxillary sinus floor augmentation by grafting with a combination of autogenous bone and demineralized freeze-dried bone allograft or hydroxyapatite. J Periodontol. 2002;73(3):266-70. [Crossref] [PubMed]
6. Landi L, Pretel RW Jr, Hakimi NM, Setayesh R. Maxillary sinus floor elevation using a combination of DFDBA and bovine-derived porous hydroxyapatite: a preliminary histologic and histomorphometric report. Int J Periodontics Restorative Dent. 2000;20(6):574-83. [PubMed]
7. Tilaveridis I, Lazaridou M, Zouloumis L, Dimitrakopoulos I, Tilaveridis V, Tilaveridou S. The use of mineralized bone allograft as a single grafting material in maxillary sinus lifting with severely atrophied alveolar ridge (1-3 mm) and immediately inserted dental implants. A 3- up to 8-year retrospective study. Oral Maxillofac Surg. 2018;22(3):267-73. [Crossref] [PubMed]
8. Ulm CW, Solar P, Gsellmann B, Matejka M, Watzek G. The edentulous maxillary alveolar process in the region of the maxillary sinus--a study of physical dimension. Int J Oral Maxillofac Surg. 1995;24(4):279-82. [Crossref] [PubMed]
9. Liu R, Yan M, Chen S, Huang W, Wu D, Chen J. Effectiveness of platelet-rich fibrin as an adjunctive material to bone graft in maxillary sinus augmentation: a meta-analysis of randomized controlled trails. Biomed Res Int. 2019;2019:7267062. [Crossref] [PubMed] [PMC]
10. Castro AB, Cortellini S, Temmerman A, Li X, Pinto N, Teughels W, et al. Characterization of the leukocyte- and platelet-rich fibrin block: release of growth factors, cellular content, and structure. Int J Oral Maxillofac Implants. 2019;34(4):855-64. [Crossref] [PubMed]
11. Dohan DM, Choukroun J, Diss A, Dohan SL, Dohan AJ, Mouhyi J, et al. Platelet-rich fibrin (PRF): a second-generation platelet concentrate. Part III: leucocyte activation: a new feature for platelet concentrates? Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006;101(3):e51-5. [Crossref] [PubMed]
12. Pichotano EC, de Molon RS, de Souza RV, Austin RS, Marcantonio E, Zandim-Barcelos DL. Evaluation of L-PRF combined with deproteinized bovine bone mineral for early implant placement after maxillary sinus augmentation: a randomized clinical trial. Clin Implant Dent Relat Res. 2019;21(2):253-62. [Crossref] [PubMed]
13. Lamster IB. Geriatric periodontology: how the need to care for the aging population can influence the future of the dental profession. Periodontol 2000. 2016;72(1):7-12. [Crossref] [PubMed]
14. Lundgren S, Cricchio G, Hallman M, Jungner M, Rasmusson L, Sennerby L. Sinus floor elevation procedures to enable implant placement and integration: techniques, biological aspects and clinical outcomes. Periodontol 2000. 2017;73(1):103-20. [Crossref] [PubMed]
15. Peleg M, Mazor Z, Chaushu G, Garg AK. Sinus floor augmentation with simultaneous implant placement in the severely atrophic maxilla. J Periodontol. 1998;69(12):1397-403. [Crossref] [PubMed]
16. Mardinger O, Nissan J, Chaushu G. Sinus floor augmentation with simultaneous implant placement in the severely atrophic maxilla: technical problems and complications. J Periodontol. 2007;78(10):1872-7. [Crossref] [PubMed]
17. Wolf M, Wurm A, Heinemann F, Gerber T, Reichert C, Jäger A, et al. The effect of patient age on bone formation using a fully synthetic nanocrystalline bone augmentation material in maxillary sinus grafting. Int J Oral Maxillofac Implants. 2014;29(4):976-83. [Crossref] [PubMed]
18. Diserens V, Mericske E, Mericske-Stern R. Radiographic analysis of the transcrestal sinus floor elevation: short-term observations. Clin Implant Dent Relat Res. 2005;7(2):70-8. [Crossref] [PubMed]
19. Bornstein MM, Brügger OE, Janner SF, Kuchler U, Chappuis V, Jacobs R, et al. Indications and Frequency for the Use of Cone Beam Computed Tomography for Implant Treatment Planning in a Specialty Clinic. Int J Oral Maxillofac Implants. 2015;30(5):1076-83. [Crossref] [PubMed]
20. Cosso MG, de Brito RB Jr, Piattelli A, Shibli JA, Zenóbio EG. Volumetric dimensional changes of autogenous bone and the mixture of hydroxyapatite and autogenous bone graft in humans maxillary sinus augmentation. A multislice tomographic study. Clin Oral Implants Res. 2014;25(11):1251-6. [Crossref] [PubMed]
21. Gultekin BA, Borahan O, Sirali A, Karabuda ZC, Mijiritsky E. Three-dimensional assessment of volumetric changes in sinuses augmented with two different bone substitutes. Biomed Res Int. 2016;2016:4085079. [Crossref] [PubMed] [PMC]
22. Broder J, Preston R. Imaging the head and brain. In: Broder J, eds. Diagnostic Imaging for the Emergency Physician. 1st ed. USA Saint Louis: W.B. Saunders; 2011. p.1-45. [Crossref]
23. Everts PA, Overdevest EP, Jakimowicz JJ, Oosterbos CJ, Schönberger JP, Knape JT, et al. The use of autologous platelet-leukocyte gels to enhance the healing process in surgery, a review. Surg Endosc. 2007;21(11):2063-8. [Crossref] [PubMed]
24. Bolukbasi N, Ersanlı S, Keklikoglu N, Basegmez C, Ozdemir T. Sinus augmentation with platelet-rich fibrin in combination with bovine bone graft versus bovine bone graft in combination with collagen membrane. J Oral Implantol. 2015;41(5):586-95. [Crossref] [PubMed]
25. Miron RJ, Pikos MA. Sinus augmentation using platelet-rich fibrin with or without a bone graft: what is the consensus? Compend Contin Educ Dent. 2018;39(6):355-61; quiz 362. [PubMed]