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Analysis of bone quality formation in sinus lifts with immediate implants

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Abstract
Sinus lift surgeries are part of the daily practice of dentists. This study evaluates the long-term structure of the bone placed in sinus lifts through the fractal dimension. We conducted a retrospective study on a sample of 35 patients with 51 sinus lifts performed using a lateral window approach and filling material placement. We radiologically analyzed the graft bone to observe its evolution up to one and a half years after the surgical procedure. The obtained results were the average area of the sinuses analyzed was 1401.96 mm2, with a mean area occupied by the filling material of 297.75 mm2. Significant differences are observed when comparing the fractal dimension values obtained on the initial day and one year after prosthesis loading. Similarly, when comparing the values of the area occupied by the biomaterial at the start day and one year after prosthesis loading, significant differences are also obtained (*p-value* < 0.001). In conclusion, the filling material used in the lateral window sinus lift procedure undergoes significant resorption and shows changes in the fractal dimension.

Keywords Maxillary sinus, Fractal dimension, Filling material, Lateral window, Sinus lift

Introduction

Sinus lift surgeries for implant placement have become part of daily practice, with minimally invasive procedures improving postoperative symptoms [1, 2].

The anatomical characteristics of the working region largely determine the success of the surgical procedure, so it is necessary to resort to radiological tests, with CBCT being the first choice, which provides the maximum amount of information possible to proceed with adequate planning for each case [3, 4].

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In the first three months following tooth loss, 30% of the width of the alveolar bone is lost, and at one year, 50% of the total is lost, mostly affecting the vestibular plate [5].

This bone loss is compounded by the maxillary sinus pneumatization that accompanies the aging process, so the height of the alveolar crest is also significantly modified [6]. Both of these described processes lead to limitations in implant placement, requiring sinus lift surgeries. The incidence of these treatments varies according to different authors, but their frequency is increasing [7, 8]. The maxillary sinus lift procedure was first described by Boyne and James and subsequently modified by various authors [9].

It was Tatum in 1986 who described the surgical lateral window procedure for performing maxillary sinus lift [10], and Summers who introduced variations in the technique using different osteotomes and applying a sequential protocol [11]. The anatomical variability of the maxillary sinus in both volume and septa that divide it makes it necessary to analyze these factors and take them into account in the planning of the procedure [12, 13].

The material of choice as a filling material has always been autologous bone, which benefits bone regeneration processes to a greater extent, but presents complications derived from autografts such as scarcity and resorption. Therefore, there has been a tendency to use biomaterials with osteoconductive properties [14, 15].

From the point of view of analyzing the quality of the bone that forms after these surgical procedures, many techniques have been used, including fractal dimension calculation [16, 17], since it allows comparing the obtained bone with the patient's bone. The fractal dimension is a mathematical invariant that allows the quantitative analysis of the texture of certain geometric structures with a fractal pattern [18].

The main objective of our study was to retrospectively evaluate the bone pattern of the bone formed in sinus lifts with immediate implant placement in the long term, using fractal dimension value as a measure. At the same time, we analyze the volumetric changes obtained in the filling material by studying certain anatomical values.

Material and method

Analysis of the sample

The sample consists of a total of 35 patients, of which 12 are women and 23 are men. Bilateral maxillary sinus elevation was performed in 16 patients (32 sinus), and unilateral elevation was performed in 19, with 40 cases on the right maxillary sinus and 11 on the left maxillary sinus. The inclusion criteria were:

1. Edentulous patients in the maxillary sinus area with atrophy starting from 2 to 5 mm.
2. Patients with no diseases that affect bone metabolism and systemic conditions that affect healing, such as diabetes.
3. Smoking and non-smoking patients without sinus pathology.
4. Patients without infectious foci in the area are to be treated.
5. High-quality radiological images, and orthopantomographic projections. All patients were informed of the type of treatment they would undergo and the possible complications that could arise from it, as well as the possibility of withdrawing from the study at any time.
6. All subjects gave informed consent to participate.

Surgical procedure

The same surgeon always performed the surgical procedures and followed the same protocol, according to the procedure described by Tatum:

1. Lateral window with external approach without breaking the Scheridian membrane, creating a space in the sinus floor.
2. Filling the generated space with biomaterial, Endobone® (Zimmer Biomet, Palm Beach Garden, Florida, USA).
3. Placement of membrane, Collagen membrane 30 × 40 mm: BioMend® (Zimmer Biomet, Palm Beach Garden, Florida, USA).
4. Placement of implants, Biomet 3i (Zimmer Biomet, Palm Beach Garden, Florida, USA).

Radiological procedure

All panoramic radiographs were taken using the same digital panoramic radiography system (Vatech, Madrid, Spain). The radiological images obtained were orthopantomography, always following the same procedure:

a. Diagnostic radiology at the beginning, before the surgical phase.
b. Surgical radiology with the surgical procedure performed and the implant placed.
c. Post-surgical radiology, with the implant loaded after 6 months. This image was obtained one and a half years after the surgical procedure.

Image analysis

All panoramic radiographs were performed using the same digital panoramic radiography system (Vatech, Madrid, Spain).

For the processing and analysis of the images, we worked with ImageJ (National Institutes of Health).

We established a study ROI in the maxillary sinus, in which we proceeded to calculate:

a. ANGLE - resulting in degrees of the implant axis with the anteroinferior and posteroinferior points of the anterior and posterior tables of the sinus.
b. OCCUPIED AREA - the area generated by introducing the graft material in mm^2.
c. TOTAL AREA - the total area occupied by the sinus in mm^2.
d. EXCESS AREA - By tracing a line from the posteroinferior point of the posterior table to the anterior nasal spine (ENA) point in mm^2, we delimited the area occupied in its upper level about

the apex of the implant and measured the excess graft material.

Fractal dimensión values

Radiological processing is performed according to the White and Rudolph method for radiographic images [19].

We performed a segmentation of the area under study, where the bone-filling material is located. We eliminated all artifacts that could affect the calculation of the fractal dimension (FD) or box-counting dimension.

We obtained two values of FD:

FRACTAL DIMENSION 1

- obtained in the implant placement radiography.

FRACTAL DIMENSION 2

- obtained in the radiography with prosthetic loading. The steps to follow for the image processing treatment can be observed in Fig. 1.

Statistical analysis

Data were analyzed using the SPSS 20.0 statistics program (SPSS Inc, Chicago, IL, USA). A descriptive study was made of each variable. The Kolmogorov-Smirnov normality test and Levene variance homogeneity test were applied, and the data showed a normal distribution and were analyzed using parametric tests. The associations between the different qualitative variables were studied using Pearson's chi-squared test. The associations between different quantitative variables were studied using the Student t-test for two related samples. Statistical significance was accepted for $p \leq 0.050$.

Results

The total sample consisted of 35 patients with a mean age of 52.94 years, of whom 23 were men and 12 were women. The variables studied were: tobacco use, alcohol consumption, brushing frequency, and bone-related pathologies. The analysis of all of them can be seen in Table 1.

Regarding the number of implants placed, there were 72 with the characteristics described in Table 2.

Of the sinus lifts performed were 51, of which 19 were unilateral and 16 were bilateral (32). The average area of the sinuses analyzed was 1401.96 mm2, with a mean area occupied by the filling material of 297.75 mm2 (Table 3).

Significant differences are observed when comparing the fractal dimension values obtained on the initial day and one year after prosthesis loading. Similarly, when comparing the values of the area occupied by the biomaterial at the start day and one year after prosthesis loading, significant differences are also obtained (Table 4).

Discussion

In the realm of assessing surgical success, bone density values have emerged as a prominent indicator. This parameter can be evaluated using various techniques, with the fractal dimension standing out as a cost-effective option. A notable study by Scaf de Molon et al. [17]

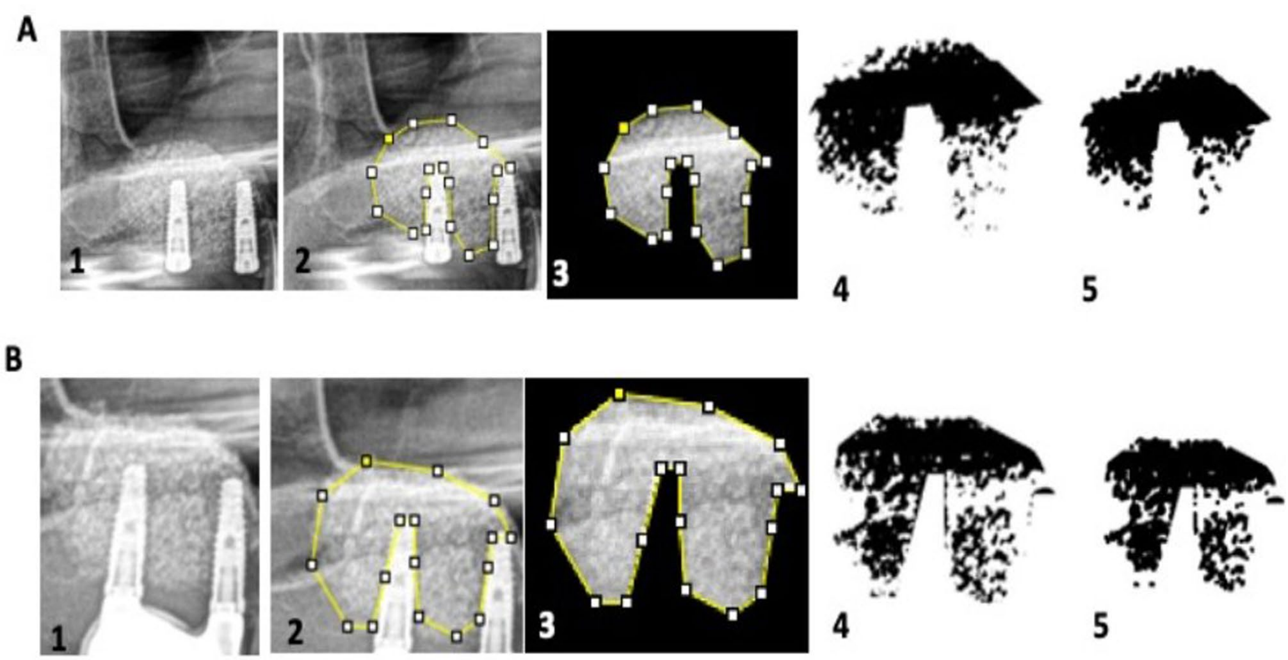

Fig. 1 Description of the image analysis process to obtain fractal dimension values:1. Selection of the area to analyze; 2. Marking and segmentation of the region of interest (ROI); 3. Delimiting the ROI and creating a mask for cropping; 4. Thresholding to 255 and binarization; 5. Refinement through erosion and dilation to calculate the fractal dimension value

Table 1 Characteristics of the study population

Characteristics	Patients with sinus floor elevation (n = 35)
Age: mean ± SD*	52.94 ± 10.13
Sex: n (%)	
Male	23 (65.71)
Female	12 (34.29)
Smoking behaviour: n (%)	
Non-smoker	22 (62,85)
≤10	9 (25.71)
11–20	4 (11.44)
>20	0 (0)
Alcohol consumption: n (%)	
None	17 (48.58)
Daily	0 (0)
Weekend drinker	18 (51.42)
Tooth brushing: n (%)	
1/day	2 (5.73)
2/day	15 (42.85)
≥3/day	18 (51.42)
Diseases: n (%)	
Arthrosis	1 (2.85)
Venous thrombosis	1 (2.85)
Osteoporosis	1 (2.85)
Anaemia	1 (2.85)
Arterial hypertension	2 (5.71)
Diabetes mellitus type II	1 (2.85)
Hypercholesterolemia	1 (2.85)

* SD = standard deviation

Table 2 Implant distribution

Characteristics	Total (n = 72) n (%)
Length	
8.5 mm	34 (47.22)
10 mm	25 (34.72)
11.5 mm	13 (18.06)
Diameter	
3.25 mm	31 (43.05)
4.00 mm	34 (47.22)
5.00 mm	7 (9.73)
Site	
1.4	2 (2.68)
1.5	7 (9.73)
1.6	20 (27.77)
1.7	7 (9.73)
2.4	4 (5.55)
2.5	9 (12.50)
2.6	17 (23.71)
2.7	6 (8.33)

delved into the analysis of grafted bone structure in maxillary sinus lifts through the prism of fractal dimension. Intriguingly, their findings diverged from our study, as they did not identify significant disparities in values six months post-surgery.

The rehabilitation of the posterior maxillary sector often leans toward lateral windows with filling material, a preferred treatment choice. Yet, alternative avenues

Table 3 Characteristics of maxillary sinus lift

Characteristics lift	Maxillary sinus (n = 51)
Unilateral/Bilateral: n (%)	
Unilateral	19 (37.26)
Bilateral	16 (62.74)
Right/Left: n (%)	
Rights	40 (78.43)
Left	11 (21.57)
Opposing dentition: n (%)	
None	2 (3.93)
Natural teeth	29 (56.86)
Metal-porcelain	20 (39.21)
Total sinus area before surgery (mm^2): mean ± SD*	1401.96 ± 449.74
Sinus area occupied by biomaterial on day 0 (mm^2): mean ± SD	297.75 ± 137.74
Implants angle on maxillary sinus (degrees): mean ± SD	84.14 ± 8.86

*SD = standard deviation

Table 4 Changes in biomaterial area above the apex of dental implant and fractal dimension between day 0 and 1 year after loading (student t-test)

Characteristics value	Day 0 mean ± SD*	1 year after loading mean ± SD	*p*-
Biomaterial area above the apex of dental implant	111.04 ± 62.51	98.33 ± 56.01	< 0.001
Fractal dimension	1.78 ± 0.04	1.71 ± 0.04	< 0.001

*SD = standard deviation

like the indirect sinus lift technique, involving osteotome expansion and short implant placement, as well as innovations like zygomatic implants [20], have broadened the therapeutic spectrum. A remarkable innovation by Menassa G. et al., the graftless lateral sinus lift approach (GLSLA), has garnered attention. This method advocates for the lateral window technique without filling material and has exhibited success in promoting implant osseointegration [21]. Another option would be the use of minimally invasive techniques for maxillary sinus elevation with the placement of implants and filling material, such as the study carried out by Zadrożny Ł et al. where they found that this technique reduces the number of interventions in the patient with good results [22].

Within our study framework, the lateral window with filling material emerged as the treatment of choice, resulting in a staggering 100% success rate after a year and a half. This achievement was anchored by optimal implant and filling material osseointegration. An interesting twist is presented by Cosola S. et al., who proposed the sinus elevation technique but in this case with a crestal approach but employed absorbable collagen instead of traditional filling material. Their histopathological analysis after six months showcased well-structured bone, surpassing the initial structure's quality [23].

Additionally, Comuzzi L. et al. delved into dimensional changes during the resorption process using varied filling materials. They deduced that once the remodeling process stabilizes, bone alterations are minimal. Our examination of bone loss through occupied area assessments echoed their findings, revealing significant disparities between initial values and those recorded after a year and a half. This underscores the conclusion that filling material evolution is a gradual process, leading to apical and lateral loss around the implant.

The realm of maxillary sinus augmentation was also explored by Trindade-Suedam I. et al., who employed two groups of mice to investigate the combination of autogenous bone graft and bioglass alongside leukocyte-poor platelet-rich plasma for maxillary sinus augmentation. Their study yielded significant differences in bone density and fractal dimension values. Notably, despite the absence of a direct correlation between histological and radiological values, both proved valid indicators of trabecular architecture formation [24]. This aligns with our study's observations of bone structuring over time, mirroring the characteristic distribution of septa and trabecular spaces.

Furthermore, Comuzzi L. et al. contributed a comprehensive three-year retrospective analysis of implants placed in maxillary sinus lateral windows, exploring various filling materials and implant attributes. Their findings underscored the critical role of design in determining surgical success rates [25, 26]. This echoes the significance of meticulous implant attributes in achieving optimal outcomes.

Entrenching itself as a crucial facet of our discussion, the dimension fractal assumes paramount importance as a diagnostic tool for analyzing the intricate changes within the trabecular bone. This metric offers a unique vantage point, allowing us to decipher not only the extent of bone resorption but also the underlying restructuring processes. By harnessing the power of fractal dimension analysis, researchers and clinicians can gain deeper insights into the temporal evolution of bone architecture, aiding in the early detection of structural shifts that might otherwise go unnoticed through conventional radiographic assessments. This facet of fractal dimension analysis holds the promise of enhancing our capacity to monitor bone health, contributing to the fine-tuning of surgical interventions and treatment strategies for maxillary sinus augmentation and implant osseointegration [27, 28].

Paradowska-Stolarz A. et al. conclude that the integration of fractal dimension and texture analysis into the study aligns with the broader understanding of bone structure changes over time. They employ fractal dimensions to analyze diverse materials, discerning the inherent discrepancies among them. The fractal dimension emerges as a valuable, straightforward, and cost-effective parameter, furnishing diagnostic insights and guiding clinicians in the prudent selection of suitable materials.

One of the limitation of this study is the lack of comparable studies in the existing literature. The absence of similar previous research makes it difficult to directly compare our findings and limits the context in which the results can be interpreted. While this underscores the novelty of our work, it also highlights the need for future research to explore this topic further, enabling more robust comparisons and validation of our findings.

Conclusions

In summation, our findings substantiate that the filling material employed in the lateral window sinus lift procedure experiences substantial resorption, a process that, notably, attains stabilization within one year under the influence of loading forces. However, the narrative does not merely encapsulate a singular trajectory of resorption. The dynamic dimension of fractal analysis uncovers an additional layer of complexity, shedding light on the nuanced interplay between resorption and a captivating phenomenon of structural restructuring. This intricate orchestration of events culminates in the remarkable recomposition of the trabecular framework, merging into a definitive meshwork that harmonizes with the initially dense osseous substrate. In essence, our exploration portrays a multi-faceted transformation, wherein the filling material's evolution is marked not only by resorption but also by the orchestration of a structural symphony. This choreography befits the ultimate constitution of the trabecular architecture within the originally compact bone matrix.

Abbreviations

CBCT	Cone beam computed tomography
ROI	Region of interesting
FD	Fractal dimensión
GLSLA	Graft less lateral sinus lift approach

Author contributions

Conception and design: SSA, YGS, FCA, OGA, JCBM. Provision of study materials and/or patients: SSA, YGS, FCA, OGA. Data collection and assembly: SSA, YGS, FCA, OGA. Data analyses and interpretation: SSA, YGS, FCA. Manuscript writing: SSA, YGS, FCA, OGA, JCBM.All data will be kept under the email fcamacho@um.es.

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Data availability

The data that support the findings of this study are available from the authors but restrictions apply to the availability of these data, which were used under license from the University of Murcia for the current study, and so are not publicly available. Data are, however, available from the authors upon reasonable request and with permission from the University Dental Clinic of the University of Murcia.All the data that has been worked with in this article is guarded by Fabio Camacho Alonso, fcamacho@um.es.

Declarations

Ethics approval and consent to participate
The study was conducted following the principles of the Helsinki Declaration (last revised in Seoul, Korea, 2008) and with the approval of the bioethics committee of the University of Murcia ID: 3203/2021. All subjects gave informed consent to participate.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References
1. Omori Y, Nakajima Y, Imai H, Yonezawa D, Ferri M, Apaza Alccayhuaman KA, Botticelli D. Influence of anatomical parameters on the dimensions of the Subantral Space and Sinus Mucosa Thickening after Sinus Floor Elevation. A retrospective cone Beam Computed Tomography Study. Dent J (Basel). 2021;9(7):76. https://doi.org/10.3390/dj9070076. PMID: 34202457; PMCID: PMC8304157.
2. Molina A, Sanz-Sánchez I, Sanz-Martín I, Ortiz-Vigón A, Sanz M. Complications in sinus lifting procedures: Classification and management. Periodontol 2000. 2022;88(1):103–115. https://doi.org/10.1111/prd.12414. PMID: 35103321.
3. Kawakami S, Botticelli D, Nakajima Y, Sakuma S, Baba S. Anatomical analyses for maxillary sinus floor augmentation with a lateral approach: a cone beam computed tomography study. Ann Anat Anat Anz. 2019;226:29–34. [CrossRef].
4. Lozano-Carrascal N, Salomó-Coll O, Gehrke SA, Guirado JLC, Hernández-Alfaro F, Gargallo-Albiol J. Radiological evaluation of maxillary sinus anatomy: a cross-sectional study of 300 patients. Ann Anat Anat Anz. 2017;214:1–8. [CrossRef].
5. Cosola S, Di Dino B, Traini T, Kim YS, Park YM, Marconcini S, Covani U, Vinci R. Radiographic and histomorphologic evaluation of the Maxillary bone after Crestal Mini Sinus lift using Absorbable collagen-retrospective evaluation. Dent J (Basel). 2022;10(4):58. https://doi.org/10.3390/dj10040058. PMID: 35448052; PMCID: PMC9024729.
6. Gastaldi G, Felice P, Pistilli R, Barausse C, Trullenque-Eriksson A, Esposito M. Short implants as an alternative to crystal sinus lift: a 3-year multicentre randomized controlled trial. Eur J Oral Implantol. 2017;10:391–400.
7. Seong WJ, Barczak M, Jung J, Basu S, Olin PS, Conrad HJ. Prevalence of sinus augmentation associated with maxillary posterior implants. J Oral Implantol. 2013;39(6):680–8. https://doi.org/10.1563/AAID-JOI-D-10-00122. Epub 2011 Jun 8.
8. Parra M, Atala-Acevedo C, Fariña R, Haidar ZS, Zaror C, Olate S. Graftless Maxillary Sinus lift using lateral window Approach: a systematic review. Implant Dent. 2018;27(1):111–8.
9. Nolan PJ, Freeman K, Kraut RA. Correlation between Schneiderian membrane perforation and sinus lift graft outcome: a retrospective evaluation of 359 augmented sinuses. J Oral Maxillofac Surg. 2014;72(1):47–52.
10. Tatum H. Maxillary and sinus implant reconstructions. Dent Clin North Am. 1986;30:207–29.
11. Summers RB. A new concept in maxillary implant surgery: the osteotome technique. Compendium. 1994;15:152–62.
12. Marino MJ, Riley CA, Wu EL, Weinstein JE, Emerson N, McCoul ED. Variability of Paranasal Sinus pneumatization in the absence of Sinus Disease. Ochsner J. 2020 Summer;20(2):170–5.
13. Mirdad A, Alaqeely R, Ajlan S, Aldosimani MA, Ashri N. Incidence of maxillary sinus septa in the Saudi population. BMC Med Imaging. 2023;23(1):23.
14. Kent JN, Block MS. Decisión making for sinus graft surgery: Techniques based in clinical and histologic success. American Academy of osseointegration fifteenth annual meeting. New Orleans. March 10th, 2000.
15. Hall HD, Mckenna SJ. Maxillary sinus augmentation using different grafting materials and dental implants in monkeys. Part I. evaluation of porous hydroxyapatite. Clin Oral Impl Res. 1997;8:847–96.
16. Gurbuz E, Dursun E, Vatansever A, Caglayan F. Microcomputed tomographic analysis of bone microarchitecture after sinus augmentation with hyaluronic matrix: a case-control study. Oral Maxillofac Surg. 2022;26(3):431–7. https://doi.org/10.1007/s10006-021-01002-5. Epub 2021 Sep 18. PMID: 34535840.
17. De Molon RS, de Paula WN, Spin-Neto R, Verzola MH, Tosoni GM, Lia RC, Scaf G, Marcantonio E Jr. Correlation of fractal dimension with histomorphometry in maxillary sinus lifting using an autogenous bone graft. Braz Dent J. 2015 Jan-Feb;26(1):11 – 8. https://doi.org/10.1590/0103-6440201300290. PMID: 25672378.
18. Jolley L, Majumdar S, Kapila S. Technical factors in fractal analysis of periapical radiographs. Dentomaxillofac Radiol. 2006;35:393–7.
19. White SC, Rudolph DJ. Alterations of the trabecular pattern of the jaws in patients with osteoporosis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1999;88:628–35.
20. Kadkhodazadeh M, Moscowchi A, Zamani Z, Amid R. Clinical and radiographic outcomes of a Novel Transalveolar Sinus Floor Elevation technique. J Maxillofac Oral Surg. 2022;21(2):548–56.
21. Menassa G, Kassir AR, Landi L, Naaman NBA, Chakar C. Implant Placement with Graftless Sinus Floor Elevation via the lateral Approach: a Case Series with 4 years post-loading Radiographical outcomes and Implant Survival Rate. J Craniofac Surg 2022 Jul-Aug 01;33(5):e461–5.
22. Zadrożny Ł, Wagner L, Rosenbach D. Minimally Invasive Transcrestal Sinus Floor Elevation Procedure in Severely Atrophic Ridge: A Case Report. J Oral Implantol. 2021;47(3):215–222. https://doi.org/10.1563/aaid-joi-D-19-00166. PMID: 32663275.
23. Cosola S, Di Dino B, Traini T, Kim YS, Park YM, Marconcini S, Covani U, Vinci R. Radiographic and histomorphologic evaluation of the Maxillary bone after Crestal Mini Sinus lift using Absorbable collagen-retrospective evaluation. Dent J (Basel). 2022;10(4):58.
24. Comuzzi L, Tumedei M, Piattelli A, Tartaglia G, Del Fabbro M. Radiographic Analysis of Graft Dimensional Changes in Transcrestal Maxillary Sinus Augmentation: a retrospective study. Mater (Basel). 2022;15(9):2964.
25. Trindade-Suedam IK, de Morais JA, Faeda RS, Leite FR, Tosoni GM, Neto CB, Marcantonio E Jr, Scaf G. Bioglass associated with leukocyte-poor platelet-rich plasma in the rabbit maxillary sinus: histomorphometric, densitometric, and fractal analysis. J Oral Implantol. 2010;36(5):333–43.
26. Comuzzi L, Tumedei M, Petrini M, Romasco T, Lorusso F, De Angelis F, Piattelli A, Tatullo M, Di Pietro N. Clinical and radiological evaluation of a Self-Condensing Bone Implant in one-stage sinus augmentation: a 3-Year Follow-Up Retrospective Study. Int J Environ Res Public Health. 2023;20(3):2583.
27. Smith A, Johnson B, Anderson C. Fractal Dimension Analysis: a Novel Approach to assess trabecular bone changes. J Med Imaging. 2020;7(3):032501. https://doi.org/10.1117/1.JMI.7.3.032501.
28. Paradowska-Stolarz A, Wieckiewicz M, Kozakiewicz M, Jurczyszyn K, Mechanical Properties. Fractal Dimension, and texture analysis of selected 3D-printed resins used in Dentistry that underwent the Compression Test. Polymers. 2023;15(7):1772.

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