Delayed Volumetric Change after Horizontal Augmentation by Autogenous Ramus Block Graft in Anterior Esthetics Area and Correlation with Basal Bone Angulation, a Retrospective Study

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Abstract

Dental implants need to be placed in good bone quality and quantity. If the implant site is defective or inadequate, bone augmentation is needed before or during implant placement. Autogenous bone is the gold standard for bone augmentation, but the problem is rapid bone resorption. This study aimed to evaluate the delayed volumetric shrinkage of horizontally augmented bone in the anterior esthetic area using a ramus block graft, assessing the percentage of volumetric shrinkage over time and its correlation with bone angle. This research is a retrospective clinical study investigating 10 subjects (male: 5, female: 5) analyzing the pre-operative and recall CBCT images. The results showed that the mean and median of recall years were 7.7 ± 3.16 and 7 years. The mean percentage of volumetric shrinkage and bone's angle were 9.93 ± 3.0 and 48.48 ± 8.18 degrees. To test the difference between groups, the samples were classified into 2 groups by using the median of recall years, group 1: less than 7 years, group 2: equal to or more than 7 years. The independent T-test was used to analyze the percentage of volumetric shrinkage and recall years. Pearson's correlation coefficient was used to investigate a correlation between the percentage of volumetric shrinkage and bone angle. All statistical analysis was performed at a significant level of 5% (p-value < 0.05). The conclusion was the percentage of volumetric shrinkage was statistically significantly different between both groups. There is no correlation between the percentage of volumetric shrinkage and patients' bone angles.

Keywords: *Bone Angle, CBCT, Delayed Volumetric Shrinkage, Dental Implant, Ramus Block Graft, Recall Year.*

1. Introduction

Dental implants have been widely used to replace a missing tooth for many years. Dental implants have become one of the predictable treatments for teeth replacement in partial or fully edentulous patients. Treatment planning is key to the success of dental implant treatment. In the past, dental implants were placed in the site according to available bone without concerning any prosthetic condition. However, nowadays the concept has changed to a prosthesis-driven implant treatment plan. According to this concept, restorations need to be planned and designed before implant surgery without concerning implant sites. If the bone is not

adequate, the augmentation will be done during or prior to implant placement. Treatment planning of implant position should be accurate to create a proper implant position, improve the longevity of implants, and reduce the chance of complications. A sufficient amount and quality of bone were necessary for the dental implant to be successful and last over time. Prior to implant placement, having sufficient alveolar bone quality left can help minimize physiologic bone loss and prevent peri-implant disease.

A prolonged period following a tooth extraction, persistent periodontitis, infection, trauma, or other causes can create substantial bone loss at an implant site. It is often necessary to enhance bone before or during implant implantation. Various augmentation strategies have been devised based on the bone defect's categorization, severity, and location. As a result, we must use the right bone augmentation tools and methods to produce the right bone contour.(Lutz, Neukam, Simion, & Schmitt, 2015; Sanz-Sánchez, Ortiz-Vigón, Sanz-Martín, Figuero, & Sanz, 2015; Smeets et al., 2022)

Using autogenous bone is regarded as the gold standard for reconstructing alveolar ridges because of their osteogenic property.(Alérico et al., 2014). The most common intraoral harvest sites were ramus and symphysis due to the minimally invasive procedure and the size of the surgical field. Many studies reported the predictability and success outcome when augmentation with intraoral autogenous bone blocks in case of moderately to severely inadequate alveolar ridges. According to one study (Cordaro, Amadè, & Cordaro, 2002), patients with partially edentulous ridges appeared to be good candidates for alveolar ridge augmentation with autogenous bone blocks taken from the mandible.

The main problem of horizontal augmentation by using a ramus block graft is bone resorption. The rate of bone resorption or remodeling was different depending on the individual. This resorption of the bone block at the grafted area could compromise the success of dental implant treatment in an anterior esthetics area in terms of esthetic and function problems at the recall visit. The clinical outcome resulted in the darkening of the gingival from a metal shadow of a dental implant, gingiva inflammation, or flattening contouring of the gingiva. After the radiographic investigation, the result showed that the dental implant flowed away from the bone or without radiopaque of a bone mass-covered dental implant. (Acocella, Bertolai, Colafranceschi, & Sacco, 2010; Alérico et al., 2014; Chiapasco et al., 2009; Lee, & Kim, 2015; Yu, Chen, Zhu, & Qiu, 2016)

Many studies reported the volumetric change of autogenous bone block from clinical and radiographs. According to a retrospective analysis which compared between autogenous onlay blocks and xenogenic inlay grafts for bone augmentation (Barone, Ricci, Mangano, & Covani, 2011), the autogenous onlay block success rate was 82.4%, which was lower than that of the inlay group (93.8%). Another study reported bone resorption rates compared between intraoral block bone and guided bone regeneration augmentation for the reconstruction of horizontally deficient maxillary alveolar ridges before implant placement. The result showed the GBR has a significantly increased bone resorption rate than the ramus bone graft.(Gultekin et al., 2016)

Some studies used a radiographic approach to investigate the volumetric change in 3 dimensional. Stricker, Schramm, Marukawa, Lauer, and Schmelzeisen (2003) used cone-beam computed tomography (CBCT) to examine the volumetric change of retromolar bone grafts after a year, and the result showed that onlay block graft from ascending ramus underwent a significant volumetric change.(Stricker et al., 2003) Another study by Wang et al. compared the resorption rate between the customized allogenic and autogenous bone blocks after six months following surgery. The results indicated that allogeneic bone block had more horizontal bone gain and less horizontal bone resorption than autogenous bone block. (Wang, Li, Su, & Mo, 2023)

There were numerous errors in using CBCT to assess the volumetric change, such as picture distortion, blurring, and artifacts. Artifacts are the most frequent issue with X-ray images when it comes to

dental implants. These mistakes lead to insufficient data that cannot be used to assess the volume of the bone in 3 dimensions following bone augmentation. The metal artifacts cause low-quality radiography images in areas with dental implants or metal restorations. This radiopaque structure surrounds a metal structure in CBCT pictures; however, it is not present in the individual. The widespread use of metal products in dentistry, such as dental implants and metal artifacts, has presented a significant difficulty for medical professionals when analyzing and diagnosing CBCT pictures.(Terrabuio et al., 2021)

The clinical outcome of patients who had bone augmentation for a horizontal bone deficiency revealed that bone resorption occasionally occurs in the enhanced area. This study is the clinical investigation into the delayed volumetric shrinkage of horizontal bone augmentation with autogenous (ramus graft) in the anterior esthetic area, recall years, as well as the correlation with patients' bone angles.

2. Objectives

This study aims to investigate the correlation between delayed volumetric shrinkage in horizontal bone augmentation by using an autogenous ramus block graft in the anterior esthetics area with the anterior maxillary edentulous ridge's angle.

3. Materials and Methods

3.1 Study design: Retrospective clinical study

Patients who had undergone horizontal bone augmentation by using autogenous ramus block graft in anterior teeth at the esthetics restorative and implants dental clinic at Chulalongkorn University, Bangkok, Thailand from January 2011 until now were recruited for this study. This study was approved by the ethics board committee of the Faculty of Dentistry, Chulalongkorn University (Ethic approves number HRCE-DCU 2023-037) All participants were informed and signed consent forms. The participants included in this study were 10. (Male:5, Female:5).

Table 1: The inclusion and exclusion criteria of samples in this study.

Inclusion criteria	Exclusion criteria
Patients presented with a horizontal alveolar bone defect in the anterior esthetics area.	Patients who exhibited signs of systemic disease related to bone metabolism.
Patients who had undergone augmentation with autogenous ramus block graft.	Patients who cannot come for a recall visit.
Patients who had available cone-beam computerized tomography (CBCT). - Pre-operative - Recall visited	
Patients who placed an implant at the anterior esthetic area (canine to canine).	

3.2 Cone beam computed tomography imaging

All CBCT images were acquired using the same CBCT scanner (iCATVision) (Imaging Science International, Hatfield, PA, USA). The radiographic images were compared between pre-operative and recall

visit treatment in terms of delayed volumetric shrinkage. The required CBCT images in this study were pre-operative CBCT image (V_1) and recall-visited CBCT image (V_2).

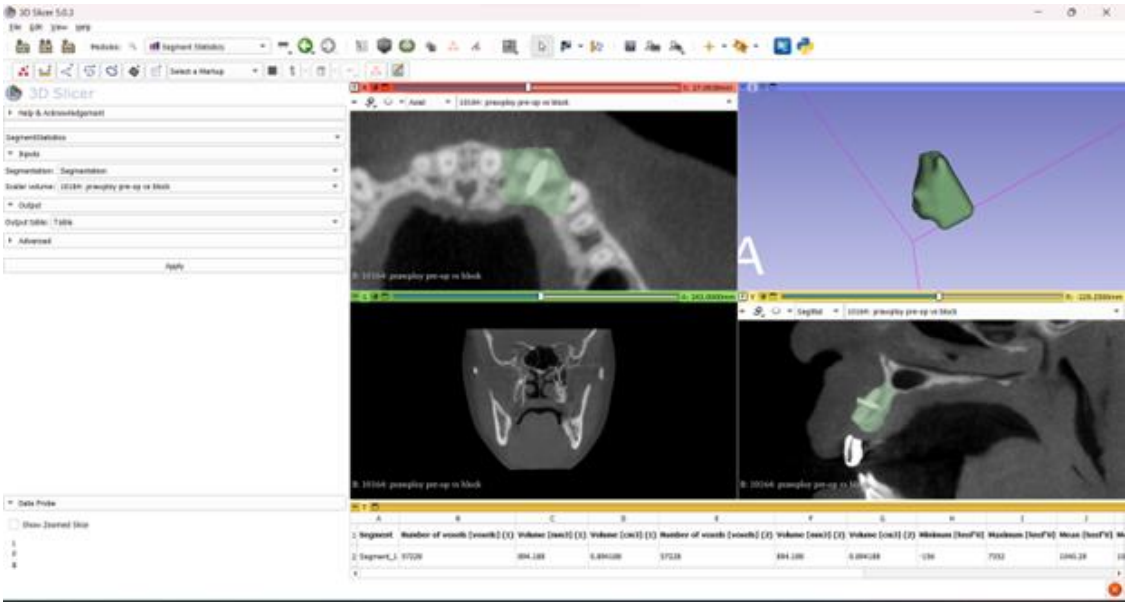

Figure 1: Volumetric measurements in the pre-operative visit by using imaging software.

3.3 3-Dimensional volumetric measurements

All CBCT images were analyzed by using 3-dimensional image software (3dSlicer) and sectioned the interest area by using the intensity of the ROI unit with different threshold radiopacity autonomically and correcting manually. The interest area that was used for calculating the volume of delayed volumetric shrinkage was measured in 3 dimensions. The reference point of the section in the mesio-distal aspect was a marginal bone of adjacent teeth between dental implants in the labial-palatal aspect which was the anterior part of the labial bone until the palatal bone. The percentage of delayed volumetric change was calculated by subtracting between pre-operative volume(V_1) and recall volume(V_2) and compare as a percentage.

$$Percent\ bone\ change = \frac{V2\ (recall) - V1\ (pre-op)}{V1(pre-op\ )} x100\%$$

** V1: Pre-operative volumes.
** V2: Recall visited volumes.
** The final volume is a negative number: There is a delayed volumetric shrinkage of the grafted area.
** The final volume is a positive number: There is a bone gained at the grafted area.

3.4 Bone angle measurement

Bone angle was measured by creating an imaginary line from the hard palate to point A, an arbitrary measure point on the innermost curvature from the maxillary anterior nasal spine to the crest of the maxillary alveolar process; and to point B (PNS), the tip of the posterior nasal spine of the palatine bone, at the junction of the soft and hard palate. The angle of the basal bone triangle was created by using two reference points in the palatal and vestibular areas at the middle part of the basal bone triangle. A perpendicular line passes across these horizontal lines and mid crestal bone of the labial bone plate. The angle between these two lines was measured as a degree by using implant planning software (Codiagnotix).

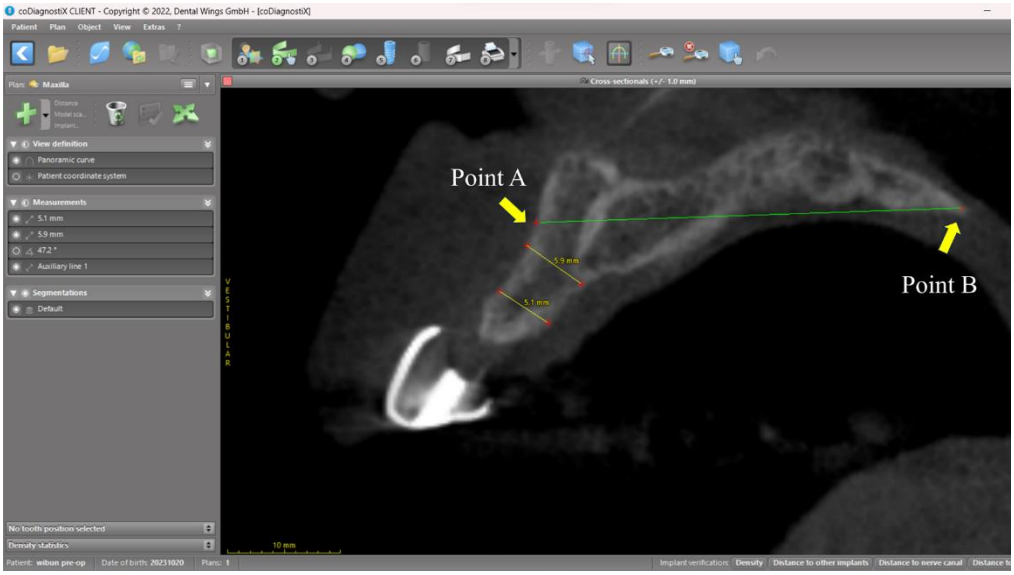

Figure 2: Reference point for bone angle measurements (point A: the innermost curvature from the maxillary anterior nasal spine) and (point B: the posterior nasal spine of the palatine bone)

3.5 Image observation

The 3-dimensional volumetric measurements were done by using imaging software by a single examiner. Intra-examiner calibration was done by re-evaluating random CBCT images at a 2-week minimum interval. The intraclass correlation coefficient was 0.99, indicating excellent reliability(Koo, & Li, 2016).

3.6 Statistical analysis

The data were analyzed using SPSS version 22.0 (SPSS Inc., Chicago, Illinois, USA). The recall years had a normal distribution. The independent T-test was tested to compare the difference between groups in terms of the percent of delayed volumetric shrinkage and recall years. The samples were classified into two groups by using the median of recall years. To investigate the correlation between the percent of bone change and the patients' bone angles, Pearson's correlation coefficient was used. All statistical analysis was performed at a significant level of 5% (p-value < 0.05).

4. Results and Discussion

4.1 Result

All the data in this study were tested for normality by using Shapiro-Wilk due to the sample size included in this study being 10 (male:5, female:5). The result showed that the mean recall years and median were 7.7 ± 3.16 and 7 years respectively. The mean bone angle was 48.48 ± 8.18 degrees. The mean delayed volumetric shrinkage was 9.93 ± 3%.

To investigate the difference between groups, an independent-sample t-test was run to determine the delayed volumetric shrinkage of patients who undergo horizontal augmentation in the anterior esthetics area. The median was used as an indicator to classify the sample into 2 groups: group 1 was the sample who had recall years less than 7, and group 2 was the sample who had recall years equal to or more than 7 years. Group 1 (recall years less than 7 years) has a mean bone change of 7.71 ± 1.64%, and group 2 (recall years equal to or more than 7 years) has a mean of 12.15 ± 2.30. The result showed that the difference between groups 1 and 2 was significant at a p-value of 0.008 (p-value < 0.05), which means the patients who had recall years

equal to or more than 7 years had significantly more delayed volumetric shrinkage than the patients who had recall years less than 7 years.

To investigate the correlation of delayed volumetric shrinkage with recalled years and the patients' bone angles, the statistical tests were used differently depending on the normality test of each parameter. The recalled years have a normal distribution; therefore, Pearson's correlation coefficient was used for testing. The results showed a correlation between delayed volumetric shrinkage and recalled years, with a correlation coefficient of 0.802 and a significant level of 0.005 ($p-value \leq 0.05$).

The bone's angle did not have a normal distribution. For this reason, Sperman's correlation coefficient was used for testing. The results show there is no correlation between delayed volumetric shrinkage and bone angle, with a correlation coefficient of 0.273 and a significant level of 0.446 (p-value > 0.05).

Table 2: The overall data (percent bone change, recalled years)

Sample	Percent bone change (%)	Recalled years
1	7.77	3
2	8.68	4
3	9.86	6
4	5.79	6
5	6.46	6
6	8.47	8
7	12.48	10
8	12.65	11
9	14.86	11
10	12.27	12
Median	10.46	7
Mean ± SD	9.93 ± 3	7.70 ± 3.16

Table 3: The pre-operative volumes, recall visited volumes, and percent bone change.

	Volumetric measurement (N=10) Mean ± SD
V_1, mm^3	1442.36 ± 669.33
V_2, mm^3	1273.68 ± 569.06
$V_1 - V_2$ (%)	9.93 ± 3

V1 and V2: Pre-operative volumes and recall visited volumes respectively.
V1-V2 (%): Percentage of bone change.

Table 4: The patients' bone angles.

Sample	Bone angle (degrees)
1	39.80
2	49
3	42.50
4	46.10
5	65.50
6	50.40
7	57.70
8	47.20
9	48.40

10	38.20
Median	47.80
Mean ± SD	48.48 ± 8.18

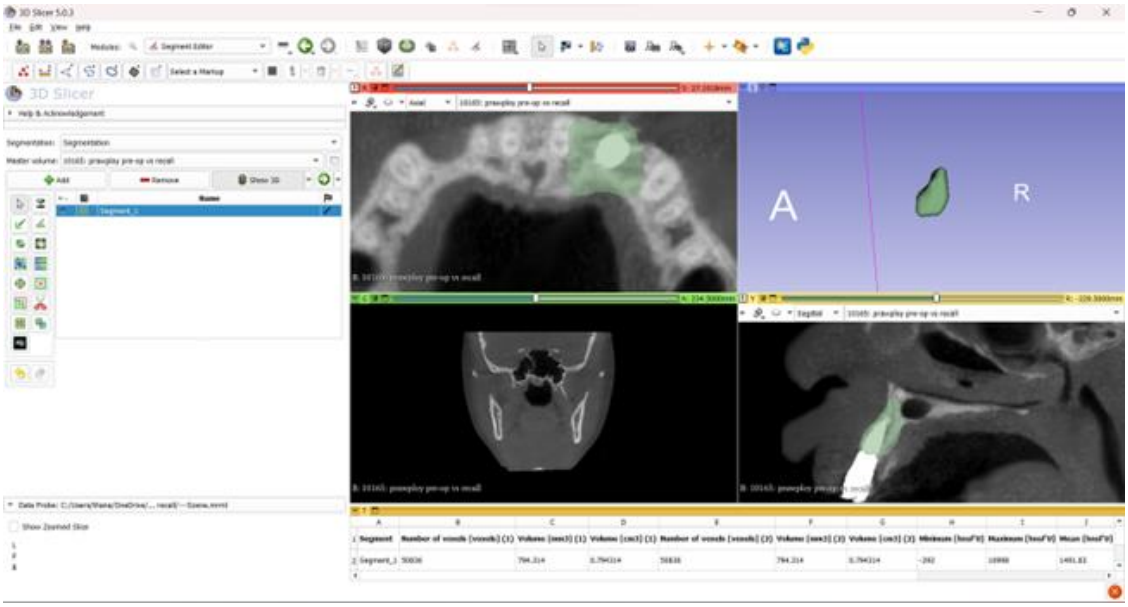

Figure 3: The volumetric measurements in recall visit by using imaging software.

4.2 Discussion

The prosthetically driven concept for dental implant planning is essential to achieving a successful treatment outcome. Compared between the maxilla and mandible, the resorption rate of basal bone after tooth extraction is more prevalent in the maxilla than the mandible. The purpose of this current study was to assess the delayed volumetric shrinkage of horizontal augmentation with an autogenous ramus block graft in the anterior esthetic area. In the present study, the results show that the mean percentage of delayed volumetric shrinkage was 9.93 ± 3%. We also found that there is a relationship between the recall years and the delayed volumetric shrinkage.

The resorption rates at implant sites augmented with mandibular bone blocks were reported by many studies, and to conclude, all of the results show the resorption rate ranges from 5 to 28%. (Alérico et al., 2014; Cordaro et al., 2010; Felice et al., 2009; Kim, 2015; Marianetti et al., 2016) One study reported that patients who underwent maxillary augmentation with a mandibular autogenous block graft after four months had a resorption rate of 22%. (Cordaro et al., 2010) Similar to the study of Felice et al. (2009), the results show that bone resorption from the original volume of autogenous onlay blocks was 25%. (Felice et al., 2009) Lumetti et al. (2014) reported a 28% resorption rate following autologous bone block grafting for symphysis or ramus for horizontal ridge augmentation (Lumetti et al., 2014). The rate of resorption between autogenous iliac particles and bone blocks was studied by Dasmah, Thor, Ekestubbe, Sennerby, and Rasmusson (2012). The result showed a remarkable resorption rate (80%) in both groups, even though the results did not reveal a statistically significant difference between them. (Dasmah et al., 2012) Compared to the present investigation, our result resorption rate was lower than studies by Dasmah et al. (2012) but still in the range of other studies (Alérico et al., 2014; Cordaro et al., 2010; Felice et al., 2009; Kim, 2015; Marianetti et al., 2016).

The removable provisional prosthesis could be one of the factors that may also be the cause of the reduced rate of resorption in the current study compared to earlier investigations. In our study, all cases of patients wearing a removable provisional prosthesis were adjusted to relieve space and prevent grafting site compression throughout the healing period. It is commonly known that any prosthesis supported by soft tissue has the potential to accelerate the rate at which the grafted and residual areas resorb. (Chiapasco, Gatti, & Gatti, 2006)

After the tooth was extracted, the alveolar process started to resorb, following the normal healing process. The classification of jawbone quality was also proposed by Lekholm and Zarb. (Bra-nemark, Zarb, Albrektsson, & Rosen, 1986) They divided the remaining alveolar bone in the anterior jaw regions into four categories based on its quality. The anterior esthetic area from the Leklhom and Zarb classification showed that the direction of alveolar process resorption in the upper jaw was upward and inward. In this study, the angulation of the patient's alveolar process was at a slightly sharp angle. The pattern of alveolar process resorption results in a change in patient skeletal classification from class I, and II, to class III. The angulation of the alveolar process is related to the palatal plane. The sharper the angle, the more proclination of the dental implant. This situation implies an increased chance of cemented retained type restoration than screw retainer types.

In this study, the examiner was investigating the contour of the donor site after an autogenous bone block graft, which can increase patients' basal bone angles and the correlation between delayed volumetric shrinkage. The residual crestal bone's alignment with the palatal plane was known as the bone angle. The method of measurement of bone angle in this study was modified from the previous study by López-Jarana et al. (2018) which used a horizontal line from labial bone and palatal bone as a reference to create an axis of alveolar bone and palatal plan. (López-Jarana et al., 2018) In relation to the angle of the root axis and basal bone axis, our research found that the mean of patients' bone angles was 48.48 ± 8.18 degrees. Several studies have investigated the delayed volumetric bone change after bone augmentation. In most of the earlier studies, measurements were made linearly, which increases the possibility of bias. (Alérico et al., 2014; Chiapasco, Casentini, & Zaniboni, 2009; Chiapasco, Gatti, & Gatti, 2007; Cordaro et al., 2010; Kim, 2015; Yu et al., 2016) In this study, the bone angle was measured digitally by using implant planning software to reduce error and bias. The outcome demonstrated that the percentage of delayed volumetric shrinkage and bone angle were uncorrelated. Because the autogenous ramus graft resorption rate was rapid, overgrafting was advised in all published studies to augment the bone defect sites and reduce the incidence of graft resorption.

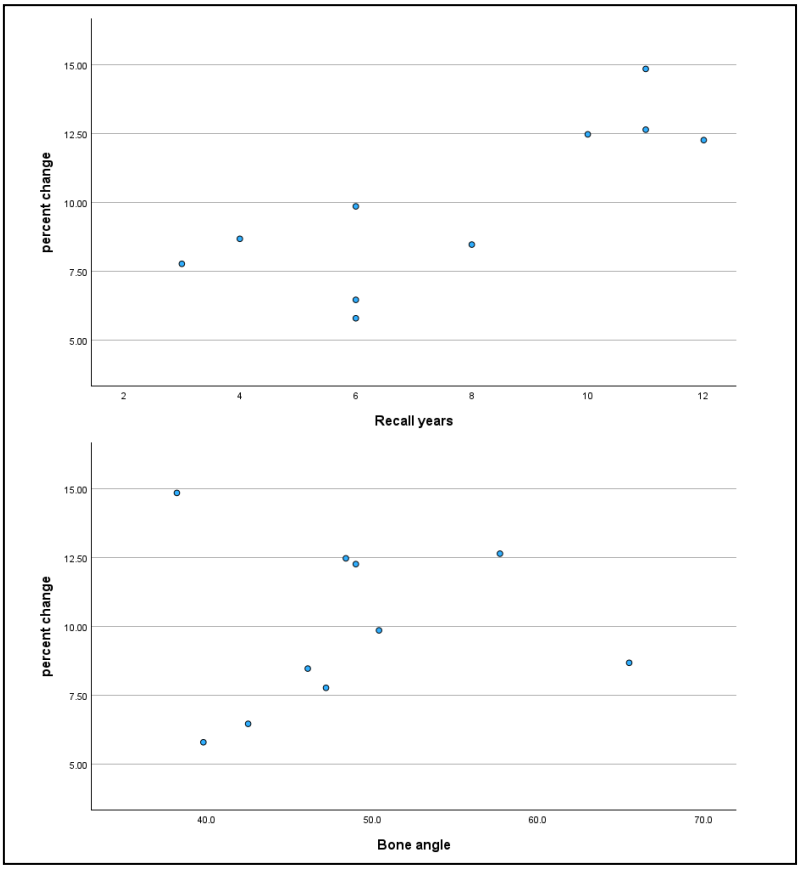

Figure 4: Graphs showing the correlation of percent bone change with bone angle and recall years.

The present study used CBCT images to evaluate treatment effects in 3-dimensional instead of utilizing a caliper, periodontal probe, or 2-dimensional radiographs like panoramic radiographs to make linear measures. A sufficient and reliable measurement set for the assessment of volumetric changes in alveolar crest grafts over time is not provided by 2D approaches. Furthermore, it is not possible to assess 3D changes precisely with these techniques. (Aghaloo, & Moy, 2007; Urban, Nagursky, & Lozada, 2011) After ridge augmentation, CBCT is a potentially reliable and consistently accurate 3D radiography method to get high-quality volumetric measurements. Therefore, to reduce the possibility of bias and inaccuracy, our study used imaging software to measure the volumetric shrinkage of the ramus block graft in three dimensions from the pre-operative and recall visited CBCT images.

The result of this study showed that there is a correlation between delayed volumetric shrinkage and recalled years but not a correlation with the patients' bone angles. Albrektsson et al. created criteria for assessing and evaluating the success and survival of implants. From one of those criteria, it was reported that there is a marginal bone remodeling of less than 2.0 mm in the first year after implant placement and less than 0.2 mm each year after. (Albrektsson et al., 1986) There are many factors that affect peri-implant bone loss, for example, infection like peri-implantitis, mechanical overload, implant geometry, connection design, and microgap. (Elsayed, 2019) Another important factor is patient maintenance and oral hygiene. If the patient comes for a recall, cleaning properly can improve implant life. Patients' bone angles affect the difficulty of bone augmentation techniques, for example, flap closure technique and overcontour grafting. Therefore, patients' bone angles had less direct effect on bone loss from the dental implant.

Due to the limitations of the retrospective study such as inadequate data collection, the CBCT scan periods in this study were pre-operative and recall visits. If the CBCT scan photos were taken at every recall appointment, the outcome would be clearer. The volumetric shrinkage rate of a ramus block graft can be determined annually. It should be mentioned that our study had numerous limitations because it was retrospective in nature. We only looked at the delayed volumetric shrinkage in our study. However, it is crucial to evaluate additional crucial elements of autogenous ramus block graft horizontal augmentation, like implant survival rate, soft tissue state, and esthetic score. Additionally, some of the CBCT images were lost and could not be opened due to the hospital transfer from analog to digital, and the sample size was too small. To further understand the impact of the volumetric shrinkage of the ramus block graft in the anterior esthetic area, future research with a larger sample size and CBCT scan images is necessary.

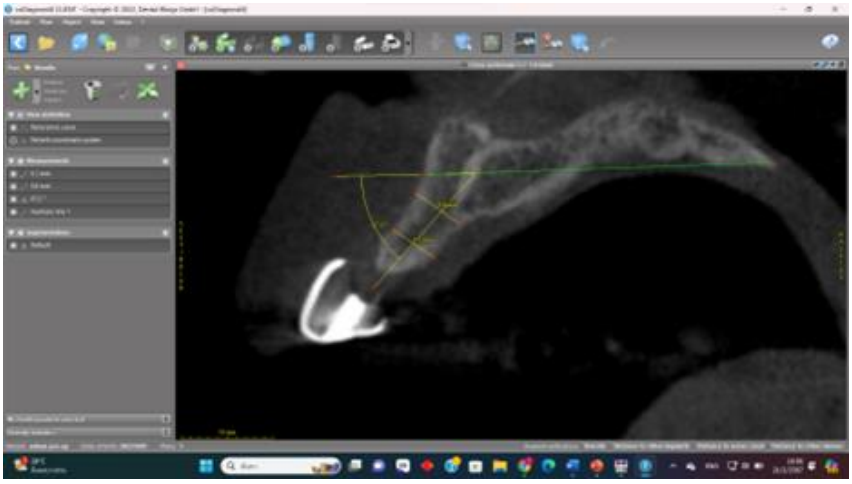

Figure 5: Bone angle measurements.

5. Conclusion

Within the limitations of this study, it could be concluded that the recall year has influenced delayed volumetric shrinkage of using autogenous ramus block graft for horizontal augmentation in the anterior esthetic area. Plus, there is no correlation between the percent of delayed volumetric change and patients' bone angles.

6. Acknowledgements

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