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## Pre-operative evaluation of the volume of bone graft in sinus lifts by means of CompuDent

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### Abstract

**Objective:** This study aims to evaluate the usefulness of the CompuDent program in determining the pre-operative volume of bone graft in maxillary sinus floor lifts, and to calculate the volume of graft necessary for rehabilitation using varying lengths of implants.

**Study design:** Based on the CompuDent program, we calculated the volume of graft necessary for 47 sinus lifts. This volume was measured in order to raise the floor of each sinus to 13.4 and 15 mm in height.

**Results:** The average volume of graft in order to achieve a lift of 13.4 mm was 2.42 cm<sup>3</sup> for the right maxillary sinus, with a range from 1.4 cm<sup>3</sup> to 4.1 cm<sup>3</sup>, and 2.50 cm<sup>3</sup> for the left maxillary sinus, with a range from 1.04 cm<sup>3</sup> to 3.79 cm<sup>3</sup>. The average volume of graft in order to achieve a lift of 15 mm was 3.01 cm<sup>3</sup> for the right maxillary sinus, with a range from 1.78 cm<sup>3</sup> to 4.59 cm<sup>3</sup>, and 3.09 cm<sup>3</sup> for the left maxillary sinus, with a range from 1.42 cm<sup>3</sup> to 4.49 cm<sup>3</sup>. The statistical results provided by the Pearson Correlation show a significant inversely proportional correlation between the average of the heights and the volume of graft in the sinus. In addition, there is a clear correlation between the average volumes to be grafted for the respective heights 13.4 mm and 15 mm.

**Conclusions:** The CompuDent program is an effective tool in determining the volume of bone graft given its simplicity, rapidness and possibility of standardization in all pre-surgical procedures.

**Key words:** Sinus lift, volume of graft, bone graft, CompuDent, maxillary CT scan.

**Introduction**

Since 1993, various softwares that enable pre-implant planning and performing volume measurements have been developed, combining CT images with computer design. However, the studies found in the literature, such as those published by Uchida et al. (1), or more recently by Krennmair et al. (2), do not use this software to measure the volume of bone graft needed for a floor lift of the maxillary sinus, rather they employ sophisticated methods that are difficult to extrapolate to routine use in pre-operative planning.

Recently, programs such as CompuDent have emerged, which has been designed for pre-implant diagnostic evaluation, offering new and better possibilities. During pre-operative evaluation, the use of this diagnostic tool would thus enable us to find out the volume of graft necessary, thereby reducing surgery time, as well as costs and patient expectations.

The objectives of this study are, firstly, to define the usefulness of the CompuDent program in determining pre-operatively the volume of bone graft needed for implant treatment, and secondly, to calculate the volume of graft necessary for rehabilitation using implants of varying lengths.

**Material and Methods**

This study involved a total of 32 patients (16 women and 16 men with an average age of 59.7 years and ranging in age between 38 and 78 years old) with unilateral posterior maxillary edentulism (N=17) or bilateral posterior

maxillary edentulism (N=15). Patients were included in this study after applying the established inclusion criteria: present posterior maxillary edentulism and a distance of less than 5 mm from the ridge crest to the maxillary sinus floor.

A CT scan of the jaw was performed for all patients using HiSpeed CT/E equipment with helical acquisition (GE Medical Systems), and was combined with the CompuDent program. After making all the necessary incisions, the width and height of the residual alveolar process was measured in the paraxial incisions using CT, selecting the incisions that ranged from the mesial incision where the maxillary sinus begins, up to the end of the maxillary tuberosity, adding up all the data and calculating the average.

Afterwards, on the panoramic and the various transversal scans selected, we marked the height up to which the sinus is to be lifted. In this study, we marked heights of 13.4 and 15 mm, as they are the measures that are most often used (2). We then marked the perimeter of the volume of graft desired on the panoramic measurement and in the transversal scans (Fig. 1), marking the height in each of the paraxial incisions and following the contour of the sinus until we obtained the total volume for each of the predetermined heights (Fig. 2 and 3).

**Results**

As for the age variable, we observed that the average age of the patients was 59.7 years old, with a range between 38 and 78 years old. The average age was 58.4 years

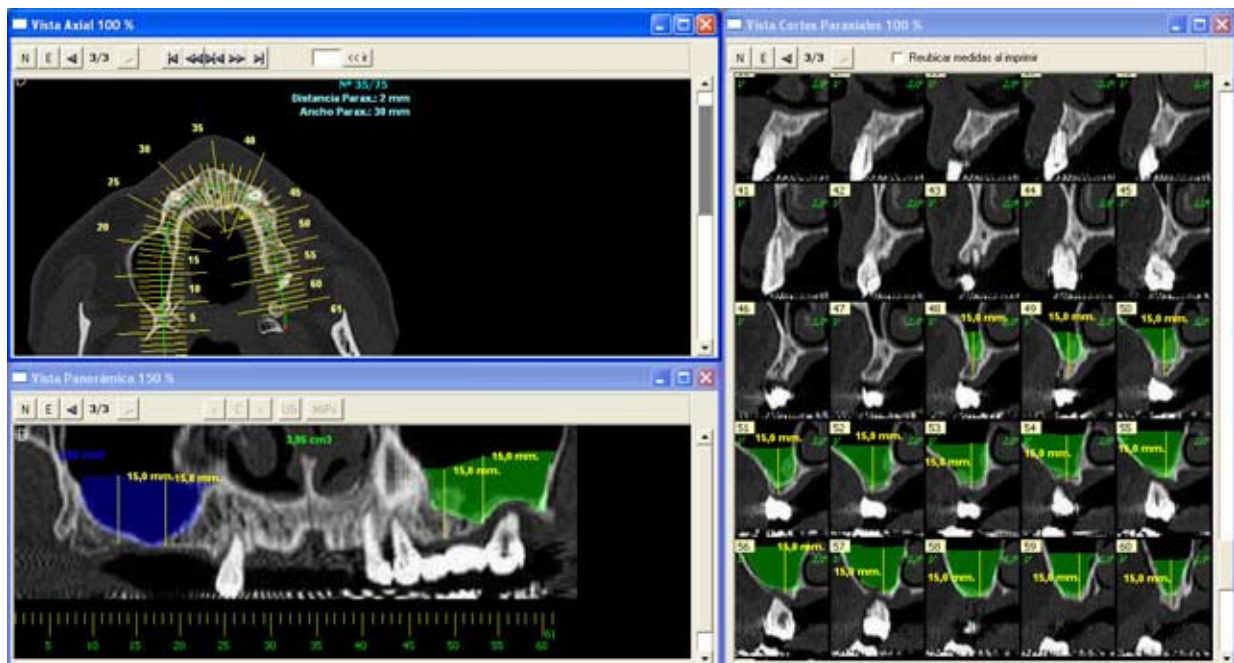


Fig. 1. Image of CompuDent in which the volume is measured for 15 mm.

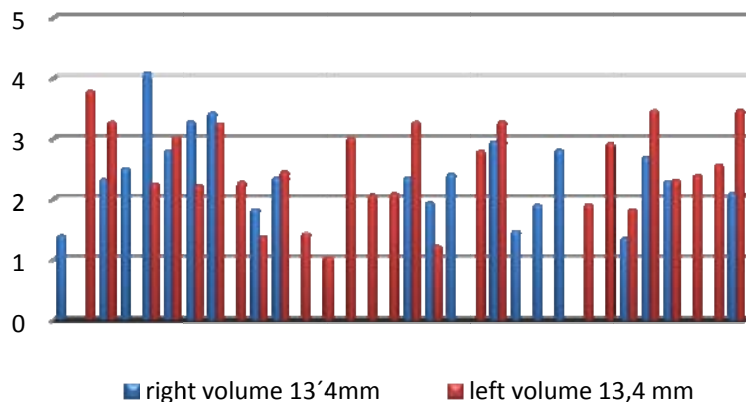


Fig. 2. Individual measurements of volume for lifts of 13.4 mm.

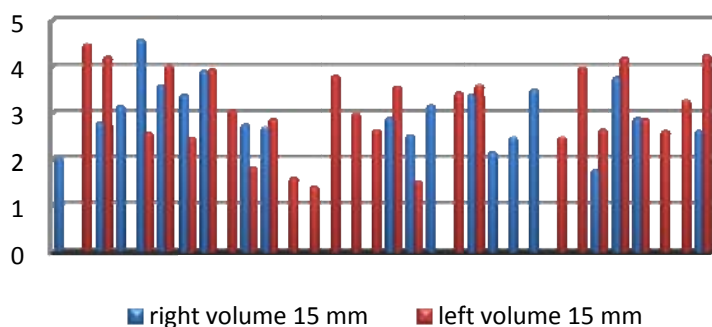


Fig. 3. Individual measurements of volume (n=47) for lifts of 15 mm.

old among women, and 60.9 years old among men, with ages ranging from 44 to 78 years old and from 38 to 74 years old respectively. The ANOVA of a factor allows us to detect that there are no statistically significant differences for 95% of the group with respect to the age of the individuals and the width, height, and volume of the graft.

With respect to the patient’s sex, we found that of the 32 subjects, 50% were male and 50% were female, which provides a 1:1 ratio. In this section, we have sought to assess whether the patient’s sex affects each of the factors analyzed. The Student T test for comparing two measurements allows us to assess that there are statistically significant differences up to 95% with respect to the patient’s sex and the right width ( $p = 0.016$ ), as well as the left volume for lifts of 13.4mm ( $p = 0.02$ ) and lifts of 15mm ( $p = 0.017$ ). By contrast, no significant differences are observed with respect to the left width, height, and the volumes of grafts on the right side.

In addition, we evaluated the edentulous region, obtaining a statistical difference of 46.9% in the bilateral sinus cases, 15.6% in the right sinus and 37.5% in the left sinus of the total cases analyzed. In this section, we also observed whether the patient’s unilateral or bilateral edentulism influences each of the factors analyzed. The

ANOVA of a factor showed that there are no statistically significant differences for 95% of the group with respect to the type of the patient’s edentulism and the width, height, and volumes of graft.

As for the presence or absence of hyperplasia in the maxillary sinus mucosa, we observed the presence of mucosal hyperplasia on the right side in 2 cases (6.3%), on the left side in 7 cases (21.9%), and this was observed to be bilateral in 18.8% of the patients.

With respect to the width of the alveolar ridge, we found that the average on the right side was 7.73 mm, with a range between 5.66 mm and 11.15 mm, whereas on the left side, the average was 7.65 mm, with a range between 3.98 mm and 11.27 mm. The width is greater in men than in women on both sides.

With respect to the width of the alveolar ridge, we found that the average on the right side was 4.83 mm, with a range between 2.79 mm and 6.51 mm, whereas on the left side the average was 4.58 mm, with a range between 2.58 mm and 7.03 mm. The height is greater on the right side in men than in women, whereas on the left side, the height is greater in women than in men.

In this study, as far as the average volume of graft in order to achieve a lift of 13.4 mm, this was observed to be 2.42 cm<sup>3</sup> for the right maxillary sinus, with a range

from 1.4 cm<sup>3</sup> to 4.1 cm<sup>3</sup>, and 2.50 cm<sup>3</sup> for the left maxillary sinus, with a range from 1.04 cm<sup>3</sup> to 3.79 cm<sup>3</sup>. The average volume is greater in men than in women for both maxillary sinuses.

On the other hand, the average volume of graft for achieving a lift of 15 mm was 3.01 cm<sup>3</sup> for the right maxillary sinus, with a range from 1.78 cm<sup>3</sup> to 4.49 cm<sup>3</sup>, and 3.09 cm<sup>3</sup> for the left maxillary sinus, with a range from 1.42 cm<sup>3</sup> to 4.49 cm<sup>3</sup>. The average volume is greater in men than in women for both maxillary sinuses.

Finally, we assessed whether the greater or lesser volume of graft could be influenced by the residual height or width. The statistical results provided by the Pearson Correlation show a significant inversely proportional correlation between the averages of the heights and volume of graft in the sinus. In addition, there is a clear correlation between the average volumes to be grafted for 13.4 and 15 mm. With regard to the relationship between the width of the alveolar ridge and the volume of graft, the Pearson Correlation indicates that is not a significant correlation between the two.

## Discussion

The implant is, at present, the technique of choice for the rehabilitation of edentulous spaces, and because of this, it is in constant evolution, seeking among other objectives, to increase its predictability. More and more software is being designed to assist the surgeon in planning and simulating the surgery to be performed, so as to minimize possible errors or setbacks during surgery. Following a tooth extraction, a bone loss occurs, which can result in moderate to severe resorption of the maxilla. This, in many cases, causes the residual alveolar ridge height to be insufficient for placing the proper length of implants.

In 1980, Boyne et al. (3) described the procedure for sinus floor lift by insertion of bone graft between the sinus floor and the alveolar process, with the aim of increasing the height available in the posterior section. In 1996, the Maxillary Sinus Consensus Conference (SCC) presented a review based on an extensive database of patients treated with this procedure (4). The purpose of the SCC was to examine the influence of different parameters on the success of the treatment. This conference resulted in an increase in the number of published articles that analyze the survival of implants placed in grafted sinuses, however no article discusses the volume of bone to be grafted. Autologous bone grafts are considered by many authors the ideal graft material for implant surgery (5-7). However, authors like Yamamichi et al. (8) observed in their studies that the highest failure rate was associated with this type of bone graft. They believe that this may be due to an inadequate volume of graft material, which is why it is essential to know the precise volume to be used.

In the bibliographic search conducted, we have not found any research paper similar to our study in which measurements were carried out using specific software programs for implant diagnosis. Therefore, the comparisons established below refer to measurements obtained in the maxillae of cadavers and CT using procedures designed by the authors. For example, Krennmair et al. (2) calculate the volume using the sum of the predefined dimensions of the pixels on the monitor.

This study was conducted on a sample population of 32 patients with unilateral or bilateral maxillary edentulism, which provided the study with a total of 47 maxillary sinuses to be studied. The sample size collected in this study, although not very high, is significantly more than that used by authors such as Uchida et al. (1), Krennmair et al. (2), and Gaggl et al. (9) who studied 20, 44 and 6 maxillary sinuses respectively, allowing a comparative analysis of the results to be made.

The average age of the patients studied was 59.7 years old, making our sample, in this respect, similar to the average age reported in the study conducted by Krennmair et al. (2), which was 53.1 years old. Moreover, according to the average ages of the patients used in several studies on sinus lifts, the population in which these procedures are most frequent is between 50 and 60 years old (10,11).

The second objective of this study was to estimate the volume of graft necessary for rehabilitation using implants of varying lengths. The statistical analysis shows that for lifts of 13.4 mm on the right side, the average volume was 2.42 cm<sup>3</sup>, with a standard deviation of 0.69 cm<sup>3</sup>, and minimum measurement of 1.4 cm<sup>3</sup> and maximum measurement of 4.1 cm<sup>3</sup>. For lifts of 15 mm on the same side, the average volume is 3.01 cm<sup>3</sup>, with a standard deviation of 0.68 cm<sup>3</sup> and minimum measurement of 1.78 cm<sup>3</sup> and maximum measurement of 4.59 cm<sup>3</sup>. For the left side, the average volume for lifts of 13.4 mm is 2.50 cm<sup>3</sup>, with a standard deviation of 0.75 cm<sup>3</sup>, and a minimum measurement of 1.04 cm<sup>3</sup> and maximum of 3.79 cm<sup>3</sup>. And for ipsilateral lifts of 15 mm, statistics show that the average volume is 3.09 cm<sup>3</sup>, with a standard deviation of 0.89 cm<sup>3</sup> and a minimum measurement of 1.42 cm<sup>3</sup> and maximum measurement of 4.49 cm<sup>3</sup>. These results contrast with those obtained by Uchida et al. (1) which report an average volume of 4.02 cm<sup>3</sup> for lifts of 15 mm. On one hand, this difference of 23.13% may be due to the fact that these authors used only axial CT without taking into consideration the height of the residual alveolar ridge, and secondly, they may also be explained by the complexity of the procedure used. In another study conducted by the same author (12), in which he measures the volume of graft necessary for a lift of 15 mm. on cadaver subjects, the results obtained were 3.5 cm<sup>3</sup>. These results are similar to ours, and therefore, we are able to use them as an indication

of the similarity between the results of the CompuDent program and the results obtained on actual maxillary sinuses.

Our study, like that of Krennmair et al. (2), measures the heights and widths of residual ridges in order to more accurately calculate the volume of graft. And with respect to the attempt to correlate the morphology of the residual alveolar ridge with the volume obtained, we would like to point out that the Pearson Correlation concluded that there is a significant relationship between the width and the volume of graft, preventing the establishment of a clinical correlation that would indicate a volume relationship according to the horizontal measurement of the ridge. However, it confirms that the volume depends on the residual height of the ridge, which seems obvious, and contrasts with the study conducted by Uchida et al. (1), which did not find this parameter to be important as it can cause a bias in the results.

Our attempt is to correlate all the parameters together and to show that there are no statistically significant relationships between the volume and the age and edentulous side of the subjects. These results are consistent with those obtained in a study by Uchida et al. (12), in which they employ a broader age range [46-94 years of age], which seems to confirm the absence of correlation at any age. A significant correlation has only been obtained for that of the sex of the subject and the volume of the left graft and the right width, which was observed to be higher for males; however, this data must be confirmed with a larger sample size.

Attempts by several authors (1,2,8) to establish procedures that would enable the surgeon to determine pre-operatively the amount of biomaterial needed to perform a sinus lift, allowing the rehabilitation of the antral region with implants of at least 11.5 mm in height, have not gained much traction. This may be due to the complexity of their methods, and as consequence, it may also be due to the difficulty of standardizing the procedure for consistency. Since software programs such as CompuDent first began to be developed, which pursue a comprehensive pre-operative plan in implant treatments, there are no references in the literature to its use in the field of sinus lifts. If we add this to the fact that there is a high demand for treatments of the posterior maxillary sinus requiring a maxillary sinus lift, it appears we need to examine these new tools we have at our disposal.

There are numerous studies that examine the results of sinus lifts and the success of osseointegration of dental implants placed in these areas. However, there is an important parameter that they do not take into account, and that is the volume of the graft, in order for rehabilitation with implants to be predictable by establishing the size prior to performing the sinus lift implant, particularly given that their success hinges, among other

factors, on the length of the implants (5,13,14). This study was conducted on the use of CompuDent in the pre-operative evaluation of sinus lifts, it being evident that the results are similar to those published by other authors. This program is a tool that can be quickly and easily used, which is why we present it as a useful tool for surgeons. However, we only analyze the volume before performing the surgery. Therefore, it would be interesting to correlate these predictions of the volume with the post-operative volume measured using CompuDent, and with the resorptions that have occurred at the time of implant placement.

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