

# COMPUTER EVALUATION OF THE CHANGES IN THE BUCCAL BONE PLATE IN THE FRONTAL MAXILLA DURING IMMEDIATE IMPLANTATION WITH AND WITHOUT THE USE OF GRAFT MATERIALS

## КОМПЈУТЕРСКА ЕВАЛУАЦИЈА НА ПРОМЕНИТЕ НА ВЕСТИБУЛАРНАТА КОСКЕНА ЛАМИНА ВО ФРОНТАЛНА МАКСИЛА ПРИ ИМЕДИЈАТНА ИМПЛАНТАЦИЈА СО УПОТРЕБА И БЕЗ УПОТРЕБА НА ГРАФТ МАТЕРИЈАЛИ

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### Abstract

**Introduction:** Planning and placement of dental implants in the aesthetic zone represents a great treatment challenge due to the fact that patients often evaluate the overall therapeutic success based on the aesthetic result and have high aesthetic criteria and expectations. The buccal bone plate, as one of the key anatomical structures, is of great importance for the success of implant therapy in the frontal maxilla and is particularly prone to changes that occur post-extraction. One way to preserve the buccal bone plate is to place an immediate implant at the extraction site. Immediate implantation is combined with various bone augmentation techniques to maintain the thickness of the buccal bone plate over a long period of time. **Aim of the study:** To analyze buccal bone plate changes, via CBCT images and computer software, that occur in all dimensions, at different time periods, in patients in which immediate implantation was performed, with and without graft material. **Material and method:** The bony changes of the buccal bone plate in horizontal and vertical direction were analyzed in 40 patients divided into two groups of 20 patients who underwent immediate implantation in the anterior maxilla without bone augmentation, and 20 patients who underwent immediate implantation with bone augmentation. **Results:** Analysis of buccal bone plate changes showed that the greatest changes are observed in patients who underwent immediate implantation without using augmentation techniques, with pronounced resorption of the buccal bone plate in all dimensions. The greatest changes in the horizontal dimension were observed in position 1, where the initial average dimension of 1.51 mm decreased to 0.47 mm in 12 months. In contrast, in the second group of patients in the same position, 6 months after implantation, the average values ranged from 1.29 mm - 1.38 mm, to 1.06 mm after 12 months. Changes in the vertical dimension after 12 months of implantation, in the first group, occurred in 60% of the patients that had changes in the vertical dimension ranging from 1.1 - 3.2 mm. In the second group of patients, the changes that occurred after 6 months remain stable after 12 months, ranging from 1 to 1.4 mm on average. Over time, in the first group the bone density has a milder growth, in contrast to the group of patients where bone augmentation was performed. Nevertheless, the most characteristic changes are in position 0 where, for the first group of patients, the bone density decreased from 830Hu at the beginning to 426Hu, and in the second group from 516Hu, it increased to 714Hu, for the same period of time. **Conclusion:** Stability in all dimensions of the buccal bone plate was achieved in those cases where implantation was combined with bone augmentation. Compensating the empty spaces and dehiscences of the buccal bone plate with biological and biocompatible materials visibly increases the buccal bone plate clinically, radiologically and statistically, thus improving the prognosis of placed implants. **Key words:** immediate implantation, buccal bone plate, bone augmentation, aesthetic zone, CBCT.

### Апстракт

**Вовед:** Планирањето и поставата на денални импланти во естетската зона претставува голем терапевтски предизвик поради фактот што пациентите често, врз основа на естетскиот резултат, го проценуваат целокупниот тераписки успех и имаат високи естетски критериуми и очекувања. Букалната ламина како една од клучните анатомски структури е од голема важност за успех на имплантолошката терапија во фронталната максила и е особено склона на промени кои настануваат постекстракционо. Еден од начините да се зачува булакната ламина е да се постави имедијатно имплант на самото место на екстракција. Иmediјатната имплантација се комбинира со различни техники на коскена аугментација за да се задржи дебелината на булакната ламина во долг временски период. **Цел на трудот:** Да се анализираат промените на вестибуларната ламина, преку CBCT снимки и компјутерски софтвер, кои настануваат во сите димензии, во различни временски периоди, кај пациенти кај кои имедијатно се поставени импланти со користење и без користење на техники на коскена аугментација. **Материјал и метод:** Анализирани се коскените промени на вестибуларната ламина, хоризонтална и вертикална насока, кај 40 пациенти поделени во две групи по 20 пациенти кај кои е изведена имедијатна имплантација во предна максила без аугментација и 20 пациенти кај кои е изведена

имедијатна имплантација со аугментација. **Резултати:** Анализата на промените на вестибуларната ламина покажа дека најголеми промени постојат кај пациентите кај кои е изведена имедијатна имплантација без да се користат техники на аугментација, со нагласена ресорпција на вестибуларната ламина во сите димензии. Најголеми промени во хоризонталната димензија се забележаа во позиција 1 кадешто почетната просечна димензија од 1,51мм, за 12 месеци се намали на 0,47мм. За разлика од неа, кај втората група на пациенти во истата позиција, 6 месеци по имплантација просечните вредности се двејак од 1,29мм - 1,38 мм, до 1,06мм по 12 месеци. Промените во вертикалната димензија по 12 месеци од имплантација, во првата група, кај 60% од пациентите имаше промени на вертикалната димензија кои се движеа од 1,1 - 3,2мм. Кај втората група на пациенти промените настанати по шестиот месец остануваат и по 12 месеци, кои се движат од 1 до 1,4мм во просек. Со текот на времето, коскениот дензитет во првата група има поблаг раст, за разлика од групата на пациенти кадешто е извршена коскена аугментација, но најкарактеристични промени има во позиција 0 кадешто за првата група на пациентите коскениот дензитет од 830Hu на почетокот се намалил до 426Hu, а кај втората група од 516Hu, се зголемил до 714Hu, за истиот временски период. **Заклучок:** Стабилност во сите димензии на вестибуларната ламина се постигна кај оние случаи каде имплантацијата беше комбинирана со аугментација. Надоместувањето на празните простори и дехисценции на вестибуларната ламина со биолошки и биокомпатибилни материјали, видно клинички, рентгенолошки и статистички ја зголемува букалната ламина, со што ја подобрува прогнозата на поставените импланти. **Клучни зборови:** имедијатна имплантација, вестибуларна ламина, коскена аугментација, естетска зона, компјутеризирана томографија.

## Introduction

The planning and placement of dental implants in the aesthetic zone represents a great therapeutic challenge, especially due to the fact that patients, often based on the aesthetic result, evaluate the overall therapeutic success and have high aesthetic criteria and expectations<sup>1</sup>. The aesthetic benefit will be complete and desirable only if the peri-implant soft and hard tissues are minimally traumatized during implantation<sup>2</sup>.

Immediate implantation in the anterior maxilla is one of the most desirable and effective therapeutic procedures for solving toothlessness in the anterior maxilla<sup>3</sup>. This type of implantation, as a treatment method for compensation of teeth in the anterior maxilla, reduces the time period for prosthetic rehabilitation and gives excellent aesthetic results, if well planned and analyzed<sup>4</sup>.

The buccal bone plate, as one of the key anatomical structures, is of great importance for the success of implant therapy in the frontal maxilla, and is particularly prone to changes that occur post-extraction<sup>5</sup>. One of the ways to preserve the buccal bone plate post-extraction is to immediately place an implant at the site of extraction, although this will not prevent its resorption, but will only slow it down over time<sup>6</sup>. Previous research shows that the thinner the buccal bone plate, the more pronounced its resorption will be post-extraction. Therefore, to overcome these processes, immediate implantation is often combined with bone augmentation techniques<sup>7</sup>. In the last 40 years, various methods and techniques of bone augmentation have been described and performed, but it seems that most successful are the combined methods that use combined biomaterials for augmentation, from autograft and xenograft, due to the osteoinductive and osteoconductive effect<sup>8</sup>.

## Material and methods

Bone changes of the buccal bone plate were analyzed in 40 patients divided into two groups:

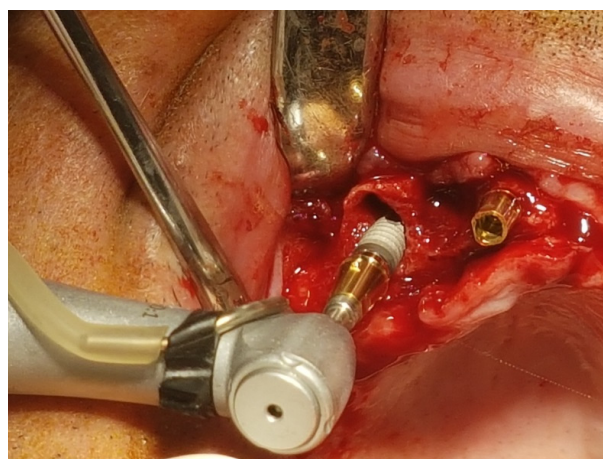
**GROUP 1 (III)** - 20 patients who underwent immediate implantation in the anterior maxilla without bone augmentation.

**GROUP 2 (II2)** - 20 patients who underwent immediate implantation with bone augmentation.

A detailed medical history was taken from all patients, based on which the patients included in the study were selected. Patients under 18 years of age, patients with acute diseases, patients on anticoagulant therapy, patients who do not maintain oral hygiene and patients who have bruxism were excluded from the study.

The surgical protocol included atraumatic extraction of the tooth under local anesthesia

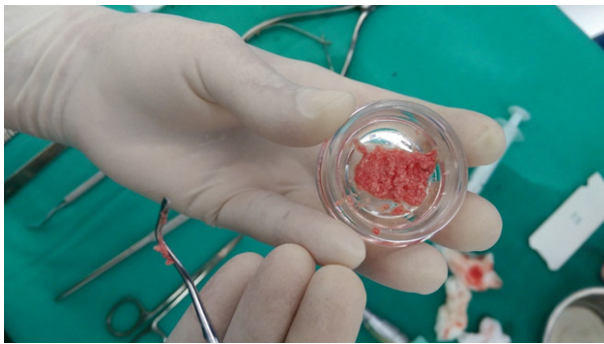
(Artinibsa 4% - Inibsa Dental Spain), and then, with a selected flap design, all the bone structures of the region with visible 4 alveolar walls were exposed: buccal bone plate, palatal bone plate, and interalveolar septa mesially and distally. The bearing of the implants was made with a slight palatal tilt in the empty alveolus, according to the protocol for implantation in the anterior maxilla. For the preparation of the implant beds, physiodispenser (KaVo Intrasurg 300 – Germany) was used, with constant cool-



**Figure 1.** Immediate implant placement in the fresh post extraction socket



**Figure 2.** Immediate implant placement with bone augmentation



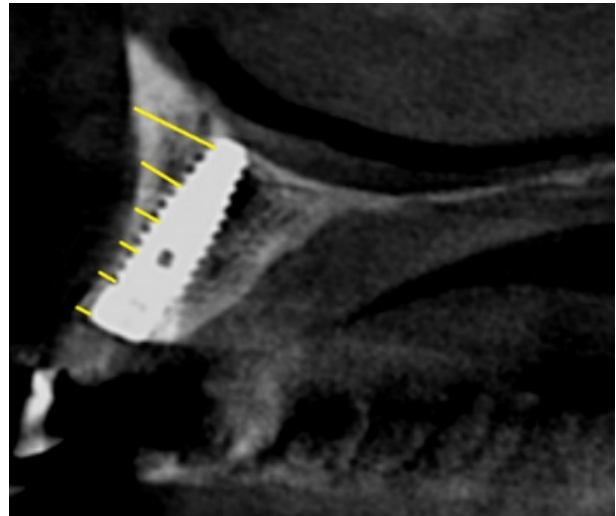
**Figure 3.** Xenograft and autograft material mixture

ing with saline, and a conventional implantology set. The dimensions of the placed implants were 3.8x12mm, and they were from the same manufacturer. The criteria for using bone augmentation was the presence of bone defects and dehiscences of the buccal bone plate as well as the presence of a space (gap) between the external surface of the implant and the buccal bone plate larger than 2 mm (Figure 1). In those cases, a mucoperiosteal flap was elevated (Figure 2), deperiosteation was performed, and xenograft material (BioOss Geistlich Pharma AG Switzerland) and collagen membrane (BioGide Geistlich Pharma AG Switzerland) were placed, in combination with autograft material provided during preparation of the implant site (Figure 3). All study implants were loaded 6 months after the period of osseointegration. During that period, a temporary partial aesthetic denture was made.

Antibiotic therapy, anti-edematous therapy and analgesic therapy were prescribed for each patient postoperatively.

### Radiographic examinations

Postoperative radiological examinations and implant therapy planning were performed based on 3D images

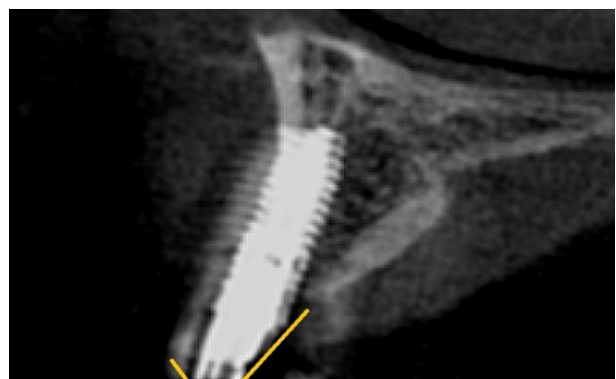


**Figure 4.** Sagittal section of the upper jaw showing 6 points for measuring the horizontal dimension

recorded with Rotograph Prime 3D - (Villa systemi medicali Italy). The exposure time for 3D CBCT images with this device was 21.2 seconds, with a tube strength of 2 to 12.5 mA. The nominal tomographic thickness of the sections is 0.175 mm, with a maximum permissible deviation of  $\pm 10\%$ .

The resolution of the images has a size per voxel of 87.5  $\mu\text{m}$  and an image reception area of 144x118.6. The 3D analysis of sagittal sections and measurements was made using Villa 3D Planner software, on the day of implantation, 6 and 12 months postoperatively. Three parameters were analyzed, as follows:

**Horizontal dimension (HD)** - represents the dimension from the external surface of the implant to the buccal bone plate. It is measured from the implant platform starting from position 1 moving apically to positions 3, 6, 9, 12 and position 15 every 3 millimeters, for a period of 0 months, 6 months and 12 months, expressed in millimeters (Figure 5).



**Figure 5.** Sagittal section of the upper jaw showing points for measuring the vertical dimension

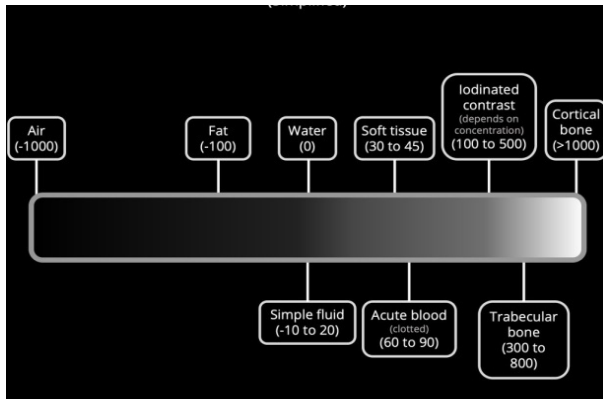


Figure 6. Hounsfield Scale

**Vertical dimension (VD)** - is a dimension measured from the platform of the implant (position 0) to the most coronal part of the alveolar bone, measuring the loss, or resorption of bone tissue from the buccal and palatal side, expressed in millimeters.

**Bone density (BD)** - is measured in three positions:

- 0 position - bone plate at the level of the implant platform
- 1 position - bone plate at the level of the middle of the implant
- 2 position - bone plate at the apical level of the implant

The values are expressed in HU (Hounsfield Units), according to the scale of the same name - Hounsfield Scale (Figure 6).

### Statistical analysis

In the attributive variables (gender), the difference of the distributions between the II1 and II2 groups was made with Pearson's chi-square test and Fisher's exact test. Differences between distributions of continuous numerical variables were tested with the parametric Student's t-test for two independent samples or the non-parametric Mann-Whitney U test for two independent samples. All tests were performed with a significance level of 5% ( $p=0.05$ ).

### Results

The structure of groups according to gender showed that immediate implantation without augmentation in (II1) was male-dominated, while the gender distribution in immediate implantation with augmentation (II2) had equal representation. (Diagram 1)

According to medical anamnesis, i.e. representation of patients with comorbidities, the most common comorbidities in both groups were patients with high blood pressure,

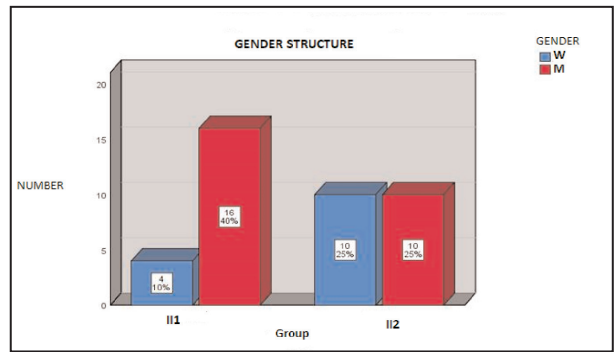


Diagram 1.

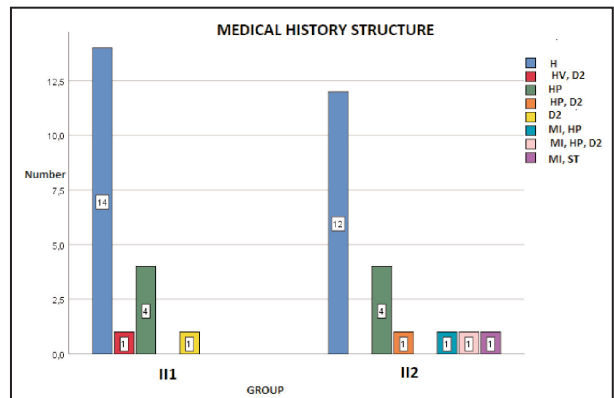


Diagram 2.

while the distribution of other comorbidities was equally distributed. Most of the patients in both groups were without comorbidities: II1 – 70% and II2 – 60%. (Diagram 2)

According to the age variable, the average age of the patients in the first group was 56.5 years, and in the second it was 55.4 years.

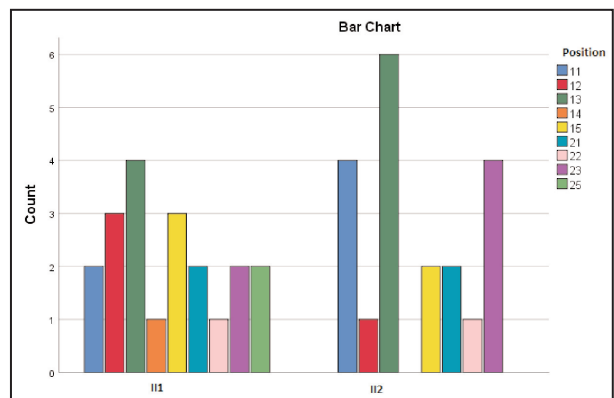


Diagram 3.

According to the position of the placed implant in the first and second groups, the largest number of placed implants is at position 13. The smallest number of placed implants is at positions 14, 12 and 22.b (Diagram 3)



**TABLE 1.** – Average values of horizontal dimension for different positions and periods (in mm)

Position	II1/ HD0	II1 / HD0	II1 / HD6	II2 / HD6	II1/HD12	II2/HD12
1	1.51	1.29	0.53	1.38	0.45	1.4
3	1.44	1.37	0.89	2.1	0.67	2.05
6	1.5	1.69	1.3	2.2	1.2	2.2
9	1.6	2.0	1.4	2.2	1.4	2.3
12	1.8	2.1	1.7	2.3	1.7	2.2
15	2.6	2.4	2.5	2.4	2.5	2.4

The obtained average results of measuring the horizontal dimension of the buccal bone plate (HD) for different periods (0, 6 and 12 months) showed that changes in the horizontal dimension of the buccal bone plate in both groups took place mostly in position 1.3 and 6 in all time intervals (table 1).

The changes in the horizontal dimension in the first group of patients, in position 1 on the day of implantation (period 0) have a value of 1.51 mm, which indicates the existence of a bony intact buccal bone plate at the level of the shoulder of the implant, whereas in the second group, the average value is 1.29 mm, in the same position, which is not statistically significant by itself, but in part of the patients of that group, dehiscence, lack of buccal bone plate at the level of the shoulder of the implant is observed, which is the basis for using an augmentative technique complementing the implantation.

From the values obtained 6 months after implantation, for the same positions, it can be concluded that we have statistically significant differences, i.e. the average value of 0.53 mm in the II1 group at position 1, at the level of the shoulder of the implant, indicates large resorptive processes of the buccal bone plate. Compared to the II2 group, the average value was 1.38 mm, which is not sta-

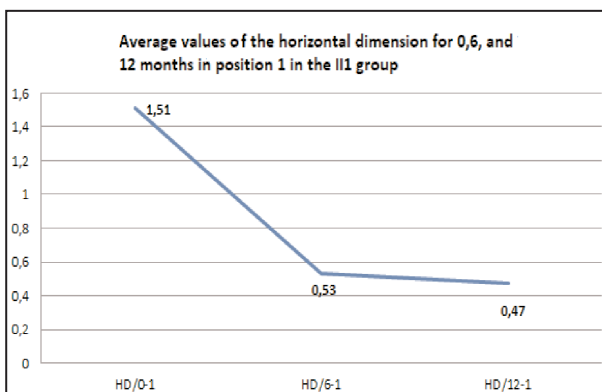
tistically different from the initial average value and is stable in relation to the day of implantation, but it was clearly different from the values obtained at 6 months in relation to the first II1 group

From the obtained values 12 months later, in the same positions in the II1 group, a slight decrease is observed in the II1 group, while in the II2 group the values remain the same or are slightly increasing. (Chart 1a and Chart 1b)

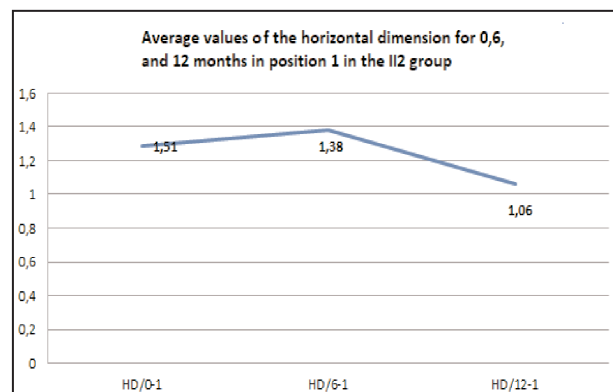
The changes in the horizontal dimension in the first group of patients, in position 3 on the day of implantation (period 0) have a value of 1.44 mm, while in the second group the average value is 1.37 mm in the same position.

The changes in the horizontal dimension in the first group of patients, in position 3 (period 6) have a value of 0.89 mm, while in the second group the average value is 2.1 mm in the same position, which indicates a loss of the buccal bone plate, in the first group II1, and a slight increase in the second group where augmentative techniques were performed.

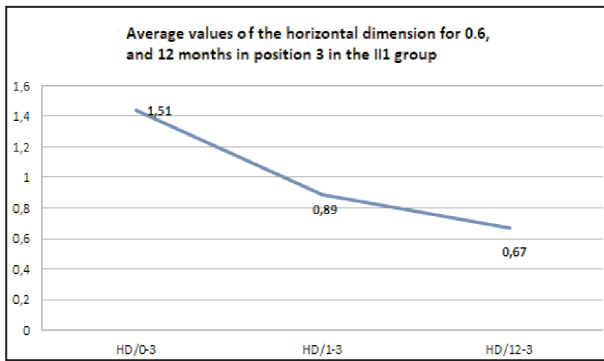
The changes in the horizontal dimension in the first group of patients, in position 3 for a period of 12 months have a value of 0.67 mm, while in the second group the average value is 2.05 mm in the same position, which indicates a loss of the buccal bone plate, in the first group



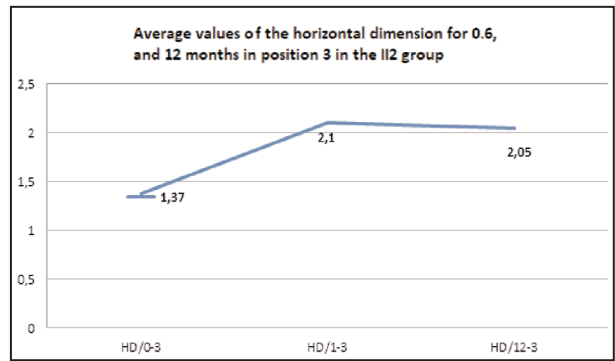
**Chart 1a**



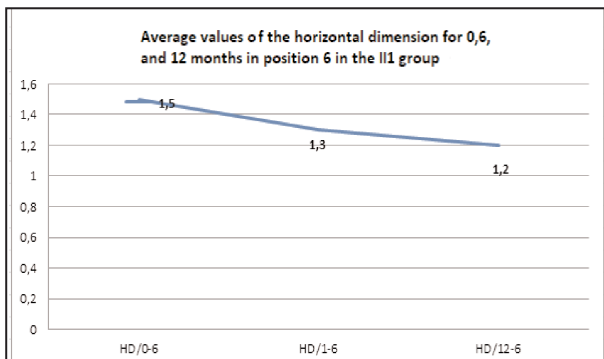
**Chart 1b**



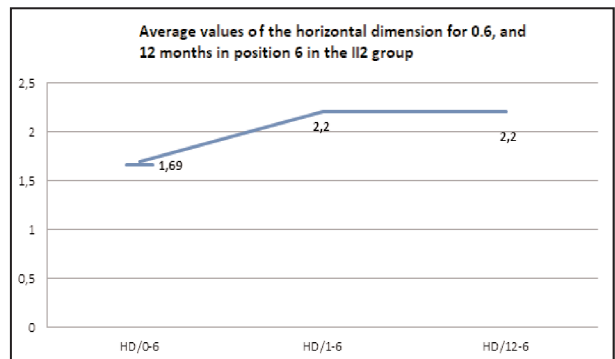
**Chart 2a**



**Chart 2b**



**Chart 3a**



**Chart 3b**

II1, while the values in II2 are stable, indicating the absence of bone resorption 12 months after implantation. (Chart 2a and Chart 2b).

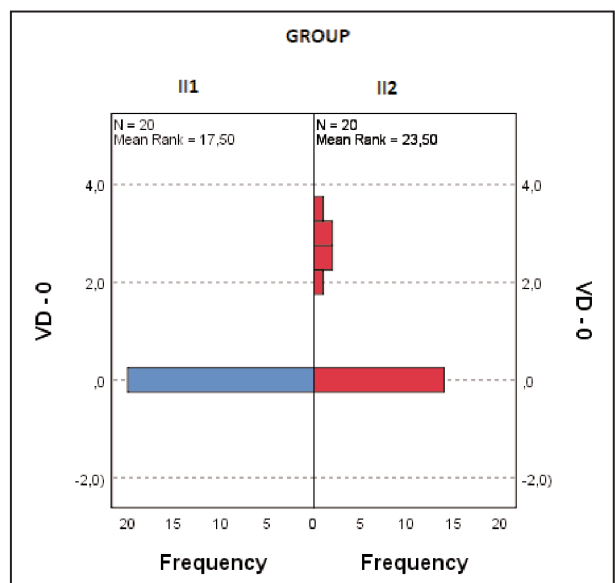
The changes in the horizontal dimension in the first group of patients, in position 6 on the day of implantation (period 0) have a value of 1.5 mm, while in the second group the average value is 1.69 mm in the same position.

The changes in the horizontal dimension in the first group of patients, in position 6 (period 6) have a value of 1.3 mm, while in the second group the average value is 2.2 mm in the same position, which indicates a slight decrease in the dimensions of the buccal bone plate, in the first group II1, and a slight increase in the second group where augmentative techniques were performed. The changes in the horizontal dimension in the first group of patients, in position 6 for a period of 12 months, have a value of 1.2 mm, while in the second group the average value is 2.2 mm in the same position of the absence of evident changes, i.e. that in both groups the buccal bone plate has stable dimensions 12 months after implantation (Chart 3a and Chart3b).

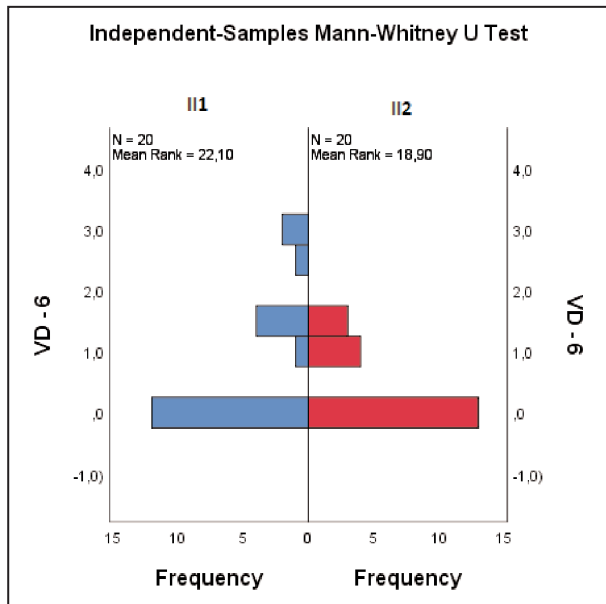
From the obtained results, of the measurement of the vertical dimension, it can be concluded that in the first group II1, at the time of placement of the implants (period 0), there is no vertical loss of the buccal bone plate. In 70% of the second group of patients (II2) there was no

buccal bone plate loss, and in 30% the loss ranged from 1.9 to 3.9mm (Diagram 4 - Mann Whitney U Test 1).

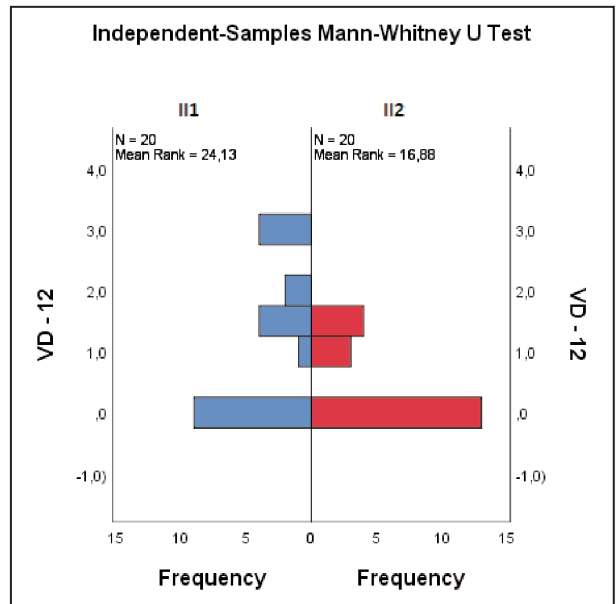
6 months after implantation, in the first group II1, in 12 patients (60%) there was no vertical loss of the buccal bone plate, and in 8 patients (40%) the loss ranged from 1.1 to 3.2 mm. In the second group II2, in 13 patients



**Diagram 4. Mann Whitney U Test 1**



**Diagram 5.** Mann Whitney U Test 2



**Diagram 6.** Mann Whitney U Test 3

(65%) there was no vertical loss, and in the remaining 35% the loss ranged from 1.0 to 1.4 mm. (Diagram 5 - Mann Whitney U test 2)

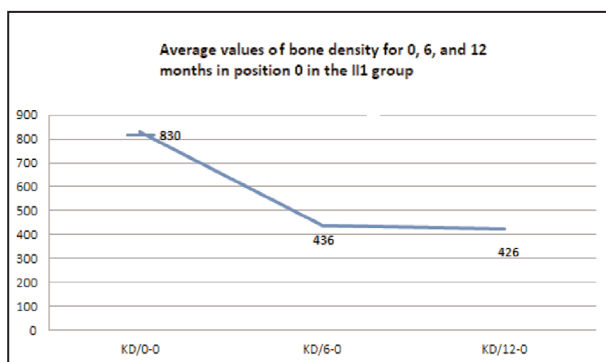
Twelve months after implantation in the first group II1, in 8 patients (40%) there are no vertical changes, and in 12 patients (60%) the changes range from 1.1 to 3.2

mm. In the second group of patients (II2), the changes that occurred in 6 months remain after 12 months. (Diagram 6 - Mann Whitney U Test 3)

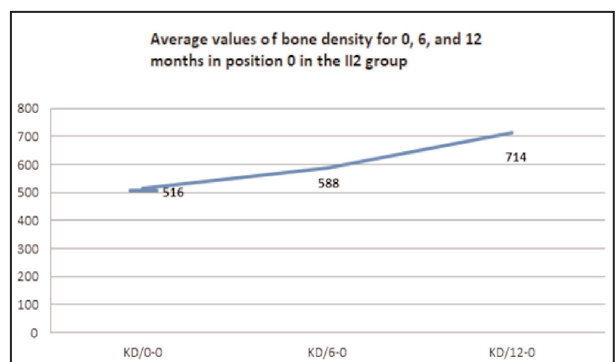
Table 2 shows the average values of bone density, measured in three positions (0, 1 and position 2) for three periods (0 months, 6 months, 12 months).

**TABLE 1.** Average values of bone density (in Hu)

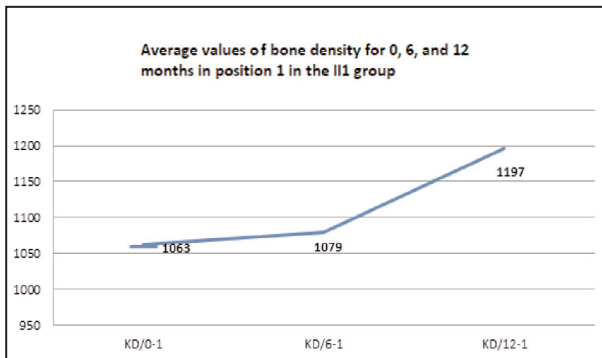
	Position 0		Position 1		Position 2	
	II1	II2	II1	II2	II1	II2
0 months	830 Hu	516 Hu	1063 Hu	809 Hu	1299 Hu	1188 Hu
6 months	436 Hu	588 Hu	1079 Hu	1137 Hu	1364 Hu	1420 Hu
12 months	426 Hu	714 Hu	1197 Hu	1403 Hu	1498 Hu	1621 Hu



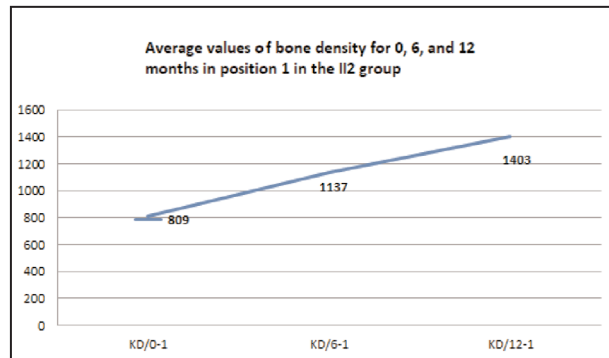
**Chart 4a**



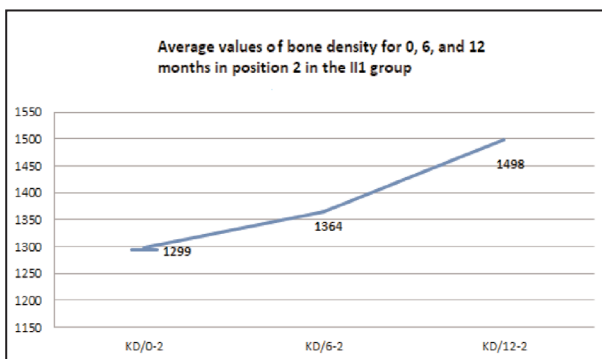
**Chart 4b**



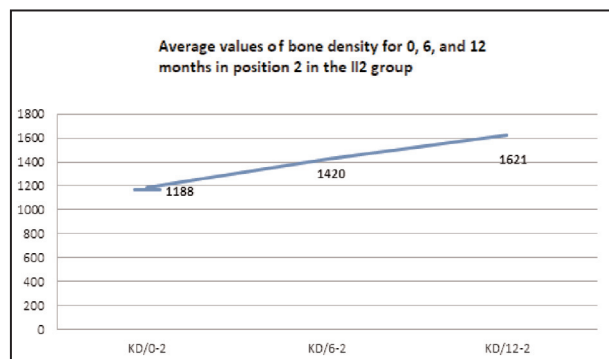
**Chart 5a**



**Chart 5b**



**Chart 5c**



**Chart 5d**

The bone density on the day of implantation in the position 0 in the first group II1 is 830 Hu, and 516 Hu in the second group. Six months later, the bone density in the first group II1 decreases by about 50% and is 436 Hu, while in the second group it increases slightly. After 12 months, in the first group it remains the same or slightly decreases, and in the second group it increases. (Chart 4a and Chart 4b)

In position 1 and 2, i.e. the middle and the apex of the implant, the bone density increases over time (Chart 5a, Chart 5b, Chart 5c and Chart 5d)

## Discussion

Although there are several ways to compensate for toothlessness in the frontal maxilla, the most preferred method is immediate implantation. Immediate implantation, as an implant placement technique, is a subject to strict criteria that begins with the extraction of the tooth. The benefits of immediate implantation are multiple, especially for the buccal bone plate<sup>9</sup>. This method of implantation slows down the resorption processes of the buccal bone plate, and thus of the alveolar ridge as a whole<sup>10</sup>. The difficulties that occur during this type of implantation are often related to achieving the correct position of the implant, as well as managing the space

(gap) between the implant and the buccal bone plate, which represents a medium that will further dictate the resorptive and regenerative processes of the buccal bone plate<sup>11</sup>. That is why implantation is often combined with augmentative techniques that aim to correct all its deficiencies. It has been experimentally proven that regardless of the method of implantation, the resorptive processes of the buccal bone plate continue even after placement of the implants. It is important to take into account the fact that immediate implant placement is always the therapy of choice provided there is an intact alveolus with adequate dimensions and intact 4 alveolar walls<sup>12</sup>.

In our study, we analyzed the horizontal and vertical dimensional changes of the buccal bone plate in patients with immediate implants the anterior maxilla. In the patients where the implant was placed without using the augmentation technique, large resorptive differences were observed in relation to the initial state and the state after 6 and 12 months, where the average values for the horizontal dimensions decreased almost twice, and that in the first group, from an average of 1.51 to .47mm, for the first two positions 1 and 3. This correlates with the studies of Jan Cosyn<sup>13</sup>, who analyzed 32 patients who had immediate implants placed in the anterior maxilla over a period of 3 years. In all of them, there were almost double resorptive differences that went parallel to mesial and distal loss



(1.13 mm and 0.86 mm). In our studied group of patients, the greatest buccal bone loss existed in the first year postoperatively. Berberi et al.<sup>14</sup> also analyzed marginal bone loss in immediately placed implants in the anterior maxilla. 20 patients with 20 immediately placed implants were analyzed. Evaluation of bone marginal changes was performed 8 weeks after implantation, 1 and 3 years postoperatively. The mean value of the marginal bone loss (vertical dimension) at 8 weeks postoperatively was 0.16mm, at one year 0.275 mm, and after three years 0.265 mm. Berberi concluded that the greatest bone resorption takes place in the first year post-implantation, following which there is a stabilization of the results, similar to our study. In those patients where we used an augmentation technique, and where a mix of xenograft and autograft was placed in the empty space, and dehiscences from the buccal side of the implant, these resorptive changes were mild and poorly expressed. It should be noted that in both groups there was resorption of the buccal bone plate, but in the second group of II2 patients, that resorption was compensated by the apposition of newly created bone tissue. Thus, the horizontal dimension increased in the second group of patients after 6 and 12 months, and decreased in the first group of patients, for the same time interval. This trend of resorption of the buccal bone plate in the vertical direction also runs in the same time. In patients where no augmentation technique was used, resorption is much more pronounced after 6 and 12 months.

In addition, the augmentative material in the second group does not stop the loss of the vertical dimension, but apparently stabilizes it and visibly slows it down after a period of 6 and 12 months. However, the resorption of the buccal bone plate has been shown not only to depend on the augmentative material, but also on the slight palatal position of the implant in the alveolus. In all patients in whom there was a slight palatal tilt, the buccal bone plate was preserved and the resorption was minimal, which is similar to the study of Cosyn<sup>13</sup>, where the slightly palatally placed implants explained the achieved aesthetic moment and the preservation of facial contours despite the varying loss of the buccal bone plate and the marginal bone. Although bony dehiscences were present, healthy peri-implant buccal tissue was detected in 11 of 12 implants studied within one year postoperatively. The same conclusion is reached by Tarnow and Chu<sup>15</sup> who provided clinical and histological evidence that immediate palatal placement of an implant in the alveolus, but with a partially preserved buccal bone plate, allows healing and osseointegration and stability of the soft tissue and bone tissue, even in cases where there is no primary flap closure or bone augmentation. During the period of implantation, bone density decreases due to osteoclast activity in both

groups, over time it increases in both groups, but with a greater difference in patients where a combination of xenograft and autograft was used, in which cases denser and stronger bone was created.

## Conclusion

The first step when making a decision for immediate implantation is the correct analysis of the case from all anatomical and dental aspects, in order to be a reliable, safe and predictable therapeutic method for solving toothlessness in the front maxilla. Our research showed that there was a higher percentage of success in implants that were correctly placed in the palatal direction, without touching the buccal bone plate. Stability in all dimensions of the buccal bone plate was achieved in those cases where the implantation was supported by augmentation. Compensating the empty spaces and dehiscences of the buccal bone plate with biological and biocompatible materials visibly increases the buccal bone plate clinically, radiologically, and statistically, thus improving the prognosis of placed implants.

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