



# MACEDONIAN DENTAL REVIEW

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# 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 булалната 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 булалната 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:

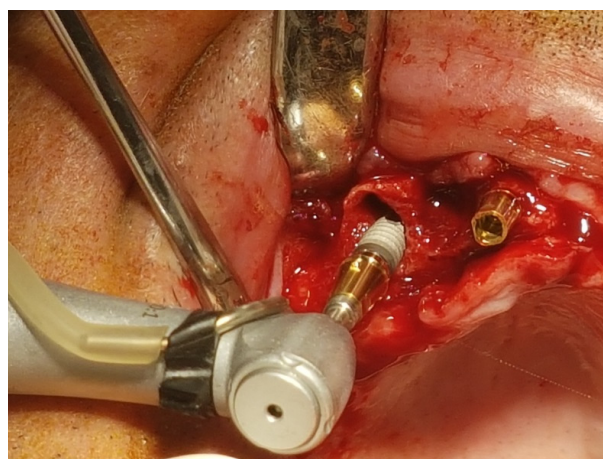
**GROUP 1 (III)** - 20 patients who underwent immediate implantation in the anterior maxilla without bone augmentation.

**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

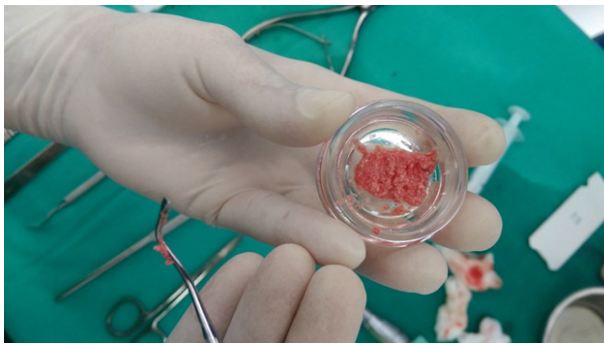
(Artinibsa 4% - Inibsa Dental Spain), and then, with a selected flap design, all the bone structures of the region with visible 4 alveolar walls were exposed: buccal bone plate, palatal bone plate, and interalveolar septa mesially and distally. The bearing of the implants was made with a slight palatal 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



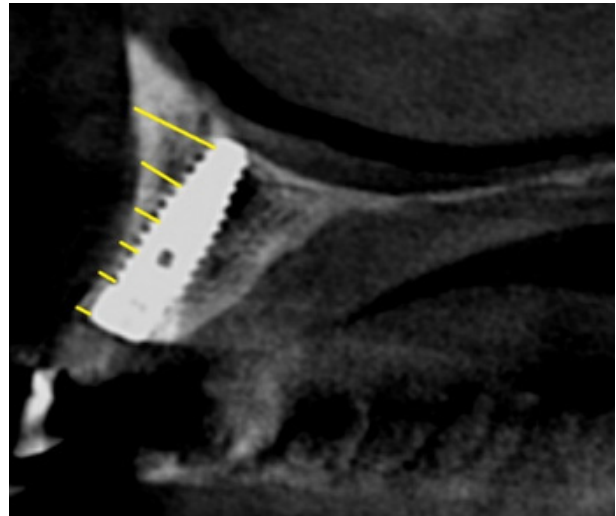
**Figure 3.** Xenograft and autograft material mixture

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

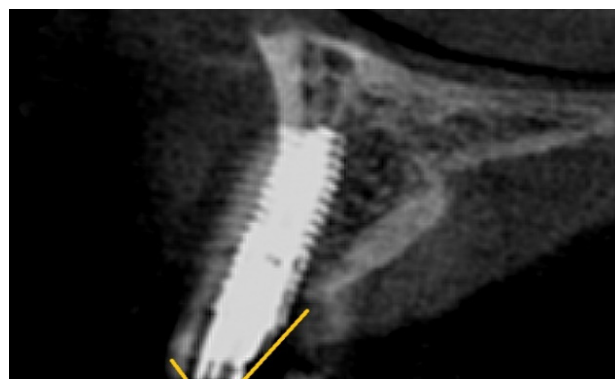


**Figure 4.** Sagittal section of the upper jaw showing 6 points for measuring the horizontal dimension

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

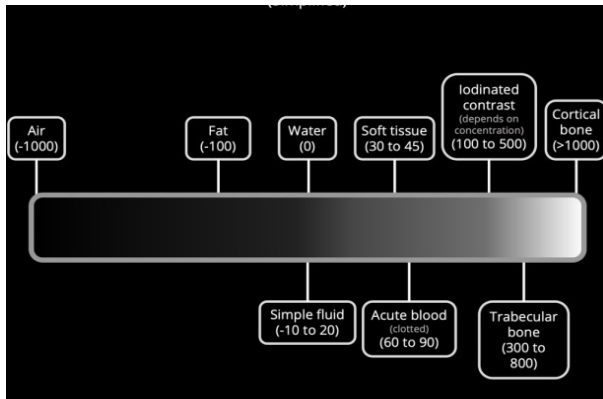


Figure 6. Hounsfield Scale

**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,

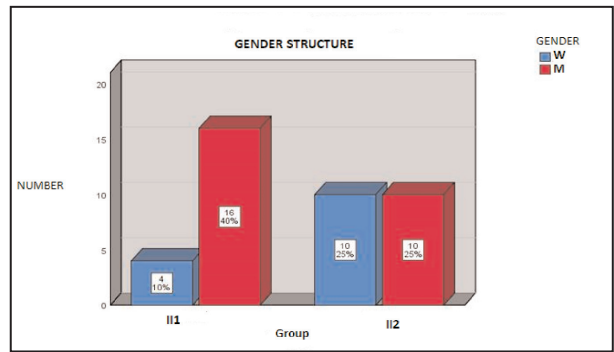


Diagram 1.

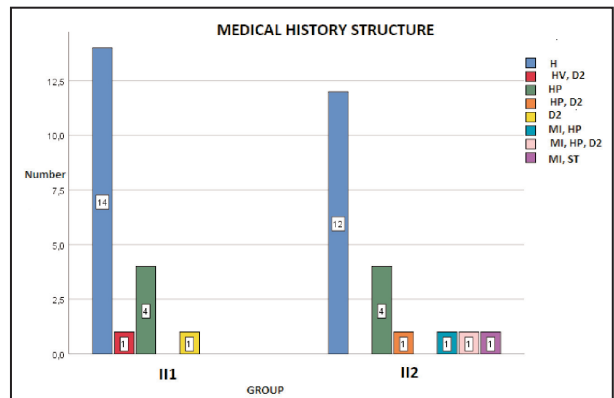


Diagram 2.

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.

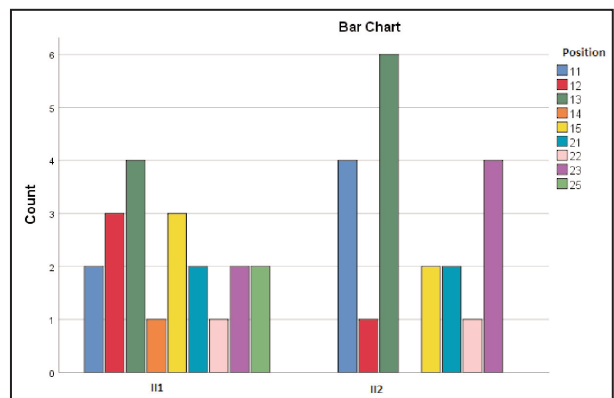


Diagram 3.

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-

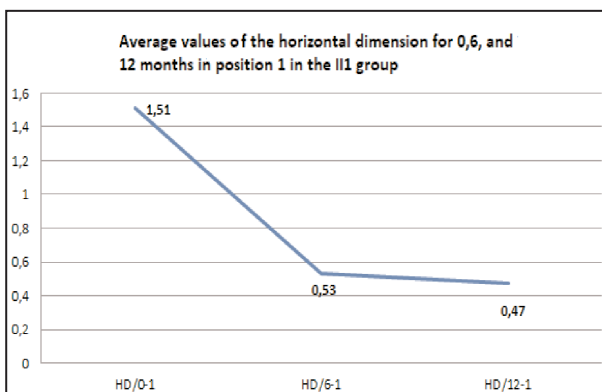
tistically different from the initial average value and is stable in relation to the day of implantation, but it was clearly different from the values obtained at 6 months in relation to the first II1 group

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)

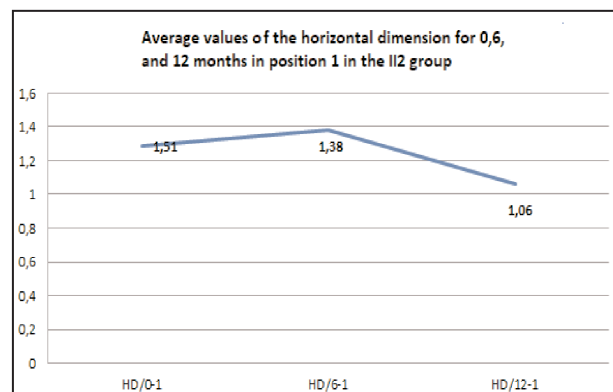
The changes in the horizontal dimension in the first group of patients, in position 3 on the day of implantation (period 0) have a value of 1.44 mm, while in the second group the average value is 1.37 mm in the same position.

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

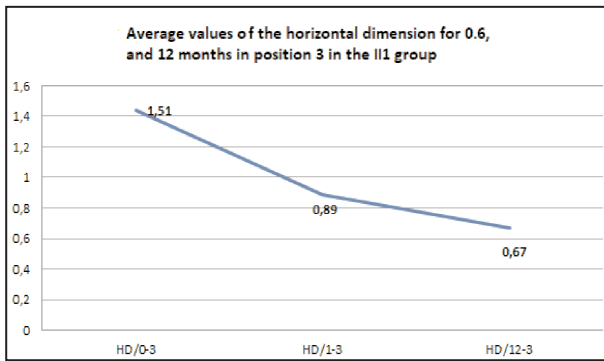


**Chart 1a**

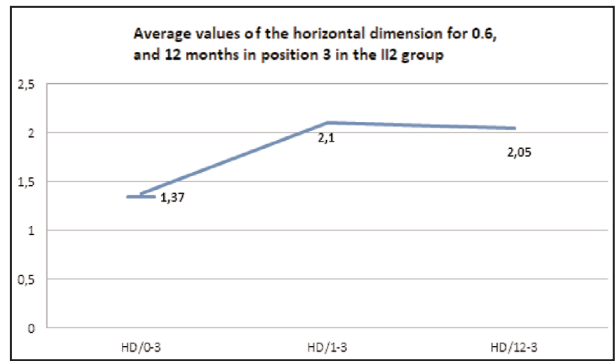


**Chart 1b**

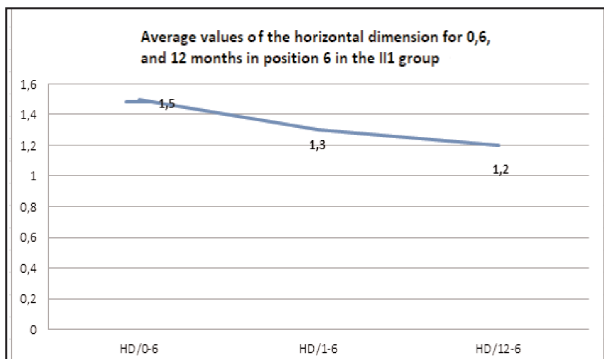




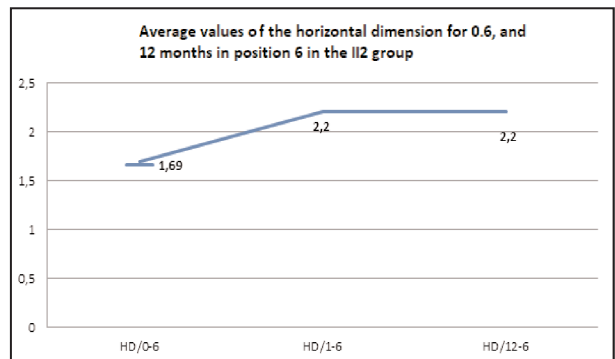
**Chart 2a**



**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).

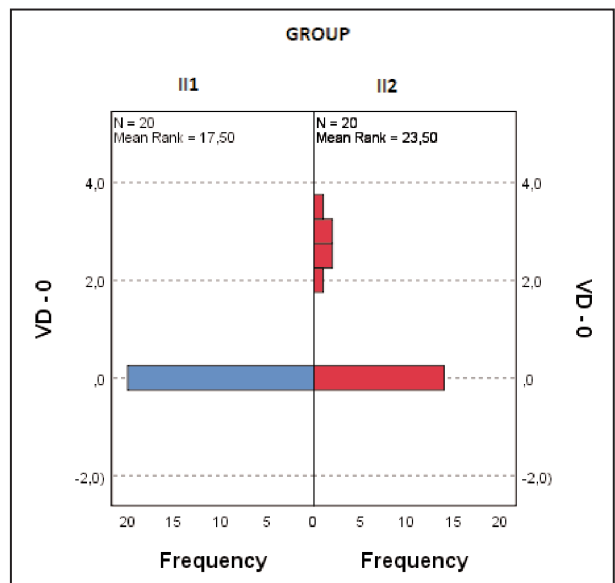
The changes in the horizontal dimension in the first group of patients, in position 6 on the day of implantation (period 0) have a value of 1.5 mm, while in the second group the average value is 1.69 mm in the same position.

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).

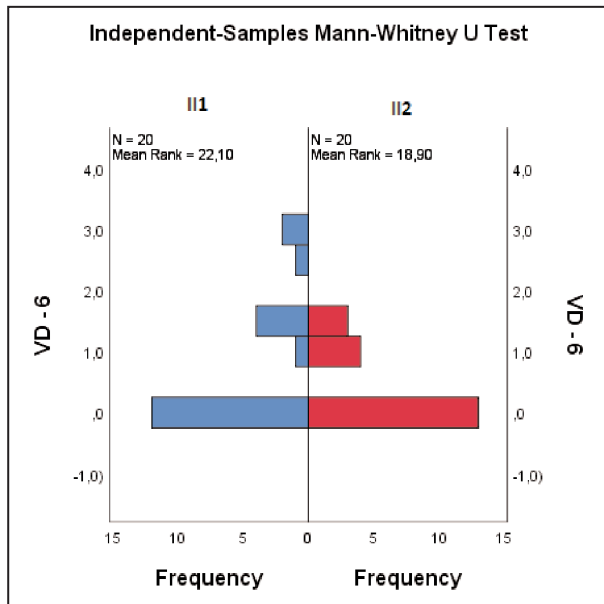
From the obtained results, of the measurement of the vertical dimension, it can be concluded that in the first group II1, at the time of placement of the implants (period 0), there is no vertical loss of the buccal bone plate. In 70% of the second group of patients (II2) there was no

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

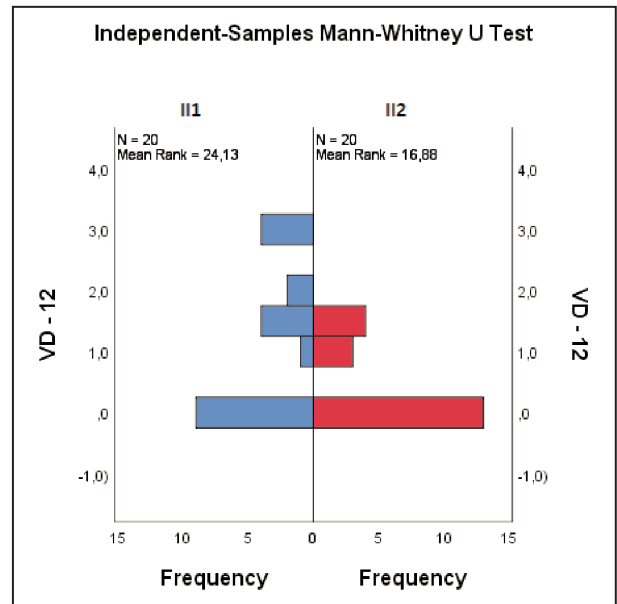
6 months after implantation, in the first group II1, in 12 patients (60%) there was no vertical loss of the buccal bone plate, and in 8 patients (40%) the loss ranged from 1.1 to 3.2 mm. In the second group II2, in 13 patients



**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)

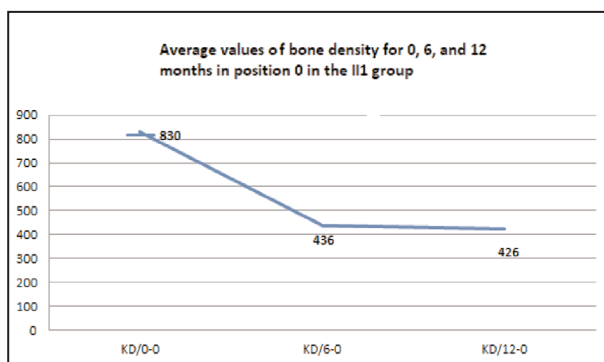
Twelve months after implantation in the first group II1, in 8 patients (40%) there are no vertical changes, and in 12 patients (60%) the changes range from 1.1 to 3.2

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)

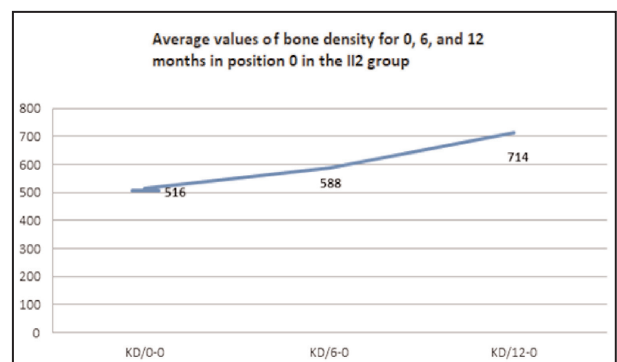
Table 2 shows the average values of bone density, measured in three positions (0, 1 and position 2) for three periods (0 months, 6 months, 12 months).

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

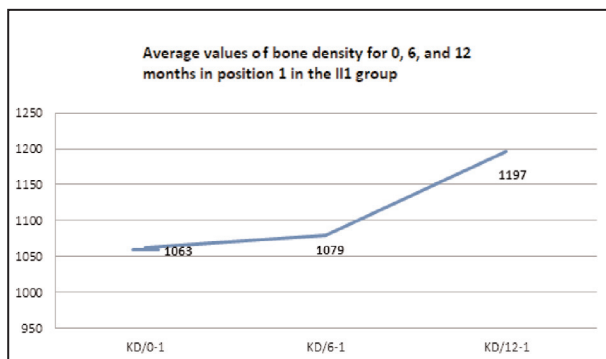
	Position 0		Position 1		Position 2	
	II1	II2	II1	II2	II1	II2
0 months	830 Hu	516 Hu	1063 Hu	809 Hu	1299 Hu	1188 Hu
6 months	436 Hu	588 Hu	1079 Hu	1137 Hu	1364 Hu	1420 Hu
12 months	426 Hu	714 Hu	1197 Hu	1403 Hu	1498 Hu	1621 Hu



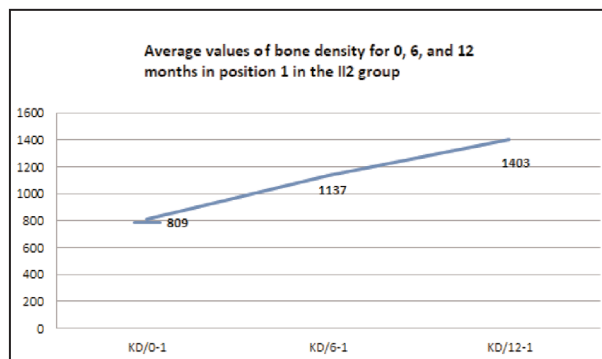
**Chart 4a**



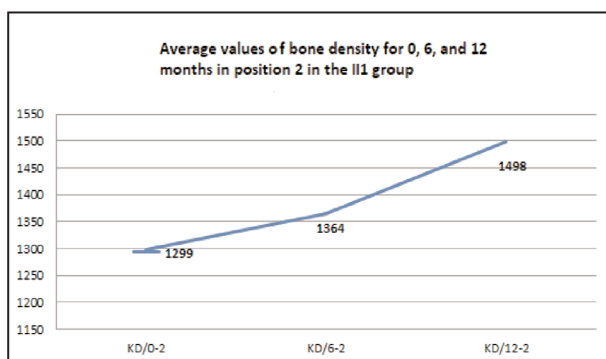
**Chart 4b**



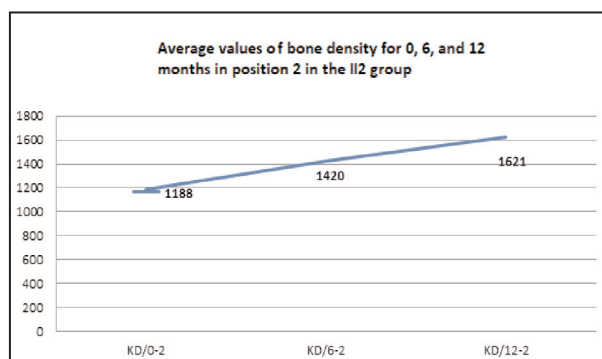
**Chart 5a**



**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

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(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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# EVALUATION OF MICROLEAKAGE OF ROOT CANALS FILLED WITH TWO DIFFERENT OBTURATION TECHNIQUES: IN VITRO

## ИСПИТУВАЊЕ НА МИКРОПРОТОКОТ КАЈ ЗАБИ ОБТУРИРАНИ СО ДВЕ РАЗЛИЧНИ ТЕХНИКИ НА ОПТУРАЦИЈА: IN VITRO

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### Abstract

**Introduction:** The ideal root canal filling should close all communications with the periodontium, be well condensed along the entire length of the root canal space and be well adapted to the canal walls. **The aim** of this study was to compare the average apical and coronary microleakage in the root canals of teeth obturated with the warm vertical condensation method in combination with injection of liquid warm gutta-percha, and teeth obturated with single cone technique. **Materials:** 20 single-rooted human teeth with straight roots were used for this experimental study. The teeth were cleaned of tissue debris. Root canals were prepared using the coronary apical processing technique using rotating ProTaper files. The teeth were randomly divided into 2 groups of 10 teeth depending on the method of obturation (single to, and warm vertical condensation). **Results:** The results obtained from our research showed the occurrence of microfluid in all examined samples. **Conclusion:** The warm vertical condensation/ injection of liquid warm gutta-percha in combination with AH plus, if performed correctly up to the apex itself, shows a minimum microflow.

**Keywords:** root canal obturation, microleakage, endodontics

### Апстракт

**Вовед:** Идеалното полнење на коренскиот канал треба да ги затвори сите излезни комуникации со пародонтот, да биде добро кондензирано низ целата должина на просторот на коренскиот канал и да биде добро адаптирано за сидовите на каналот. **Цел:** Целта на оваа студија беше да се спореди просечното апикално и коронарно микропротекување во коренските канали кај заби обтурирани со методот на вертикална кондензација во комбинација со инјектирање на течна топла гутаперка и заби оптурирани со сингл кон техника на оптурација. **Материјали:** За оваа експериментална студија беа користени 20 еднокорени хумани заби со прави корени. Забите беа исчистени од ткивни остатоци. Коренските канали беа подготвени со помош на коронарно апикалната техниката на обработка со помош на ротациони ProTaper фајлови. Забите по случаен избор беа поделени во 2 групи од по 10 заби во зависност од начинот на оптурација (сингл кон и топла вертикална кондензација). **Резултати:** Резултатите добиени од нашето истражување покажаа појава на микропроток кај сите испитувани примероци.

**Заклучок:** Оптурацијата со Fast Fill во комбинација со AH plus, доколку е коректно изведена до самиот апекс покажува минимум микропроток. Клучни зборови: канална оптурација, микропроток, ендодонција.

### Introduction

The objective of root canal filling is preventing microorganisms and their products to pass along the root canal, providing the body with conditions for biological healing through apical sealing and healing of periapical tissues<sup>1</sup>.

The success of endodontic therapy depends on shaping and cleaning of the root canal system followed by three-dimensional obturation with perfect coronal and apical seal including accessory canals<sup>2</sup>.

An ideal root canal filling should seal all portals of exit to the periodontium, be well condensed throughout

the length of the root canal space and be in close adaptation to the walls of the canal.

Apical seal is considered to be the most crucial factor for the success of a root canal treatment. Dow and Ingle suggested that 60% of root canal treatment failures can be attributed to re-entry of microorganisms from the peri-radicular area into the incompletely obturated root canals<sup>3,4</sup>.

Although numerous materials have been used for obturation, the most commonly used material is still gutta-percha<sup>5</sup>. The single cone obturation technique has been often regarded as inadequate due to its potential for apical leakage<sup>6</sup>. In the single cone technique, the root

canal is generally obturated with a fitted cone that matches the shape (taper and apical gauge) of the last rotary instrument used in combination with large quantity of sealer<sup>7</sup>.

Modern techniques of root canal obturation are routinely accomplished with the use of either “cold” or “warm” gutta-percha condensation techniques in combination with a sealer which acts as a lubricant, helping seal off voids and potentially seal any accessory canal<sup>8</sup>.

Obturation systems have been developed using heat-softened gutta-percha delivered via injection or with a carrier which delivers heat to cold gutta-percha cones cemented in the canal<sup>9</sup>.

### The aim of this study

The aim of this study was to compare the mean apical and coronar microleakage in root canals of extracted teeth obturated with the warm vertical condensation method, and thermoplasticised

### Material and methods

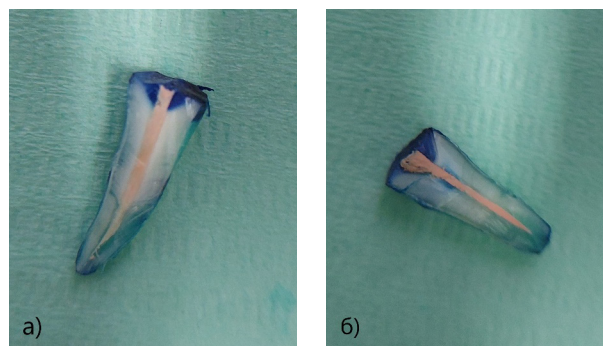
For this experimental study, 20 single-rooted human mandibular premolar teeth with straight roots were collected. The teeth were cleaned from periodontal tissue appendages and immersed in 2.5% sodium hypochlorite solution for 30 minutes. The teeth were stored in normal saline solution until the experiments (maximum of one month).

The working length was determined using #15 k file (Mani, Japan) 0.5mm shorter than the apex. Root canals were prepared using the crown down technique and ProTaper rotary files (Dentsply, Tulsa Dental Specialties, Tulsa, OK) up to F2 MAF according to the manufacturer’s instructions for the speed and torque of ProTaper files working with endomotor. Each rotary file was used for preparation of 5 canals only. A 2,5% sodium hypochlorite solution was used to irrigate the canals between usages of each instrument and after completion of instrumentation. The canals were then dried. The teeth were divided into 2 groups of 10 teeth depending on the method of obturation.

The root canals from the first group were obturated with the method of vertical condensation in the apical third in combination with a warm thermoplasticised injectable gutta-percha for the middle and coronary third. The teeth from the second group were obturated with single cone technique with F2 gutta-percha points (Dia-ProT, DiaDent) according to the last used file. We used AH plus as a siler in both groups.

All teeth surfaces except for the coronal and apical 2mm were covered with 2 layers of nail varnish.

All teeth were stored at 37°C and 100% moisture for 1 week to ensure the setting of the sealer. All specimens were immersed in 2.0% methylene blue at 37 °C for 24 hours, after which they were washed and dried. The teeth were then sectioned longitudinally in a buccolingual direction using a slow speed diamond saw. Linear apical dye penetration was measured for each specimen using Stereomicroscope at X10 magnification.



**Figure 1.** a) warm vertical condensation, b) single cone technique



**Figure 2.** Cross section of the coronary third of a tooth obtuse with warm vertical condensation

Independent Sample t-test was applied to compare micro leakage values in the two study groups. Level of significance was kept at 0.05.

### Results

The results obtained from our research showed occurrence of microleakage in all examined samples.

In both examined groups, in relation to the length of the root canal, a larger microleakage was observed in the coronary third of the root canals.

**Tabela 1.**

	Group	No. of canals	Minimum mm	Maximum mm	Mean mm	S.D
Apical	1	10	0.1	1.8	0.95	0.540
Leakage	2	10	0.5	2	1.11	0.509
Coronary	1	10	0.5	2	1.02	0.461
Leakage	2	10	1	2.5	1.52	0.442

When comparing the microleakage between the two examined groups in the apical third, the obtained results showed values for P equal to 0.5039, which indicates that there is no statistically significant difference in the microcurrent in the apical third.

When comparing the microcurrent between the two examined groups in the coronary third, the obtained results showed values for P equal to 0.0235, i.e. statistically significantly higher microleakage in the teeth of the second group obturated with single to the obturation technique.

## Discussion

It is known that adequate root canal obturation without gaps, and the possibility of microleakage is associated with more successful outcomes after root canal treatment.

Dye penetration tests are favored as they are cost effective and easier to perform with minimum armamentarium. The use of 2.0% methylene blue has been the concentration mostly employed in leakage studies. At this concentration it is detectable under visible light, is water soluble, easily diffusible but at the same time no uptake by the dentine matrix has been observed<sup>10</sup>.

Methylene blue was also the preferred choice because it has a molecular size that is comparable to a few bacterial by-products, e. g. butyric acid, that has been reported to leak from the infected root canal space into the periapex, causing irritation in the periapical tissues<sup>11</sup>.

This study was designed to evaluate the quality of root canal obturation in straight single-rooted teeth by assessing coronary and apical microleakage in root canals obturated with a single cone technique and the technique of warm vertical compaction in combination with a thermoplasticised gutta-percha.

The contraction of the gutta-percha and the lack of adhesion of the filler materials to the walls of the root canal are factors that create sufficient predispositions for microleakage. The sealer is essential for all obturation techniques. Although the behavior of different sealers and the obturation technique may differ, studies show that the gutta-percha without sealer does not have an adhesive ability to the walls of the root canal<sup>8</sup>.

Low solubility of root canal sealers has been introduced as a requirement in the International standard ISO 6876 for root canal sealing materials.

All root canal filling materials allow marginal infiltration. They are not impenetrable<sup>13,14</sup>. For AH plus the most favorable and predictable results are obtained if the root canal system is as dry as possible before obturation<sup>15,16</sup>.

In our research we used single cone technique and the technique of vertical condensation of the gutta-percha for the root canal obturation, and in both applied obturation techniques we used AH plus as a sealer.

The simplicity of the single cone technique is the main advantage of this obturation technique. The single cone technique allows the use of a single gutta-percha cone with shape and size corresponding to the final shape of the root canal, and works as a key and lock system. Currently, this method is used by several mechanical instrumentation systems. However, a research by several authors suggests that this obturation technique is inferior to other techniques when it comes to microleakage. According to some studies, the single cone technique provides inadequate obturation especially in oval root canals<sup>17,18</sup>.

The Fast fill system is a thermoplasticised gutta-percha system in which gutta-percha pellets are put in a delivery gun and expressed into the root canal space once heated to a temperature of 200 °C. To compensate for the shrinkage associated with cooling of the gutta-percha that would clinically manifest as voids in the obturation material on radiographic examination, compaction after 3–4 mm of incremental placement of gutta-percha is advocated before subsequent increment is injected<sup>19</sup>.

This recommended protocol was followed in this study to prevent the formation of voids that might otherwise result from  $\alpha$ -gutta-percha contraction upon cooling.

The results of this study showed that in the apical third there was no statistically significant difference in the microleakage of the teeth obturated with the single technique and with warm vertical compaction technique of the gutta-percha. In our study, root canals were shaped with ProTaper instruments and obturated with a sealer and



gutta-percha that matched the size of the last instrument used. According to the manufacturer but also according to some authors, ProTaper gutta-percha cones fit perfectly into the root canals shaped with the instruments of this system<sup>20</sup>.

The results obtained from our research are in accordance with the results presented by several authors<sup>20, 21, 22</sup>.

Namely Tasdemir T et al. comparing the sealing ability of the single con, lateral condensation and warm vertical condensation techniques when working with two instrumentation systems, concluded that all three examined obturation techniques showed similar sealing effects in the apical third<sup>22</sup>.

On the other hand, inferior results of single-cone obturation have been reported by Yücel and Çiftçi. They concluded that the poor seal with the Single-cone ProTaper gutta-percha may be related to the technique itself as the gutta-percha is not compacted but is only inserted to the working length with a substantial amount of sealer<sup>23</sup>. Monticelli et al. compared contemporary single-cone root filling techniques with warm vertical compaction and concluded that the warm vertical compaction provided more durable apical seal<sup>24</sup>.

When examining the microleakage in the cervical third, the results from our research showed that there is a greater microleakage in teeth filled with a single cone technique compared to teeth filled with a fast filling system. Namely, by using the Fast fill method, the heated gutta-percha adapts more easily to the irregular parts of the root canal. In addition, in the vertical condensation technique, the gutta-percha condensation in the cervical third is more direct due to easier access, optimizing the adaptation of the filling material in this part of the root canal. The results presented in our study are consistent with the results presented by Iglecias et al. Namely examining the presence of voids in the root canal filling by computed tomography, they concluded that the lowest percentage of cavities was found in the coronary thirds of the group of teeth treated with vertical condensation, compared to the single cone technique. The difference in the volume of the gaps in the middle and apical third between the two obturation techniques was negligible<sup>25</sup>.

According to Ozawa, the obturation technique has little effect on the quality of the apical third obstruction, while the thermoplastic gutta-percha application technique provides better adaptation of the gutta-percha in the canal space, the presence of a smaller amount of sealer, and thus a lower chance of occurrence of microleakage in the middle and coronary third<sup>21</sup>.

Better obturation in the coronary third contributes to the improvement of coronary sealing, which reduces the accidental microleakage of microorganisms through the root canal system into periapical tissues. The coronary

third is the first barrier between coronary restoration and root canal filling material.

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# KNOWLEDGE, ATTITUDES AND PRACTICES OF MACEDONIAN'S PEDIATRICIANS AND PRIMARY HEALTH CARE PHYSICIANS REGARDING PERINATAL AND INFANT ORAL HEALTH

## ЗНАЕЊА, СТАВОВИ И ПРАКТИКИ НА МАКЕДОНСКИТЕ ПЕДИЈАТРИ И ЛЕКАРИ ОД ПРИМАРНАТА ЗДРАВСТВЕНА ЗАШТИТА, ВО ОДНОС НА ПЕРИНАТАЛНОТО И ИНФАНТИЛНОТО ОРАЛНО ЗДРАВЈЕ

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### Abstract

**Background:** A shared approach, coordination and care for oral health as an integral part of general health should be an imperative for every primary health care worker. The aim of this study was to evaluate the knowledge, attitudes and practices, regarding infant's oral health, of pediatricians and physicians who are part of the primary health care in Republic of North Macedonia. **Methods:** The survey was conducted in January 2020 with distribution of an anonymous survey questionnaire, electronically in the form of a Google Document, to 130 pediatricians and primary care physicians. The questions examined early childhood caries knowledge, attitudes about their role in preventing childhood oral health, and practices for promoting good oral health. **Results:** 85.7 percent of doctors believed they need additional oral health education, 93.9 percent of respondents believed that they must educate parents / guardians about the importance of preventive measures to maintain children's oral health, and that they must advise parents in case of suspected caries to visit a dentist / pedodontist. Only 46.9% of respondents knew that cariogenic bacteria can be transmitted vertically from mother to newborn. A small percentage (26.5%) of respondents knew that white spots on baby teeth are early signs of caries. **Conclusions:** A Guide to Perinatal and Infant's Oral Health for all health professionals who are in contact with a child in the first years of life would help properly guide and educate parents in preserving infant's oral health. **Key words:** Knowledge, Early Childhood Caries, Infant's Oral Health, Pediatrician, Family Physicians.

### Апстракт

**Вовед:** Заедничкиот пристап, координацијата и грижата и за оралното здравје, како нераскинлив дел од генералното здравје, треба да е императив на секој здравствен работник од примарната здравствена нега. **Цел:** Целта на оваа студија е да се евалуираат знаењата, ставовите и практиките во однос на оралното здравје на педијатрите и лекарите кои се дел од примарната здравствена нега во Македонија. **Материјал и метод:** Истражувањето е направено во месец јануари во 2020 година со дистрибуција на анонимен анкетен прашалник по електронски пат во вид на GoogleDocument до 130 доктори педијатри и доктори дел од примарна здравствена нега во Македонија. Прашањата ги испитуваат знаењата за кариес во рано детство, ставовите за нивната улога за превенција на детското орално здравје и практиките за промоција на добро орално здравје. **Резултати:** Дури 85.7 проценти од докторите сметаат дека е потребна дополнителна едукација за орално здравје кај доенчиња и мали деца. 93.9 проценти од испитаниците сметаат дека мораат да ги едуцираат родителите/старателите за важноста на превентивните мерки за зачувување на оралното здравје кај децата, и дека мораат да ги советуваат родителите во случај на суспектен кариес кај доенчето/детето за посета на стоматолог/педодонт. Само 46.9% од испитаниците знаат дека кариогените бактерии може да се пренесат вертикално од мајка на новороденче. Мал е процентот (26.5%) на испитаници кои знаат дека белите дамки на млечните заби се рани знаци на кариес. **Заклучок:** Лесно достапен водич и протокол за орално здравје кај доенчиња, наменет за сите здравствени професионалци кои доаѓаат во контакт со детето во првите години од животот, би помогнал секој кој што има активна улога, правилно да ги насочи и едуцира родителите. **Клучни зборови:** Knowledge, Early Childhood Caries, Infant's Oral Health, Pediatrician, Family Physicians.

### Introduction

“Dental caries” is an important public health problem and it is the most prevalent oral disease among children<sup>1</sup>

which is five times more common than asthma and seven times more common than fever<sup>2</sup>. Dental caries is one of the most common chronic diseases of childhood, affecting between 30% to 50% of children in high-income

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countries<sup>3,4,5,6</sup> and up to 90% in low- and middle-income countries<sup>7,8</sup>. Early childhood caries (ECC) is the most prevalent infectious disease and major threat to oral health in infants and children as reported by the center for disease control and prevention and the National institute of health<sup>9</sup>. Early Childhood Caries (ECC), according to the American Dental Association, is “The presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries) or filled tooth surfaces in any primary tooth in a preschool-age child between birth and 71 months of age”<sup>10</sup>. ECC is considered as a significant public health problem in both developed and developing countries, with prevalence of 1–12% and up to 70%, respectively<sup>11</sup>. Untreated early childhood caries leads to pain, swelling, infection in the oral cavity, which can lead to difficulty when chewing and nutritional imbalance which, together with changes in child behavior and sleep, lead to reduced quality of life of the child, but also to the whole family. The American Academy of Pediatrics reported that early child caries (ECC) treatment costs \$1,000–\$2,000 per child, which is not affordable in low- and middle-income countries (LMICs)<sup>12</sup>. Therefore, preventive measures to preserve oral health need to start much earlier, in the prenatal and perinatal period. Interventions targeted at mothers both during pregnancy and in the first year after birth have the potential to prevent the initiation and progression of caries in young children, and hence reduce the burden of this disease further in life<sup>13</sup>. The AAPD recognizes that infant oral health is one of the foundations on which preventive education and dental care must be built, to enhance the opportunity for a lifetime free of preventable oral disease<sup>14</sup>.

The initiation and the application of these preventive measures is significantly associated with the child’s first dental visit, which is recommended within 6 months of the first primary tooth eruption and not later than 12 months<sup>15</sup>. The American Academy of Pediatric Dentistry (AAPD) encourages health care providers to use all recommended preventive strategies to prevent early childhood caries, and the implementation of these strategies should begin in the pediatrician’s office<sup>16</sup>. A consensus guideline, according to the American Academy of Pediatrics (AAP) and Bright Futures recommended at least eight visits for preventive pediatric health care by 12 months of age<sup>17</sup>. As a result, it is crucial for pediatricians and family physicians to recognize their role in the promotion of children’s oral health by several means, such as assessing the child’s risk for developing dental caries, providing basic screening services for early detection of dental problems, parental education, and referral of required conditions<sup>15</sup>.

Also, in Macedonia pediatricians, GPs doctors, doctor of family medicine or doctors employed in primary health

care are the first line of health professionals who get in touch with children and their parents/guardians, much earlier than dentists. This is why they can often find themselves in a situation where they need to give advice or properly educate parents/guardians regarding the prevention and preservation of oral health in infants in the first years of life. In Macedonia, since 2008, there is a national strategy and preventive program for preservation of oral health in children younger than 14 years, which includes prevention teams throughout the country, consisting of a dentist/pedodontist and a dental nurse. These teams operate within the health centers, where there are vaccination points, general and family medicine clinics and pediatric clinics, places where the primary health care of infants and young children is conducted. Joint approach, coordination and care for oral health, as an integral part of general health, should be an imperative of every primary care professional, and the inclusion of family doctors and pediatricians in the oral health prevention program would give better results and reduce the rate of caries in our country. For the purposes of full and quality implementation of the National Strategy, the Coordination Body has prepared a Manual that is intended primarily for specialists in pediatric and preventive dentistry as well as general dentists who are involved in prevention teams, but also for all those who are directly or indirectly involved in the implementation of the National Strategy (dentists, primary care gynecologists, pediatricians, preschool educators and primary school teachers)<sup>18</sup>.

## The purpose of this study

The purpose of this study is to evaluate the knowledge, attitudes and practices regarding the oral health of pediatricians, family medicine specialists, general practice doctors, doctors who are part of the primary health care in Macedonia.

## Method

The research was conducted in January 2020 by distributing an anonymous survey questionnaire, electronically in the form of Google Document, to pediatricians, family medicine specialists, residents in the same fields, and general practitioners involved in primary health care throughout the country. The questionnaire was sent to 130 doctors from private and public hospitals, private practices and health centers whose email addresses we obtained through web search and which were publicly available. All other doctors from the target groups, for whom only fixed and mobile contact telephone numbers were publicly available from personal data, were excluded from the research.

The questionnaire was based on questionnaires already used in literature, in the period 2012-2019<sup>19, 20, 21, 22</sup>. It consists of 28 questions divided into five parts.

1) The first part contains demographic data on gender, age, job, years of work experience and average number of patients (respondents) examined per day.

2) The second part provides data on the level of education, sources of information on oral health, and the need of the respondents for additional oral health education.

3) In the third part, through a total of 7 questions, the attitude of the respondents about their role in preserving oral health in infants and young children is evaluated.

4) The fourth part shows what the respondents practice in their daily practice, in order to eradicate caries and oral disease and raise the improved level of overall health through oral health.

5) The fifth part is composed of 10 questions that assess the level of knowledge about oral health in infants and early childhood. Multiple answers were available for the questions, where the respondents considered it necessary. The answered questionnaires were entered into Microsoft Excel, whereas a summary and simple mathematical data processing was performed.

## Results

The final number of respondents who answered positively to the questionnaire is 49, i.e. 37.69% of the total number of respondents. 89.8 percent of them are female and 10.2 percent are male, of which almost half (42.9%) are aged 25-35, 34.7% are aged 35-45, the percentage of respondents aged 45 -55 years is 10.2%, and 12.2% of the respondents were over 55 years old. The largest percentage (44.9%) of the doctors work in one of the state hospitals, 18 (36.7%) work in a private practice, and a small percentage of those are employed in one of the private hospitals (10.2%) or in vaccination points (8.2%) . In everyday practice, 46.9% of doctors examine more than 25 patients daily, 36.7% examine 10-25 patients daily, and 16.3% examine less than 10 patients. These demographic data are shown in Table 1. Table 2 shows data on education and type of oral health education of the respondents. Almost half (42.9%) of the total number of respondents are specialists in pediatrics or family medicine, 26.3 percent are residents of pediatrics or family medicine, the same percentage are doctors of general medicine, and 10.2 percent are doctors with title of research associate or professor. When asked where the sources of oral health information come from, the respondents used multiple answers, so 53.1% of the doctors answered that it is formal medical education, 44.9% said that they continue their medical education, 34.7% use scientific journals as a

**Table 1.** Demographic data

Demographic data	Number of respondents (%)
<b>Gender</b>	
Male	5 (10.20%)
Female	44 (89.80%)
<b>Age</b>	
23-35	21 (42.9%)
35-45	17 (34.7%)
45-55	5 (10.2%)
Over 55	6 (12.2%)
<b>Working experience(years)</b>	
<5	19 (38.8%)
5-10	5 (10.2%)
10-25	19 (38.8%)
>25	6 (12.2%)
<b>Place of work</b>	
Private practice	18 (36.7%)
Private hospital	5 (10.2%)
Public hospital	22 ( 44.9%)
Vaccination points	4 (8.2%)
<b>Average number of daily examined patients</b>	
<10	8 (16.3%)
10-25	18 (36.7%)
>25	23 (46.9%)

**Table 2.** Data on education and type of oral health education

Question	Number of respondents (%)
<b>Educational level</b>	
Doctor of medicine	13 (26,3%)
Specialist in pediatrics or family medicine	21 (42.9%)
Resident doctor	13 (26,3%)
Research fellow, professor	5 (10.2%)
<b>Sources of oral health information come from:</b>	
Formal medical education	26 ( 53.1%)
Educational course	22 (44.9%)
Scientific database	17( 34.7%)
Colleagues	14 (28.6%)
Other sources	12 (24.5%)
<b>I need more information and oral health education in infants and young children:</b>	
Yes	42 (85.7%)
No	7 (14.3%)

source of information, 28.6 percent receive information from colleagues, and 24.5% from other sources. Accurately 85.7 percent of doctors believe that they need

additional oral health education in infants and young children. Table 3 shows the views of pediatricians/family medicine doctors/general practitioners as well as residents of pediatrics and family medicine on preventive measures to preserve oral health, and their attitude towards their involvement in the same. 93.9 percent of the respondents believe that deciduous teeth play an important role in children's health and development, the same percentage believe that pediatricians, GPs, family doctors must educate parents/guardians about the importance of preventive measures to preserve oral health in children, and that they must advise parents in case of suspected caries in the infant/child to visit a dentist/pedodontist. 77.6% of the respondents answered positively to the question whether pediatricians, family doctors play an important role in the prevention of caries and the promotion of good oral health, 24.5% of them answered negatively. Slightly lower percentage, but still more than half, (67.3%) think that pediatricians and family doctors must examine infants and young children and detect caries, the rest (32.7%) are of the opinion that when examining infants and young children they do not have to detect caries. The following answers were given to the question regarding who is responsible for the oral health in infants: pediatrician, pedodontist, family doctor, family medicine doctor and all of the above. Exactly 81.6% answered that all of them are responsible for the oral health in infants, 12.2% think that it is the pediatrician's responsibility, the same percentage think that it is the pedodontist's responsibility, 3 respondents (6.1%) have the opinion that it is the family doctor's responsibility, and only two respondents (4.1%) think that the doctor of family medicine is responsible. The respondents also used the multiple answers for this question.

Table 3 shows the views of pediatricians/family medicine doctors/general practitioners as well as residents of pediatrics and family medicine on preventive measures to preserve oral health, and their attitude towards their involvement in the same. Exactly 93.9% of the respondents believe that deciduous teeth play an important role in children's health and development, the same percentage believe that pediatricians, GPs, family doctors, must educate parents/guardians about the importance of preventive measures to preserve oral health in children; and that they must advise parents to visit a dentist / pedodontist in case of suspected caries in the infant/child. 77.6% of the respondents answered positively to the question whether pediatricians, family doctors play an important role in the prevention of caries and the promotion of good oral health, 24.5% of them answered negatively. Slightly lower percentage, but still more than half, (67.3%) think that pediatricians and family doctors must examine infants and young children and detect caries, the rest

**Table 3.** Respondents attitudes about infants and young children oral health

Question	Number of respondents (%)
<b>Pediatricians, GPs, family doctors play an important role in the prevention of dental caries and the promotion of good oral health in infants?</b>	
Yes	38 (77.6%)
No	12 (24.5%)
<b>Pediatricians, GPs, family doctors must educate parents/guardians on the importance of preventive measures to preserve oral health in children?</b>	
Yes	46 (93.9%)
No	3 (6.1%)
<b>Pediatricians, GPs, family doctors must examine infants and young children and detect caries?</b>	
Yes	33 (67.3%)
No	16 (32.7%)
<b>Pediatricians, family doctors, family doctors must advise parents to visit a dentist/pedodontist in case of suspected caries in the infant/child?</b>	
Yes	46 (93.9%)
No	3 (6.1%)
<b>Who is responsible for protecting the oral health in infants?</b>	
Pediatrician	6 (12.2%)
Pedodontist	6 (12.2%)
General practice doctor	3 (6.1%)
Family medicine doctor	2 (4.1%)
All of the above	40 (81.6%)
<b>Deciduous teeth play an important role in children's health and development?</b>	
Yes	46 (93.9%)
No	3 (6.1%)
<b>Fluoride-containing pastes are not recommended for children under 3 years of age?</b>	
I agree	23 (46.9%)
Disagree	11 (22.4%)
I partially agree	15 (30.6%)

(32.7%) are of the opinion that when examining infants and young children they do not have to detect caries. The following answers were given to the question regarding who is responsible for the oral health in infants: pediatrician, pedodontist, family doctor, family medicine doctor and all of the above. Exactly 81.6% answered that all of them are responsible for the oral health in infants, 12.2% think that it is the pediatrician's responsibility, the same percentage think that it is the pedodontist's responsibility, 3 respondents (6.1%) have the opinion that it is the family doctor's responsibility, and only two respondents

(4.1%) think that the doctor of family medicine is responsible. The respondents also used multiple answers for this question. When asked whether fluoride-containing pastes are not recommended for children under 3 years of age, 46.9% agreed, 22.4% disagreed and 30.6 percent of doctors partially agreed.

Table 4 shows the respondents' practice of preventive measures to preserve oral health in infants and young children, so 91.8% of them advise parents on oral health, dental caries and regular dental examinations, 87.3 percent of respondents, when noticing the presence of caries, advise parents to take their child to the dentist, 16.3% advise parents to take their child to a pedodontist, as well as to prevention teams in public health centers (16.3%), and 18.4% of doctors choose to advise parents/guardians to take their child to the university clinic for children and preventive dentistry. Regarding their recommendation when to start cleansing the oral cavity, 46.9% of the respondents will recommend to start cleansing after the eruption of more deciduous teeth, 32.7% answered immediately after the eruption of the first deciduous tooth, 20.4% think that cleansing the oral cavity should be cleaned immediately after delivery, just after first feeding of the baby, two respondents (4.1%) answered that their recommendation is to start cleansing the oral cavity only when they have all the baby teeth and one of the respondents (2%) answered

**Table 4.** Practices among the respondents regarding infants and young children oral health

Question	Respondents number (%)
<b>I advise parents on oral health, dental caries and regular dental examinations</b>	
Yes	45 (91.8%)
No	4 (8.2%)
<b>When I notice the presence of caries, I advise parents to take their child to?</b>	
Dentist	43 (87.8%)
Pedodontist	8 (16.3%)
University clinic for child and preventive dentistry	9 (18.4%)
Prevention teams in public health institution	8 (16.3%)
<b>When Do You Recommend to Start Oral Cleansing?</b>	
Immediately after delivery, after feeding the baby	10 (20.4%)
Immediately after the eruption of the first deciduous tooth	16 (32.7%)
After the eruption of more deciduous teeth	23 (46.9%)
When the child has all its baby teeth	2 (4.1%)
After the age of 5 years	1 (2%)

**Table 5.** Assessment of respondents knowledge about oral health in infants and young children

Question	Number of respondents (%)
<b>The first baby tooth usually erupts at 6 months of age?</b>	
Yes	45 (91.8%)
No	5 (10.2%)
<b>The first dental examination should be made immediately after the eruption of the first deciduous tooth?</b>	
Yes	12 (24.5%)
No	37 (75.5%)
<b>Can cariogenic bacteria be transmitted from mother to newborn?</b>	
Yes	23 (46.9%)
No	26 (53.1%)
<b>White spots on deciduous teeth are early signs of caries.</b>	
Yes	13 (26.5%)
No	36 (73.5%)
<b>The first visit to the dentist should take place on</b>	
6 months	6 (12.2%)
1 year	38 (77.6%)
Occurrence of caries	4 (8.2%)
Occurrence of toothache	3 (6.1%)
Immediately after delivery	1 (2.0%)
<b>The most cariogenic sugar in the diet is?</b>	
Sucrose	33 (67.3%)
Glucose	14 (28.6%)
Lactose	4 (8.2%)
<b>Can the oral health of the mother during pregnancy and lactation affect the oral health of the infant?</b>	
Yes	37 (75.5%)
No	12 (24.5%)
<b>Can prenatal nutrition affect infant oral health and the development of caries in early childhood?</b>	
Yes	41 (83.7%)
No	8 (16.3%)
<b>Are breastfeeding and the occurrence of caries on deciduous teeth closely correlated?</b>	
Yes	21 (42.9%)
No	28 (57.1%)
<b>Children who use a pacifier bottle at night are more prone to caries on deciduous teeth.</b>	
Yes	42 (85.7%)
No	7 (14.3%)

that after the age of five is the right time Table 5 provides questions and answers intended for assessing respondents' oral health knowledge in infants and young children. 91.8% of doctors gave the correct answer that the

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first deciduous tooth usually erupts at the age of 6 months. Only 46.9% of respondents know that cariogenic bacteria can be transmitted vertically from mother to newborn, and a very small percentage (26.5%) of respondents know that white spots on deciduous teeth are early signs of caries. 75.5% of doctors believe that immediately after the eruption of the first deciduous tooth is not the right time for the first dental examination, and 77.6% believe that the first visit to the dentist should be at the age of 1, 8.2% answered that it should be after occurrence of caries, and 6.1% answered that the first visit should occur after the onset of toothache. Slightly more than half of the respondents (57.1%) do not think that breastfeeding and the appearance of caries on deciduous teeth are closely correlated, but 85.7% know that children who use a bottle with a pacifier at night are more predisposed to caries of deciduous teeth. To the question whether the oral health of the mother during pregnancy and lactation can affect the oral health of the infant, 75.5% answered positively; to the question whether the prenatal diet can affect the oral health of the infant and the development of caries in early childhood, 83.7% answered positively. When asked which is the most cariogenic sugar in the diet, 67.3% answered that it is sucrose, 28.6% answered that it is glucose, and 8.2% of the respondents answered that it is lactose.

## Discussion

To the best of our knowledge, this is the first study in Macedonia that examines the attitude, practices and knowledge of pediatricians, GPs and family medicine specialists for oral health in infants and young children as doctors who are directly or indirectly involved in the implementation of the National prevention strategy of oral diseases in children up to 14 years old. Also, in the world scientific database and literature, there are few studies that describe the attitude of pediatricians regarding oral health. In Geneva, the World Health Organization, through its Maternal, Child and Adolescent Health programs, is establishing a tool to improve maternal and infant health nationally and internationally<sup>12</sup>, and the World Health Organization's antenatal care programs have a vision for every mother and newborn to be provided with the necessary health services, by providing a positive experience during pregnancy, anywhere in the world<sup>23</sup>. The World Dental Federation, on the other hand, emphasizes the importance of integrating oral health into all health policies nationally and internationally, in order to prevent the occurrence of oral diseases, by encouraging governments, stakeholders and decision makers to include the promotion of oral health as an integral part of general health policy<sup>24</sup>. The preventive programs for preservation of oral health, which will start with interventions much earlier, in

the prenatal and perinatal period, will enable growth and development of the child with good oral health as an integral and essential part of general health. It was reported that 89% of children at the age of one visited a pediatric or general practice clinic, and only 1.5% had a visit to the dentist in the same period<sup>25</sup>. Precisely, because in the first year of life the meetings with the family doctor and pediatrician are more frequent and the possibility to be directly involved in the prevention of oral health is higher, we were motivated to make this study through which we will find out the attitudes, practices and knowledge of this "first line" of health professionals.

In our study, as many as 93.7% of the respondents have a positive attitude and believe that pediatricians, GPs, family doctors must educate parents/guardians about the importance of preventive measures to preserve oral health in children. Also, they must advise parents to visit a dentist/pedodontist in case of suspected caries in the infant/child, which is an approximate percentage compared to the study of Alshunaiber R et al (2019), in which 86.1% of the examined pediatricians and family doctors had a positive attitude regarding this question<sup>22</sup>. Regarding the question whether pediatricians, GPs and family doctors play an important role in the prevention of caries and the promotion of good oral health, 77.6% of respondents answered positively, compared to a study conducted in Turkey by Sezer et al, (2013) where 96.9% of the respondents had a positive attitude on this issue. Ninety-one percent of our respondents advise parents/guardians on oral health, dental caries and regular dental examinations, which is an excellent percentage compared to their colleagues from Saudi Arabia where, according to Alshunaiber R et al. (2019), only 57.9% of them practice this<sup>22</sup>. According to the American Academy of Pediatric Dentistry (AAPD), parents/guardians should be encouraged to take their child to the dentist for the first time by the 12<sup>th</sup> month at the latest in order to make the following interventions<sup>26</sup>: first visit with registering medical (for infant) and dental (for parent and infant) card, oral examination, education for proper oral hygiene according to the age, fluoride treatment if indicated<sup>27</sup>. In our study, 89.8% of respondents know that the first appointment with a dentist should be made before the child turns one year, which does not coincide with the study of Hadjipanayis A at al. (2018), according to which 43% of pediatricians in Europe recommend first visit to the dentist after the third year, and only 7 percent before the child turns one year.<sup>28</sup> According to Balaban R. at al (2012), the percentage of those who recommended the first meeting with a pedodontist in the first year of life is 63.9%<sup>29</sup>. Recent studies note a large percentage of pediatricians who do not recommend the first appointment with a dentist to be under one year, which emphasizes the need for additional



education among health professionals on the topic of infantile oral health<sup>30,31</sup>. According to the American Dental Association, in children under the age of three, if fluoridated paste is used, the amount of paste placed on the brush should not be greater than a grain of rice<sup>32</sup>. In our study, 46.9% of respondents disagreed with the use of fluoridated toothpaste in children under 3 years of age. In recent study (Hadjipanayis A et al), twenty-four percent of respondents did not know that white spots on the teeth are the first signs of caries<sup>28</sup>, compared to our study in which 73.5% of respondents did not know that white spots on deciduous teeth are signs of initial carious lesion.

The large percentage do not know that cariogenic bacteria can be transmitted from mother to newborn (53.1%), and a large percentage do not know that the first appointment with a dentist should be immediately after the eruption of a baby tooth (75.5% ), despite the positive attitude and practices regarding the oral health of the respondents, may signal the need for additional education of respondents on the topic of oral health prevention in the perinatal period.

During our research, we found that in relation to other studies on this topic, we had a small sample for analysis due to the small number of pediatricians, GPs and primary care physicians who responded positively to our call, and if we had better feedback we believe that we would have had different results, especially in the area of oral health knowledge among the respondents.

## Conclusion

We came to the conclusion that pediatricians, family physicians, GPs or physicians involved in primary health care have recognized their role in the prevention of oral health and have a positive attitude and excellent knowledge of certain aspects of early childhood caries. Nevertheless, it was also observed that there is a need for renewing the knowledge, especially in the field of etiology and diagnosis of early childhood caries. An easily accessible guide and protocol for infant oral health intended for all health professionals who come in contact with the child in the first years of life would help anyone in an active role to properly guide and educate parents/guardians.

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# PARENTAL EXPECTATIONS AND CHILDREN'S SELF-REPORTED PAIN IN THE ATRAUMATIC RESTORATIVE TREATMENT APPROACH

## ОЧЕКУВАЊАТА НА РОДИТЕЛИТЕ И БОЛКАТА ШТО САМИТЕ ДЕЦА ЈА ИЗРАЗУВАА ПРИ ПРИСТАПОТ СО АТРАУМАТСКИ РЕСТАВРАТИВЕН ТРЕТМАН

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### Abstract

The aim of this study was to assess parent's expectations and children's self-reported pain in Atraumatic Restorative Treatment approach. One hundred ART restorations were performed in children aged 3 to 8 years in school settings by a pediatric dentist according to ART guidelines. The Wong Baker facial scale was used to assess each child's self-reported pain. This scale measures the patient's pain by choosing between six different faces, each expressing a different facial emotion. The first image shows a pleasantly smiling face, followed by less happy emotions until the last image shows a very unhappy face covered in tears. The operator performing the treatment employed the scale right after each restorative treatment and parents/guardians were asked for the expectations of approach prior to the treatment. Statistical analysis showed that 81% of the children did not experience pain throughout ART approach, and only 3% of the parents expected the treatment to go very poorly. Children with a mean age of 6.0 years had no pain during atraumatic restorative treatment (ART) and parental expectations for the treatment were very decent.

**Key word:** ART, Wong-Baker Facial Scale, pain, anxiety, discomfort.

### Апстракт

Целта на оваа студија беше да се оценат очекувањата на родителите од пристапот со atraumatic restorative treatment (ART) и болката што ја изразуваа самите деца при ART-пристапот. Направени беа сто ART-реставрации кај деца на возраст од 3 до 8 години во училишна средина од страна на детски стоматолог според упатствата за ART. За оценување на болката што секоје од децата ја изразувааше се користеше скалата со гримаси на Вонг и Бејкер. Оваа скала ја мери болката на пациентот така што самиот пациент избира една од шест слики со различни гримаси, од кои секоја изразува различна емоција. Првата слика прикажува пријатно, насмевнато лице, а по неа следуваат слики со лица со помалку пријатни емоции, при што последната прикажува едно многу несреќно лице облеано со солзи. Операторот што го вршеше третманот ја применуваше скалата веднаш по секој реставративен третман, а пред третманот родителите/старателите беа прашани какви им се очекувањата од пристапот. Статистичката анализа покажа дека 81% од децата не искусија болка во текот на ART-пристапот, а дека само 3% од родителите очекуваа дека третманот ќе помине многу лошо. Децата со средна возраст од 6,0 години немаа болка во текот на atraumatic restorative treatment (ART), а очекувањата на родителите во врска со третманот беа многу коректни. **Клучни зборови:** ART, скала со гримаси на Вонг и Бејкер, болка, анксиозност, непријатност.

### Introduction

Dental anxiety is one of the main problems affecting children, which compromises giving dental care, leading to impaired quality of life. The reasons for dental anxiety are as follows: smells (eugenol and cut dentine), sights (needles, air - turbine drills), sounds (drilling) and sensations (high-frequency vibrations)<sup>1</sup>.

According to the definition of pain, it represents an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage<sup>2,3</sup>. Anyways, even though the feeling of pain is connected to tissue damage, it's not necessary dependent on tissue damage<sup>3</sup>.

The conventional method of treating dental caries is based on using electric drills to remove decayed areas of

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teeth before filling. During the procedure, local anesthetic is typically used for preventing pain. In many cases, because of the discomfort associated with conventional cavity preparation, it can result in avoiding dental care.

Unlike the conventional restorative treatment, the Atraumatic Restorative Treatment approach can be applied in different settings and is suitable for people with different profiles by providing restorations of good quality that are acceptable for excellent survival rate<sup>4</sup>. Recent systematic review reported that ART using high-viscosity glass-ionomer cement can safely be used to treat and prevent carious lesions in primary and permanent posterior teeth<sup>4</sup>.

The ART restoration implies elimination of soft, completely demineralized carious tooth tissue with hand instruments. Next step in the procedure is restoration of the cavity with an adhesive dental material which simultaneously seals any remaining pits and fissures that may pose a risk<sup>5,6</sup>.

If we interpret the 'atraumatic' component of the ART approach, we can point that this procedure causes minimum or no trauma to the patient (reducing pain, discomfort and anxiety) and at same time is 'atraumatic' to the tooth (conserving healthy tooth structures and reducing trauma to the pulp)<sup>7,8</sup>.

Because the "atraumatic" component of ART makes it a clinically acceptable restorative technique among children, anxious patients, and individuals with special needs, it is generally considered less traumatic, less painful, and friendlier than traditional restorative treatment<sup>9</sup>.

Various instruments have been developed to measure and grade pain in order to determine the degree of pain during dental treatment<sup>10</sup>. Face scales proved to be most popular way of children's self-assessment of pain<sup>10</sup>. Young children, more or less, have difficulty expressing their emotions, including describing pain levels, Wong-Baker FACES Pain Rating Scale (Wong-Baker) was specially developed to grade pain and it is considered the best scale to measure pain in the medical field<sup>11</sup>. After analyzing different assessment scales for evaluation of pediatric pain, Chambers et al.<sup>10</sup> came to the conclusion that the majority of children and parents favored the Wong and Baker scale.

The objective of the research was to assess parent's expectations and children's self-reported pain in Atraumatic Restorative Treatment approach.

## Material and methods

The research was approved by the Research Ethics Committee of the Faculty of Dentistry, Ss. Cyril and Methodius University in Skopje (N #02-264383), and

the Research Ethics Committee of Dental Chamber of Kosovo, Republic of Kosovo (N #07). The parents/guardians of each child provided a signed informed consent form. Of course, the children's voluntary consent was also required. Identification codes were used for better protection of participants' personal information and only the researchers had access to the information collected.

The research was conducted from September 2020 to December 2021 and carried out in the four municipalities of the Republic of Kosovo: Ferizaj, Mitrovica, Drenica and Vushtri.

In total, 280 children, aged 3 to 8 years, took part in the study. The inclusion criteria were as follows: collaborative children with good general health, children with high caries risk in primary dentition, approachable to ART hand instruments. The exclusion criteria were: teeth under the pulpal exposure, presence of pain, presence of abscess, or fistula, absence of access to tooth caries. The screening led to the final selection of 100 children. Out of all 280 potential participants, 180 children were rejected, 160 of them did not meet the inclusion criteria, and 20 refused to participate.

Brief questionnaire was prepared, in accordance WHO<sup>12</sup> and AAPD<sup>13</sup> with modifications, and information was obtained from each parent/guardian regarding socio-demographic data, general health, dental history, dietary behavior, oral hygiene, exposure to fluoride and parent's expectations for the ART procedure. The following resources were used for the purpose of the examinations: mouth mirrors and standard explorers. Caries status evaluation was achieved using the dmft index by the WHO<sup>12</sup> criteria, and the Silness and Loe index<sup>14</sup> was used for assessing plaque levels of teeth.

Four to five children were treated per day, following the ART guidelines by Frencken<sup>15</sup>. The occlusal surface of the primary tooth was opened and excavated with hand instrument only (SSWhite/Duflex, Rio de Janeiro, Brazil). The cleaned cavity was filled with high viscosity glass ionomer cement – GC Fuji IX GP (EU, Leuven, Belgium).

The treatments were performed in empty classroom of their local schools by one pediatric dentist accompanied by two assistants. The evaluation of restorations was performed after 3, 6, 9, 12 month with the ART restoration criteria<sup>15</sup>.

The Wong-Baker Facial Scale was used with consent to estimate each child's self-reported pain. The Wong-Baker FACES Pain Rating Scale (Wong Baker) is composed of six illustrations indicating different levels of pain from "no pain" to "severe pain"<sup>11</sup>.

This scale is used in such a way that the operator at the end of the treatment shows the illustrations to the children, but without referring to the word 'pain'. Then the children



**Figure 1.** The Wong-Baker FACES Pain Rating Scale

were instructed to point to the image that best represented their feelings about the treatment they had just received.

### Statistical methods

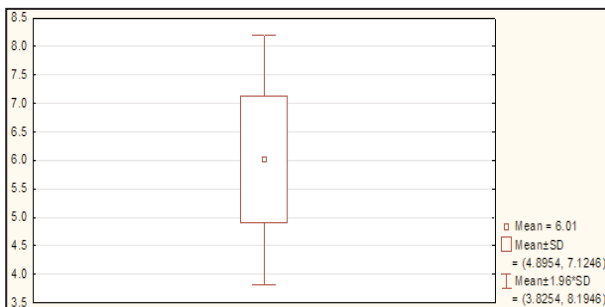
Statistical programs SPSS 20.0 were used for the statistical analysis. The results of the research were analyzed using the following statistical methods: percentages, mean, standard deviation, Me and interquartile range (IQR) and test for difference between arithmetic means.

### Results

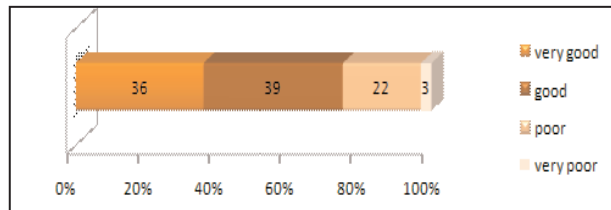
The research covers 100 children with an average age of  $6.0 \pm 1.1$  years, in the range of minimum 3 and maximum 8 years, 50% of patients were younger than 6 years for Median IQR=6 (5-7) (Graphic 1). According to gender, 44.0% of them were boys, 56.0% were girls, and the percentage difference between genders is statistically insignificant for  $p > 0.05$  (Difference test,  $p = .0897$ ).

Graphic 2 shows the expectation of parents for dental treatment: 39.0% of the parents think that the response of their children would be good, 36.0% very good, 22.0% that it would be poor, and 3.0% that it would be very poor. The percentage difference between good and very good versus poor and very poor is statistically significant for  $p < 0.05$  (Difference test,  $p = 0.02$ ).

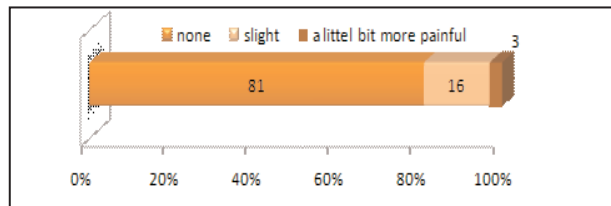
Graphic 3 represent children's self-assessment of pain: in 81.0% of the children no pain has been observed, in 16.0% of them slight pain has been observed, and in three children a slightly heavier pain



**Graphic 1.** Average age of patients



**Graphic 2.** The expectation of parents for dental treatment



**Graphic 3.** Children's self-assessment of pain

has been observed; the percentage difference between no pain and the other cases is statistically significant for  $p < 0.05$  (Difference test,  $p = 0.0000$ ).

### Discussion

Atraumatic Restorative Treatment approach can be widely used to treat cavitated caries lesions in children, and one of the many positive aspects of the approach is the "atraumatic" component<sup>16</sup>.

This can be seen from a variety of aspects, including tooth tissue preservation and patient comfort. Using mainly hand devices to open and clean, the cavity maintains the tooth structure better than the traditional technique, which suggests using a drill<sup>8</sup>. It must also be emphasized that ART approach has the potential to be more pleasant for patients as the bur's noise and vibration are eliminated. The fact that local anesthetic is rarely administered in the procedure adds to the "atraumatic" impact<sup>17</sup>.

The pioneer of the ART approach, Frencken<sup>18</sup>, recommended that when a dentine cavity needs to be restored in a child or anyone else, ART should be the primary therapeutic option. If ART or any other child-friendly therapy is unusable in treating a particular condition, the therapist should proceed to conventional treatments.

Many studies were conducted in order to research pain, anxiety and discomfort related to ART approach, and the results showed that the approach is more patient-friendly compared to other restorative treatments. However, they change in relation to the methodology used to assess the level of pain.

The Wong-Baker Facial Scale was used to assess each child's self-reported pain in the present study. This scale measures the pain of the patient by selecting between six distinct faces, each expressing a different

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facial emotion. The first image shows a pleasant smiling face, which is followed by less happy emotions until the last image, which shows a very unhappy face covered in tears. The operator performing the treatment employed the scale right after each restorative treatment.

The result of the present investigation showed that 81% of the children (aged 3 to 8) did not experience pain throughout ART approach, and only 3% of the parents anticipated the treatment to go very poorly. De Menezes Abreu et al.<sup>19</sup> also used the Wong-Baker Facial Scale for measuring children's pain and concluded that children (aged 4 to 7) felt less pain when the ART approach was used.

Possible factors that contributed to our results, aside from the atraumatic effect of the approach, are that the children were introduced and assessed in their classroom on the first visit and were also given additional oral health instruction, particularly oral hygiene/teeth brushing and sugar consumption, and were informed about the course of treatment. The fact that the parents were informed by telephone that the children should be prepared for the course of treatment at the next visit also had an effect on the satisfactory treatment. It is important to note that the treatments were carried out during school hours accompanied by the parents and the teacher.

In China, 93% of 5-year-olds reported no pain during ART procedure, and 86% were willing to receive ART during the next visit<sup>20</sup>. A multi-country research was conducted in Ecuador, Panama, and Uruguay. In this comparative study, children aged 7 to 9 reported the pain during the ART process, however this was far less common than pain associated with amalgam restoration<sup>21</sup>. Ishan et al.<sup>22</sup> came to conclusion that children had higher level of anxiety before ART treatment than during and after the treatment. The report by Mickenautsch S and Rudolph MJ<sup>23</sup> is in favor of the ART procedure. They observed changes in the expressions of the patients undergoing ART treatment. Their expression went from fearful to more relaxed as the treatment progressed.

Goud et al.<sup>24</sup> used the Modified Venhame as well as heart rate monitor to assess the discomfort during dental treatment, and concluded that ART caused less discomfort compared to rotatory instruments. In the same line of conclusion was the study conducted on 6-year old children in Indonesia<sup>25</sup>.

According to Frencken<sup>26</sup>, the ART approach is beneficial not just for improving the patient's experience of dental treatment, but at same time it can potentially reduce health costs and patient morbidity due to minimal possible need for general anesthesia and sedation. All this leads to the conclusion that ART is the best alternative and most suitable for younger children.

## Conclusion

Children with a mean age of 6.0 years reported no pain during atraumatic restorative treatment (ART), and parental expectations of the treatment were very good.

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# VIRTUAL ARTICULATORS AND INTEROCCLUSAL RECORDS IN FIXED PROSTHODONTICS - LITERATURE REVIEW

## ВИРТУЕЛНИ АРТИКУЛАТОРИ И ИНТЕРОКЛУЗАЛЕНИ ЗАПИСИ ВО ФИСКНА ПРОТЕТИКА - ПРЕГЛЕД НА ЛИТРЕРАТУРА

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### Abstract

Over the years, mechanical articulators have been widely used to design and fix prosthodontics. The mechanical articulators have had some challenges which have prompted dentists to use virtual articulators. Notably, virtual articulators utilize virtual application programs to capture occlusal movements for interocclusal records and fixed prosthodontics. The mechanical articulators have had their fair share of challenges in that it has been a challenge to capture occlusal movements while the design of the machines changed often. The materials, commonly used in mechanical articulators to register occlusal details, have often decomposed hence posing trouble for patients regarding the quality of bite. Therefore, the registration materials used to capture occlusal materials are critical in ensuring that dentists fit prosthodontics perfectly. The literature review analyzes secondary data on virtual articulators' various features. Also, the research paper focuses on the challenges dentists face when using occlusal registration materials and mechanical articulators. The study further looks at the solutions brought forth by the virtual articulators regarding registering occlusal records. **Key words:** Virtual articulators, prosthodontics, mechanical articulators, interocclusal records, and virtual reality.

### Апстракт

Долги години, механичките артикулатори се широко користени за дизајнирање и фиксирање во протетиката. Механичките артикулатори имаа некои предизвици коишто ги натераа стоматолозите да користат виртуелни артикулатори. Виртуелните артикулатори користат програми за виртуелна апликација со цел да ги забележат оклузалните движења за интероклузални записи во протетиката. Механичките артикулатори имаа големо учество во предизвиците да се регистрираат оклузалните забележувања и покрај честото менување на дизајнот. Материјалите што најчесто се користат кај механичките артикулатори за детали на оклузалното регистрирање, со тек на време претрпуваат промени, што претставува проблем во однос на квалитетот на загризот. Затоа, материјалите за регистрација на оклузијата се од клучно значење за да се осигура дека стоматолозите совршено ги изработуваат протетичките изработки. Прегледот на литературата ги анализира секундарните податоци за различните карактеристики на виртуелните артикулатори. Исто така, трудот се фокусира на предизвиците со кои се соочуваат стоматолозите кога се користат оклузални регистрациони материјали и механички артикулатори. Студијата понатаму ги разгледува решенијата донесени од виртуелните артикулатори во врска со регистрирање на оклузалните забележувања. **Клучни зборови:** Виртуелни артикулатори, протетика, механички артикулатори, интероклузални записи и виртуелна реалност.

### Introduction

There have been technological transformations in the 21<sup>st</sup> century, such as the introduction of virtual articulators in fixed prosthodontics<sup>1</sup>. The medicine field, to be specific, the branch of dentistry, has introduced virtual articulators to improve hygiene and dental health in fixed prosthodontics<sup>2,3</sup>. Notably, mechanical articulators have been widely used to register interocclusal and design prosthodontics used to fix artificial teeth<sup>4</sup>. However, mechanical articulators have had many challenges emanating from capturing accurate details and

interocclusal records, which are critical in designing and manufacturing artificial mouth components<sup>5,6</sup>.

The adoption and application of virtual articulators has been slow but steady. In the west, specifically in the US, dentists and clinics are adopting virtual reality in fixed prosthodontics<sup>7,8</sup>. DentCam technology is the most common type of virtual articulators widely used in the west due to their efficiency and cost of operating virtual reality in designing and fixing prosthodontics<sup>9</sup>. On the contrary, developing countries in Africa are slow in applying virtual articulators due to the lack of trained human resources<sup>11</sup>. Additionally, most hospitals in rural



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areas lack electricity which is essential in powering computing devices and components of virtual reality<sup>12,13</sup>.

## Objective

There are several aims that the literature review strives to meet. Firstly, the paper aims to discuss the various problems and challenges associated with mechanical articulators. Secondly, the research focuses on the difficulties related to the use of interocclusal data records registered by mechanical articulators. Thirdly, the paper outlines some of the robust solutions that virtual articulators are associating with the use of mechanical articulators. Some of the solutions include: registering accurate occlusal impressions, designing, and manufacturing prosthodontics that are custom made. Fourthly, the review gives the benefits of using virtual articulators as an effective technological tool in fixed prosthodontics.

## Material and methods

The research paper utilizes numerous journal articles and books to build the hypotheses of the paper. The journal articles are peer-reviewed by teams of scholars who have robust knowledge in medicine and, by extension, dentistry<sup>14,15</sup>. The paper leverages several books online to discuss the importance of virtual articulators in registering static and dynamic occlusal records<sup>16,17</sup>. The paper synthesizes journal articles and books to give detailed research on the effectiveness and parts of virtual articulators in registering occlusal records in designing and fixing prosthodontics<sup>18,19</sup>. The criteria used are that the journal articles and books should be scientific, containing primary and secondary data<sup>21,22</sup>. Secondly, the study done by a research material should be around virtual articulators, prosthodontics, interocclusal records, dentistry, and dynamic occlusion based on the human population.

Thirdly, the materials are supposed to be in English since the primary language of research is English. Fourthly, the research contained in the material should be authentic and based on science<sup>23,24</sup>. Fifthly, the material should have been written and published within the last decade, that is, from 2011 to 2021 to ensure that the data is updated and features technological advances such as virtual reality. The sixth criteria is that the material should be well written, organized<sup>25,26</sup> coherent and interesting in addressing the issues of virtual articulators, interocclusal records, and artificial teeth.

## Discussion

Over the years, there have been widespread complaints from dentists related to wear and tear nature of mechanical articulators. Studies have shown that the pro-

longed use of mechanical articulators interferes with registering interocclusal records<sup>27</sup>. Some of the mechanical articulators rust, making it difficult to get the exact size of occlusal in the maxilla and mandibular<sup>28,29</sup>. In addition, an overused mechanical articulator is prone to plastering excess cast on the occlusal<sup>30</sup>. The failure of mechanical articulators to plaster the correct amount of cast on the maxilla and mandibula further the bite problem of a patient by interfering with the interocclusal records.

The use of mechanical articulators has, on numerous occasions, reduced the effectiveness of fixed prosthodontics. As a result of decomposing materials that generate interocclusal data, there is the problem of casting on occlusal impressions that form the outer part of prosthodontics<sup>31</sup>. Consequently, the cast impression leaves spaces in the prosthodontics, which creates extra dental problems. The spaces left by mechanical articulators affect the quality of the bite. A patient may not be able to chew food effectively, especially if it is made up of hard contents<sup>32</sup>. Also, the use of mechanical articulators contributes to manufacture of prosthodontics with a poor orientation that may lower a person's self-esteem. Besides, mechanical articulators use excessive plasters that are detrimental to an artificial tooth's stability due to the excess weight on the mandibular and maxilla. Subsequently, the numerous challenges associated with mechanical articulators create the need to have an effective, durable, and accurate device for recording details of mouth components<sup>33</sup>.

A virtual articulator uses software designed to improve interocclusal records and prosthodontics' outcome and effectiveness<sup>34</sup>. Virtual articulators are banked on virtual reality that entails using a computer-generated simulation program that allows a dentist to interact with 3D objects registered by using specially made face bow devices. In other words, a dentist is literally placed in another world where they interact with 3D images simulated in computers<sup>35</sup>. Virtual articulators give a dentist a room to explore different possibilities of designing, manufacturing, and fixing prosthodontics before commencing the clinical work. Besides, virtual articulators play an integral role in verifying the interocclusal records registered before setting prosthodontics to determine the artificial tooth's effectiveness.

Furthermore, virtual articulators have revolutionized the practice of restorative dentistry<sup>36</sup>. Unlike mechanical articulators that are time-consuming and difficult to clone and customize prosthodontics, virtual articulators have made it possible for dentists to customize prosthodontics according to the patient's specification obtained from a virtual articulator's registry<sup>37</sup>. Prosthodontics' customizations is a growing technology that has continued to put smiles on millions of people. It is important to note that the use and application of virtual articulators has faced

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several challenges. One of the difficulties has entailed the training of dentists. Most dentists trained in the 20<sup>th</sup> century lack the necessary skills to generate computer-simulated 3D images from virtual articulators<sup>38</sup>. The number of dentists that have gone back to the university to study the use of virtual reality in restorative dentistry is minimal, depending on the number of people that require prosthodontics.

The other challenge of virtual articulators relates to virtual reality technology's initial and maintenance costs. As compared to mechanical articulators, virtual articulators are slightly expensive as they require installing information systems such as computers, the internet, and storage to aid the simulation of objects<sup>39</sup>. Virtual articulator technology requires continuous updates and verification to prevent unauthorized personnel from accessing the software. Maintaining virtual technology is expensive since it requires professionals, both trained and experts, in dentistry and information technology. The price of peripheral devices such as digital face bow is costly for hospitals and dentists to buy, and requires a budgetary allocation to facilitate the procurement of complementary technology like software.

Despite some of the challenges associated with virtual articulators, the advantages outweigh the shortcomings. Virtual articulators can give real-time data critical in improving the accuracy of interocclusal data<sup>40</sup>. The data generated from mechanical articulators takes a certain amount of time to register data, increasing the amount of time required to design and manufacture fixed prosthodontics. It is imperative to underscore that as virtual articulators transmit real-time data, the dental arches' images captured are not clear. However, the jaw movements are captured and used to determine a prosthodontics' dental arching.

Nevertheless, virtual articulators improve the quality of dentures produced through enhanced communication. The virtual reality used in fixing artificial teeth provides a fundamental platform where both the dentist and the dental technician can access data on interocclusal seamlessly. The use of virtual articulators enables dentists to send 3D simulations of interocclusal movements to dental technicians efficiently<sup>42</sup>. The technology has an option of sharing data and information from one party to another, which enhances the practice of sharing data with different people. Besides, the patient can also be enlightened on how virtual articulators are capable of improving their prosthodontics by showing them a simulation of jaw movements on the screen.

The new applications in dentistry have been instrumental in bolstering good dental health and efficient restorations. However, there have been minimal journal articles, books, and publishing that have provided credible

and updated data on the application of virtual articulators and interocclusal records in fixed prosthodontics<sup>42</sup>. One of the fundamental contributions relates to the features of virtual articulators. Different types of virtual articulators are applied in the world depending on the country, cost, and technology used in developing the articulators. In western countries such as the United States of America and the UK, DentCam virtual articulators have been widely used as the standard virtual reality technology<sup>43</sup>. The adoption of DentCam as the standard virtual articulator has been informed by the fact that DentCam offers real-time data on simulation movement of jaws and occlusal. DentCam virtual articulators have four essential features that register interocclusal records in fixing artificial teeth<sup>44</sup>. Virtual articulators' features are the rendering window, slice window, smaller window, and occlusion window.

The rendering window registers interocclusal records of the mandibular and maxilla from angles that capture the cusps of the occlusal. Additionally, the rendering window plays an integral role in showing how antagonistic movements of teeth occur<sup>45</sup>. The second feature of DentCam is the slice window that shows the dental arch's frontal part, which makes it easy to balance jaw movements. Thirdly, the occlusion windows illustrate the mandibular and maxilla jaws' occlusion that show the statistic and dynamic occlusion. The fourth feature is the smaller window that shows temporomandibular movements' features with respect to occlusal, which gives a transversal angle.

Nonetheless, virtual articulators require well-detailed images of 3D representation of jaws. The 3D images are registered using virtual reality technology<sup>46</sup>. The data about the patient's jaw movement are required to ascertain occlusal movements. It is imperative to underscore that jaw and occlusal movements differ from one person to another depending on the dental formula and the quality of the bite. After presenting 3D images and jaw movements, virtual articulators simulate the jaw movements to show a dentist how a visual image of occlusion is going to come into contact<sup>47</sup>. The simulation may be presented in terms of a video or an image, depending on the type of data the dentist requires.

Patients have different occlusal and jaw movements. When designing and manufacturing prosthodontics, there is some force applied on a mechanical articulator to adjust the interocclusal records of a patient. The process of adjusting the mechanical articulator to produce the prosthodontics' desired design affects the setting of the articulator by reducing the accuracy of customizing the right size of occlusal and jaw movements<sup>48</sup>.

Unlike mechanical articulators, virtual articulators enable a dentist to edit interocclusal records by kinematic analysis to ensure that the design of artificial teeth match-

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es the records and settings of a patient<sup>49</sup>. The virtual articulator tool allows an individual to virtually adjust the positions of occlusal simulations. On the other hand, a dentist has to adjust the settings of a mechanical articulator, which increases the chances of wear and tear. When it comes to casting, a dentist is forced to manually fix the cast on a prosthetic which may take a long time when performing a full mouth restoration. However, virtual articulators enable dentists to virtually fix cast and perform a mouth rehabilitation by applying the CAD systems<sup>50</sup>.

## Research patterns and principles

The research on virtual articulators and mechanical articulators follows certain principles and patterns to ensure that the conducted research meets the required threshold. The hypothesis behind the study is that virtual articulators are considered to be more effective than mechanical articulators, especially when it comes to registering static and dynamic occlusion data. The study is structured in a manner that either confirms or disapproves the hypotheses of the research. Subsequently, the research paper synthesizes primary and secondary data to help in identifying how virtual articulators help in the process of designing, manufacturing, and fixing prosthodontics. The clinical measurements of both dynamic and static occlusion are factored in to inform the researchers on how different occlusion generates different data in terms of interocclusal records<sup>51</sup>.

The research applies the principle of using quantitative data to generate and analyze statistics that relate to the use of virtual articulators and mechanical articulators. There are numerous secondary sources of data that contain data on the dynamic and static occlusion records with regard to articulators. The data provided by other scientific journals form a fundamental base of analysis with the data generated from the research<sup>52</sup>. In other words, secondary data plays a huge role in asserting or disapproving that virtual articulators are more effective than mechanical articulators.

Furthermore, the research leverages on secondary data to look at the trends associated with the use of virtual articulators. The research data collated shows that as much as there is still use of mechanical articulators, virtual articulators are slowly gaining traction among dentists.

The increasing trend in the use of virtual articulators is bolstering the provision and fixing of high-quality and customized prosthodontics. In countries such as the United States of America and the United Kingdom, the number of people seeking prosthodontics is constantly increasing<sup>53</sup>. The increase in the number of people seeking prosthodontics services is a clear indication that patients have a positive attitude and trust towards the use of virtu-

al articulators in improving interocclusal records registers, and fixing artificial teeth.

## Suggestions for further research

The future of dentistry is greatly hinged on virtual articulators. However, there is a need to perform further research on the future and effectiveness of virtual articulators over mechanical articulators<sup>54</sup>. One of the suggestions for future research is to find out the level of training of dentists with regard to the use of virtual articulators. The current studies show that the number of dentists that have the knowledge to operate and use virtual articulators is still minimal. Further research should be conducted to examine the strides made in training dentists on the use of technology such as virtual reality, robotics, and artificial intelligence.

Likewise, future research should be conducted on the standardization of virtual articulators. The use of technology is revolutionizing dentistry, but there is a need to standardize the use of virtual articulators<sup>55</sup>. Future research should be conducted to ascertain what dentistry boards and agencies are doing to ensure that the virtual articulators that come to the same market have a certain level of efficacy. The study on standardization will give dentists an overview of the virtual articulators in the market and how effective they are. Currently, DentCam is the standard articulator that is used widely<sup>56</sup>. More research is necessary to analyze the effectiveness of other virtual articulators with regard to simulating interocclusal data in generating 3D images and occlusal movements<sup>57</sup>.

Comparatively, more research should be done on how to improve the effectiveness of virtual articulators. Research should be conducted to examine how virtual articulators can handle more prosthodontics<sup>58</sup>. The points of focus should be on how to simulate more than one interocclusal movement and 3D images by using virtual reality technology<sup>59</sup>. In addition, the privacy of the patient's data is an aspect that should be extensively researched. Data privacy is a major issue in most countries. More studies should be done on how to secure the data handled by virtual articulators to ensure that no unauthorized person has access to the data<sup>60</sup>.

## Conclusion

For quite a long time prosthodontics has been defined by the use of mechanical articulators which have posed numerous problems. Mechanical articulators have had challenges such as destroying occlusal materials that are used in registering dentures. However, virtual articulators are defining dentistry by offering solutions to challenges posed by mechanical articulators, and improving

the design and manufacturing of fixed prosthodontics. Virtual articulators are improving the quality of life of people by improving their mouth components with definite fixed prosthodontics. The use of virtual articulators improves the effectiveness of registering interocclusal records by enabling dentists to capture different angles of occlusion in the mandibula and maxilla. Nevertheless, there is a need to conduct more research to improve the number of interocclusal records that virtual articulators can register simultaneously.

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