MACEDONIAN DENTAL REVIEW

ISSN 2545-4757 | 2-3 44 2021

Macedonian Dental Review is publishing by the Faculty of Dentistry, University „Ss. Cyril and Methodius“, Skopje, Republic of North Macedonia and Macedonian Dental Society

http://stomfak.ukim.edu.mk/msp/

MACEDONIAN DENTAL REVIEW **C o n t e n t s**

2021 ● Year **XXXXIV** ● Nummber 2-3 ● стр. 33-88

Macedonian Dental Review is publishing by the Faculty of Dentistry, University „Ss. Cyril and Methodius“, Skopje, Republic of North Macedonia and Macedonian dental society.

Editor in chief - Prof. **Kjiro Ivanovski**, PhD, e-mail: kiroivanovski@stomfak.ukim.edu.mk
Associate editor - Prof. **Elizabeta Georgievska** PhD, Department of Pediatric and Preventive Dentisty, e-mail: egjorgievska@stomfak.ukim.edu.mk
Secretary - **Vlatko Kokolanski**, MBA, e-mail: vkokolanski@stomfak.ukim.edu.mk

Adress - Macedonian Dental Review, str. Majka Tereza br. 43 Skopje, Republic of North Macedonia, **http://stomfak.ukim.edu.mk/msp/**

МАКЕДОНСКИ СТОМАТОЛОШКИ ПРЕГЛЕД **Содржина**

2021 ● година **XXXXIV** ● Број 2-3 ● Страна 33-88

Македонски стоматолошки преглед го издава Стоматолошкиот факултет при Универзитетот „Св. Кирил и Методиј" Скопје, Република Северна Македонија и Македонското стоматолошко друштво.

Одговорен уредник: Проф. д-р **Ќиро Ивановски**, e-mail: kiroivanovski@stomfak.ukim.edu.mk
Заменик одговорен уредник: Проф. д-р **Елизабета Ѓоргиевска**, е-маил: egjorgievska@stomfak.ukim.edu.mk
Секретар на списанието: м-р **Влатко Коколански**, e-mail: vkokolanski@stomfak.ukim.edu.mk

Адреса - Македонски стоматолошки преглед, ул. Мајка Тереза бр. 43 Скопје, Република Северна Македонија
http://stomfak.ukim.edu.mk/msp/

UDK: 616.314–089.843

VON MISES STRESS ANALYSIS IN 3D ALL-ON-6 MODEL WITH 1:1 C/I RATIO

АНАЛИЗА НА НАПРЕГАЊАТА ПО VON MISES КАЈ 3D МОДЕЛ ALL-ON-6 СО 1:1 СООДНОС C/I

Dejanoska T.[1], Dimoski G.[2], Kapuševska B.[3], Kokalanov V.[4], Vujasin S.[5]

[1]PZU Dental International-Dejanoski, Skopje, [2]PZU Dimargo Dent,Ohrid, [3]Department of Prosthodontics, Ss. Cyril and Methodius University in Skopje, Faculty of Dentistry - Skopje, Republic of North Macedonia, [4]Faculty of Computer Science, Numerical Analysis and Applied Mathematics, UGD, Štip, [5]Faculty of Dentistry, Department of Prosthodontics, EU, Skopje

Abstract

Implant-prosthetic treatments provide better dental rehabilitation than other treatments. However, implant overload is considered a risk factor that may compromise the treatment. The aim of the study was to analyze the stress in the implants, cortical and spongiosus bone, at an equal ratio of suprastructure and implant (C / I 1/1) in All-on-6 implant concept in the mandible. Numerical tests were performed on a 3D model of the mandible, based on the finite elements method or finite elements analysis (FEA). Static simulated vertical forces of 100 N and oblique forces of 35 N at an angle of 45 degrees, were applied. The physical characteristics of biological tissues and component materials, as necessary data for model making, are taken from the literature. The study analyzed Von Mises stress in implants and peri-implant cortical and trabecular bone. The highest values of von Misess stress were observed in implants, then in cortical bone, and the lowest ones in trabecular bone. The stress has higher values and greater variations on the loading side. Oblique loads create greater stress. Von Misess stress does not exceed the limitation values of elasticity of the implants and peri-implant bone tissue. The results give a realistic vision of the stress, that can be used for implant-prosthetic treatments planning. **Key words:** crown/implant ratio, suprastructure, implant, von Misess stress, stress analysis, cortical bone, trabecular bone, implant treatment, vertical forces, oblique forces.

Апстракт

Имплантопротетските третмани овозможуваат подобра стоматолошка рехабилитација од другите третмани, но сепак преоптоварувањето на имплантите се смета за фактор на ризик, кој може да го компромитира третманот. Целта на истражувањето беше да се анализираат напрегањата во имплантите, кортикалната и спонгиозна коска, при еднаков сооднос на супраструктурата и имплантот (C/I 1/1) кај All-on-6 имплантолошки концепт во долна вилица. Нумеричките испитувања беа направени на 3D модел на долна вилица, базиран на методот на конечни елементи. Применети се статички симулирани вертикални сили со јачина од 100 N и коси сили под агол од 45^0 од 35 N. Физичките карактеристики на биолошките ткива и градивните материјали, како потребни податоци за изработка на моделот, се земени од литературата. Во истражувањето анализирани се напрегањата по Von Mises во имплантите и периимплантната кортикална и спонгиозна коска. Најголеми вредности на напрегањата по von Mises има кај имплантите, потоа во кортикалната коска, а најмали во спонгиозната коска. Напрегањата имаат повисоки вредности и поголеми варијации на страната на оптоварувањето. Косите оптоварувања прават поголеми напрегања. Напрегањата по von Misess не ги надминуваат граничните вредности на еластичност на имплантот и периимплантното коскено ткиво. Добиените резултати даваат реална слика на напрегањата кои можат да бидат употребени за планирање на имплантопротетските третмани. **Клучни зборови:** сооднос C/I, супраструктура, имплант, von Misess stress, стрес анализа, кортикална коска, спонгиозна коска, имплантолошки третман, вертикални сили, коси сили.

Introduction

Edentulous therapy in contemporary dentistry is a choice between complete dentures or implant therapy. Each option has its advantages and disadvantages.

The advantage of implant-prosthetic therapy is that the prosthetic suprastructures above the implants provide greater stability and 60-80% restoration of the lost function. This gives the patient greater reliability[1].

Findings about the quality effect of implant treatment, the quality of contemporary materials for making dental implants and solving the problem of osseointegration, the development of modern implantation methods, have contributed to its preference for edentulous treatment in clinical practice.

Implant-prosthetic therapy in edentulous patients, with fixed suprastructures, is one of the most significant achievements in clinical dentistry.

More and more authors agree that clinical implantology has advanced to the point that today's implant treatment is a predictable approach for replacing lost teeth [2,3,4 5,6].

Literature review

Although implant treatments provide better dental rehabilitation than other treatments, implant overload is still considered one of the risk factors for implant success.

The load applied to the dental implant is distributed to the bone peri-implant tissue, where certain stresses are caused. Biological tissues can tolerate these stresses or react by initiating remodeling activity or creating new bone tissue[7,8].

In fact, the load is transferred through the implants to the bone structures and causes stress, which acts as a stimulus for bone tissue maintenance through remodeling process or bone formation process[9].

Bone remodeling of cortical bone is 7.7% per year, and 17.7% of trabecular bone[10].

Other authors note that cortical bone has annual bone turnover increased by 3%, while trabecular bone by 24%[11].

If the load is excessive, i.e. exceeds the physiological limits that the bone tissues can withstand, great stresses occur at the level of the interface implant-bone, which impairs osseointegration, increasing the risk of implant failure[12,13].

Determining the stress in implants, bone tissue and suprastructure can provide timely information on potential overload locations and thus prevent side effects.

The biomechanical interaction between the implant and the bone plays a key role in implant treatment success[14].

Therefore, it is very important to have a good understanding of the behavior of the forces applied on the implants, the transmission of forces to the surrounding bones and the response of the orofacial tissues, as important elements for ensuring the effectiveness of dental implants[15].

Stress distribution on dental implants and peri-implant bone tissue is a widely debated topic in the literature[16,17,18,19].

The impact of the dental implant on the peri-implant bone tissue mainly depends on the direction and intensity of the loading force, the type and material of the suprastructure, the implant design, the bone density and the mechanical characteristics of the connection between implant and bone tissue[20].

In literature, there is a multitude of research data on the impact of all of the above factors.

Due to the numerous differences, research results cannot often be comparatively relevant.

The Finite Element Method (FEA) is the most commonly used method for analyzing the forces and stresses occurring in the structure of peri-implant bone tissue, but also for evaluating different clinical situations and prosthetic options[21].

The Finite Element Method (FEM) is an analytical technique that is one of the most complete digital tools in dentistry for stress distribution, deformation and structural displacement studies[22].

Masticatory forces are dynamic loads, but because these loads are difficult to number, most FEAs use static loads[23, 24, 25].

However, there are limitations to this type of studies. One of them is that literature data obtained by different methods are mostly often used for physical characteristics of biological tissues[14, 27].

Therefore, the obtained results should not be considered as absolute, but should be used as a comparison for possible developments in the bone structure and implant components.

Comparative results from 3D FEA studies have shown that 3D FEA results correspond to clinical results, when matched with in vivo stress measurements[27, 28].

It is inevitable to compare the results of 3D FEA with previously obtained experimental or clinical data. Published results in literature will be used as reference values for comparison in this paper as well.

Various reference values of bone tissue tolerance have been published in literature. This is understandable since bone tissue has many individual characteristics, as well as different research methods.

The average value of bite forces and their resultants in implant treated patients is said to be 50 N whereas their maximum value is 150 N[29].

Due to the way it is formed, a bone shows a higher compressive strength of about 170 MPa, a lower tensile strength of 104–121 MPa and a very low shear stress strength (51.6 MPa)[30, 31].

According to Bajraktar et al. the cortical strength on tensile yield strains is 104 MPa. On the other hand, the trabecular strength on tensile stress is 82 Mpa[32].

According to Shikha et al. physical characteristics of the bone are as follows: cortical tensile strength is 115 MPa, and trabecular 32.4 MPa, cortical bone compression strength is 133 MPa, and trabecular 37.5 MPa[22].

Baggi realized that the cortical bone could withstand compressive stress of less than 170–190 MPa and tension of 100–130 Mpa under normal loads[33].

During vertical loading, Macedo observed maximum values of von Mises stress from 73 to 118 MPa in cortical bone and values from 6 to 7Mpa in trabecular bone. At oblique load, the values of maximum von Mises stress were 15 to 21 MPa for trabecular bone, while values of 150 MPa were obtained for cortical bone[34].

Also, Vijapure et al. obtained higher values when subjected to oblique loading[35].

2.5 to 8 times higher Von Mises strains in cortical bone were received than those in trabecular bone by Pessoa et al. and Vijapure et al.[35, 36].

According to Hingsammer et al., stress is much more pronounced in cortical bone due to higher mechanical strength and larger elasticity modulus, and thus can accumulate larger amount of stress[37].

In studies where the load is unilateral, the stress in the peri-implant bone tissue is higher on the loading side compared to the contralateral side[38, 39, 40, 41, 42].

However, finite element analysis has its limitations because it simulates living tissue that is not constant in its natural state and cannot replicate its characteristics as accurately as in the oral cavity[43, 44].

Aim of the study

The aim of this study was to create a numerical three-dimensional (3D) model, with equal ratio of suprastructure and implant on All-on-6 implant concept, to examine the stress in implant and peri-implant tissue, as well as to compare the results with literature data, and to assess whether the created model can serve as a benchmark for future research.

Material and methods

Numerical tests were performed on a three-dimensional (3D) model based on the Finite Element Analysis. The finite elements network is generated by software package SOFiSTiK AG, a German software company.

A model of an edentolous mandible with implants was created, according to the All-on-6 implant concept, on which a circular (latefrontolateral) fixed prosthetic suprastructure is modeled, with a ratio of 1/1 to the placed implants.

The model is created based on 3D computer tomography of the mandible.

The incisions are made by computer scan, digitalized, the thickness of the cortical bone tissue is determined, and then the data are entered in the SOFiSTiK AG software package.

The analysis was performed using the Finite Elements Analysis (FEA).

The research uses static simulated vertical occlusal forces with strength of 100N and oblique forces of 35N that will act at an angle of 45 degrees, according to literature data on functional masticatory forces.

The loading point of the simulated force will be unilateral, on the occlusal surface of the suprastructure.

The physical characteristics of biological tissues and materials, as necessary data for model creation, are collected from literature.

There are certain numerical codes for monitoring the stress on implants and peri-implant bone tissue.

Results and discussion

Excessive strain on the implant and surrounding tissues, caused by loading forces, is one of the possible causes for implant failure. Since force is transmitted directly from the implant to the bone, a well-made plan of the number of implants and their position is crucial to ensure proper distribution of masticatory forces.

Von Mises stress is used to predict the yield of materials under complex load as seen from the results of one-way tensile tests.

1. The results of the research of the All-on-6 model with Crown/Implant ratio 1/1

The study analyzed von Mises stress in implants and peri-implant cortical and trabecular bone (Figure 1. a, b, c, d, e, f).

Table 1. Numerical codes of implants

Implant – loading site	Implant – non-loading site
5 implant (distal)	6 implant (distal)
15 implant (middle/angled)	16 implant (middle/angled)
25 implant (front, anterior)	26 implant (anterior)

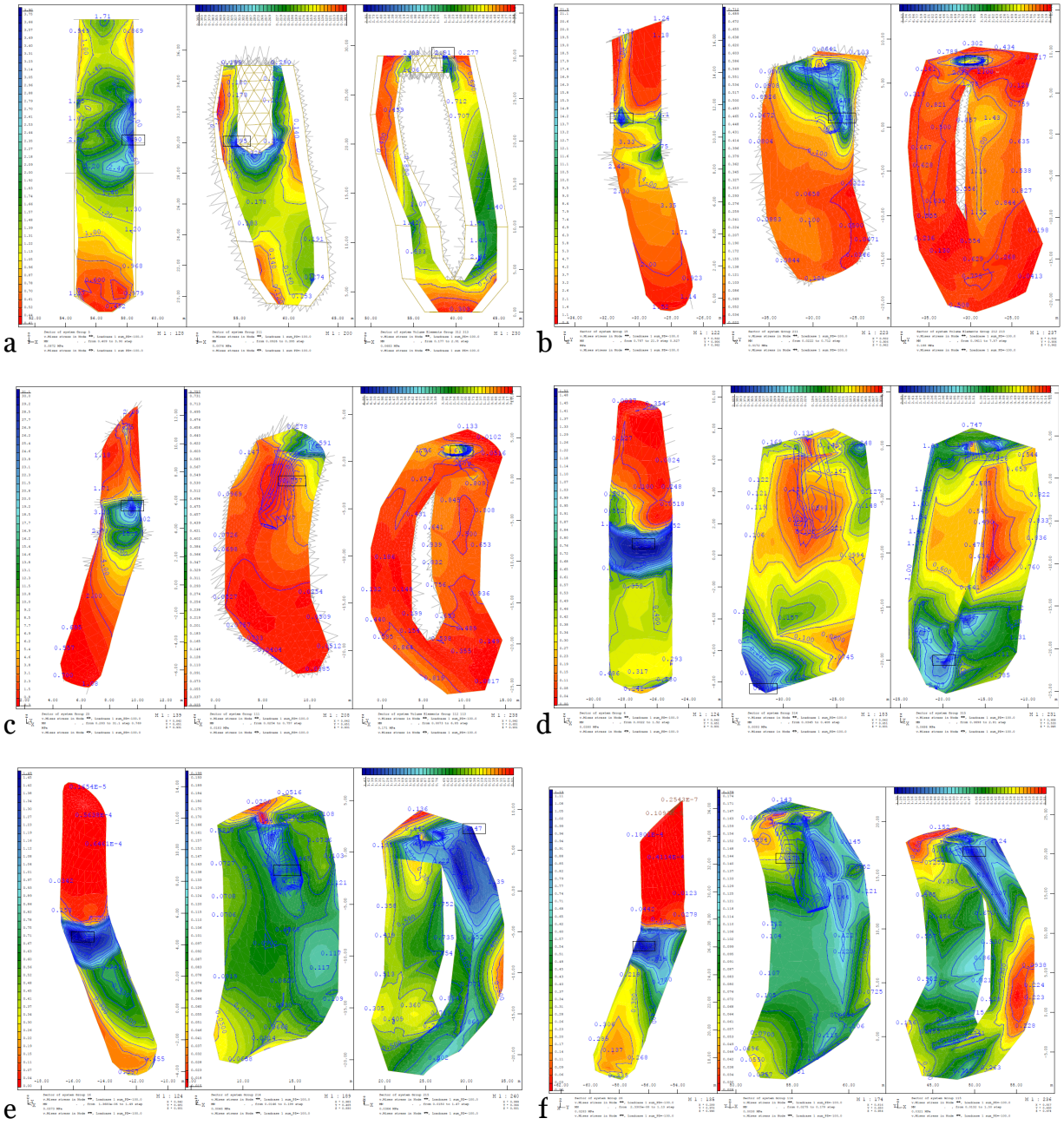
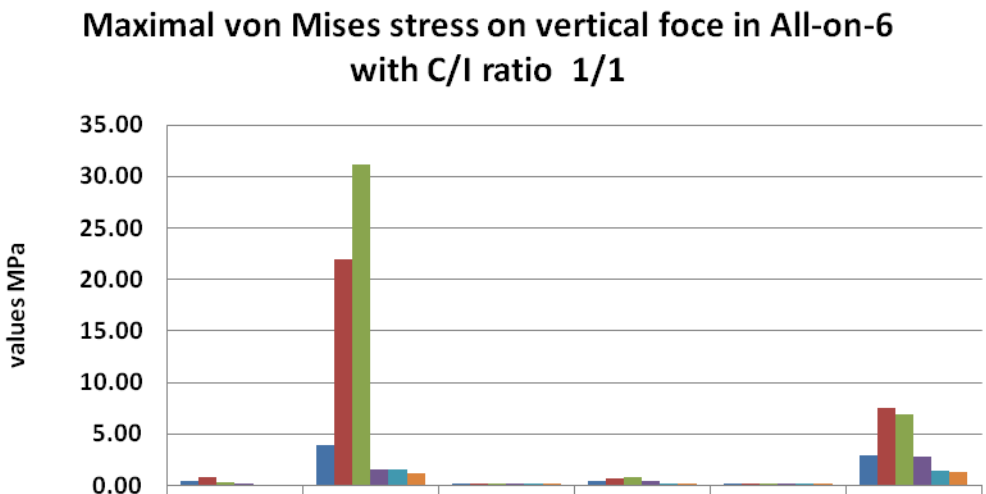


Figure 1. *Display of von Mises stress on vertical forces at All-on-6: a) distal implant 5, b) middle/angled implant 15, c) anterior implant 25, d) distal implant 6, e) middle/angled implant 16, f) anterior implant 25*

Figure 1 shows that the maximum v. Mises stress has different characteristics in each implant and peri-implant bone tissue. It is characteristic that maximum von Mises stress on distal implant 8 on the non-load side is located far from the implant zone in the basal part of the mandible (Figure 1.d.).

Figure 1 shows the values of the minimum and maximum von Mises stress in implant, cortical and trabecular bone.

The results in Figure 2 show that on vertical occlusal forces load, the higher values of maximum v. Mises stress are on the loading side. Stress values are higher on



	Implant		Cortical Bone		Trabecular Bone	
	min	max	min	max	min	max
5 implant	0.41	3.90	0.09	0.40	0.18	2.91
15 implant	0.79	21.90	0.02	0.71	0.04	7.57
25 implant	0.28	31.10	0.03	0.76	0.01	6.85
6 implant	0.00	1.52	0.03	0.41	0.07	2.81
16 implant	0.00	1.49	0.01	0.20	0.02	1.47
26 implant	0.00	1.13	0.0275	0.179	0.0132	1.3

Figure 2. *Values of maximum Von Mises stress (MPa) on vertical forces at All-on-6 model with Crown/Implant ratio 1/1*

implants. Values of maximum v. Mises stress of peri-implant bone tissue are higher in the cortical bone.

On the non-loading side, the highest values of maximum v. Mises stress are higher on the distal implant 6 and its peri-implant bone tissue.

On implants – On the loading side, the highest values of maximum v. Mises stress are on the middle implant[15] with values of 21.9 MPa, and on the front implant[25] with values of 31.3 MPa. The distal implant[5] on the same side has much lower values, less than 3.90 MPa.

On the non-loading side, the obtained values for maximum v. Mises stress differ. On the distal implant[6], the maximum v. Mises stress is 1.52 MPa, on the middle (angled) implant[16] values are 1.49 MPa, and values on the front implant[26] are the lowest, 1.13 MPa.

In cortical bone - the values of maximum v. Mises stress are higher on the loading side. The highest value of 7.57 MPa is on the middle (angled) implant[15], and the anterior[25] has slightly lower values of 6.85 MPa. In the cortical bone around the distal implant 5, the values of maximum v. Mises stress are the lowest, 2.91 MPa.

On the opposite side, the non-loading side, the values for maximum v. Mises stress are close, 1.47 MPa on the middle (angled) implant 16 and 1.30 MPa on the anterior implant 26. The highest values for maximum v. Mises, approximately twice as high, are in the area of the distal implant 6, 2.81 MPa

In trabecular bone - on the loading side, the highest values for v. Mises stress are in the anterior implant[25] - 0.757 MPa and the middle (angled) implant[15] - 0.712 MPa. Around the distal implant[5] on the same side, the values of maximum v. Mises stress are approximately twice less, 0.395 MPa.

On the non-loading side, the highest values for maximum v. Mises stress of 0.408MPa are around the distal implant[6], and around the middle angled implant[16] and the anterior implant[26], there are approximate stress values of 0.199 and 0.2179 MPa.

Figure 3 shows that maximum von Mises stress on oblique forces is with higher intensity on the loading

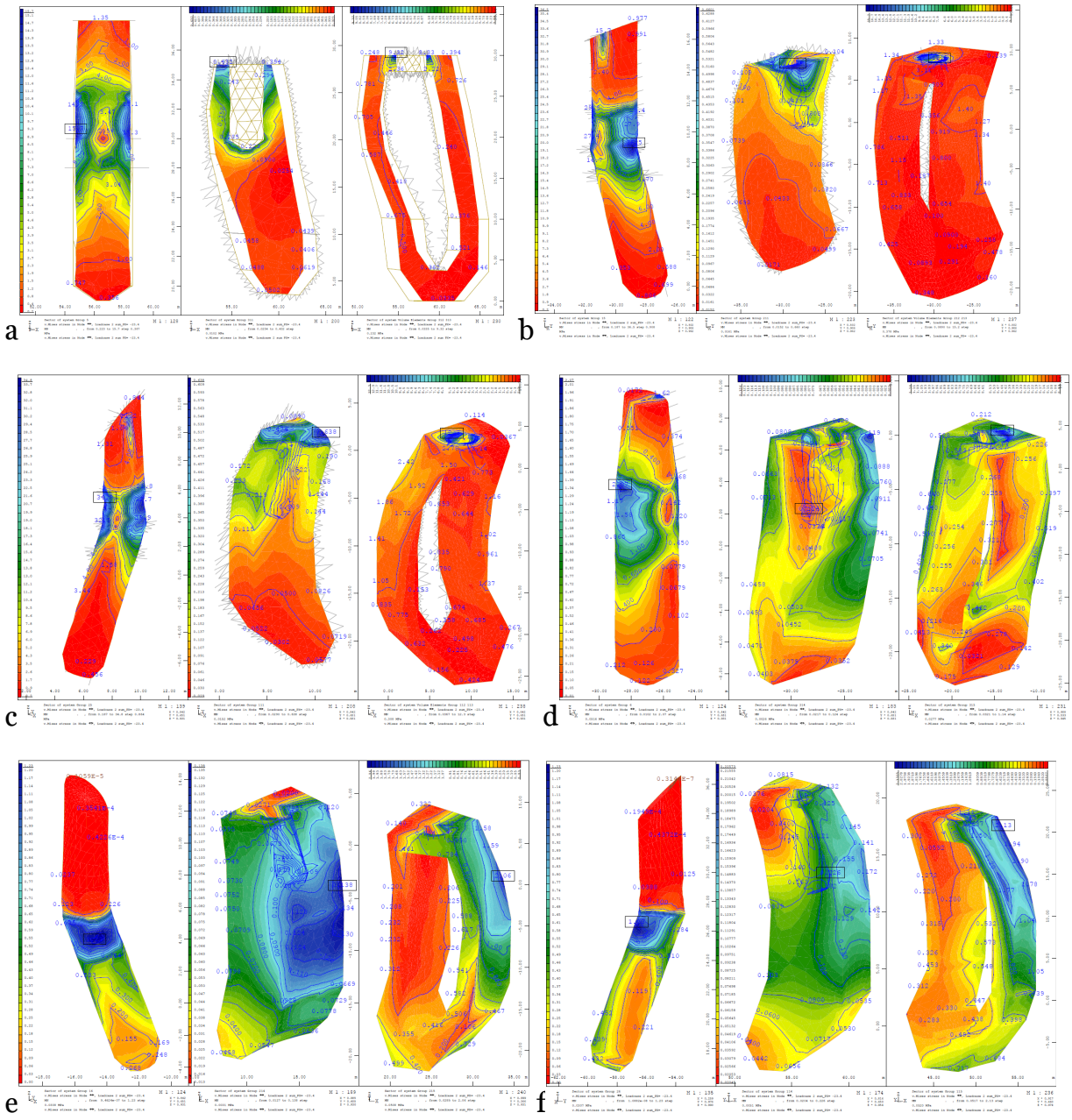
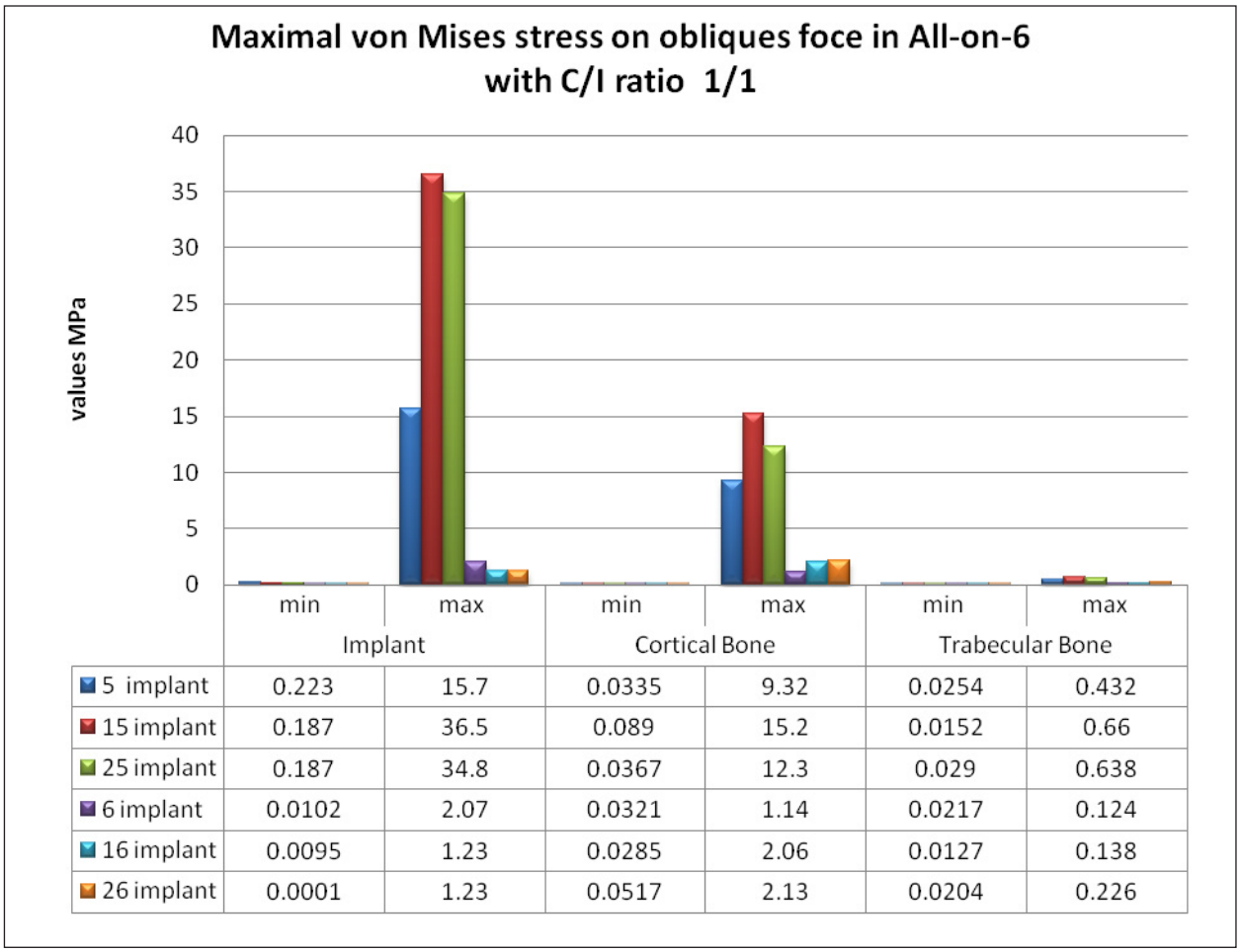


Figure 3. *Display of von Mises stress on oblique forces at All-on-6: a) distal implant 5, b) middle angled implant 15, c) anterior implant 25, d) distal implant 6, e) middle angled implant 16, f) anterior implant 25*

side. The maximum strains on the loading side are localized in the cervical part of the implants, in the cortical and the trabecular bone. On the opposite side stress has different localization in implants and peri-implant bone tissue. In implants, stress is always localized in the cervical part. In the trabecular bone, stress is always localized at the apical level of the implant, in the vestibular part, and in the cortical bone, in the distal[6], the anterior[26] and middle implant[16], stress is localized at the apical level of the implant, in the vestibular part.

The results show that, when loaded with oblique forces, higher values of maximum v. Mises stress are on the loading side. This is noted in implants, as well as in the trabecular and the cortical bone around them. The highest values have the strains in the middle implant zone[15].



	Implant		Cortical Bone		Trabecular Bone	
	min	max	min	max	min	max
5 implant	0.223	15.7	0.0335	9.32	0.0254	0.432
15 implant	0.187	36.5	0.089	15.2	0.0152	0.66
25 implant	0.187	34.8	0.0367	12.3	0.029	0.638
6 implant	0.0102	2.07	0.0321	1.14	0.0217	0.124
16 implant	0.0095	1.23	0.0285	2.06	0.0127	0.138
26 implant	0.0001	1.23	0.0517	2.13	0.0204	0.226

Figure 4. *Values of maximum Von Mises stress (MPa) on oblique forces at All-on-6 model with Crown/Implant ratio 1/1*

On the non-loading side, the highest values of maximum v. Mises stress are in the distal implant 6 and the values are approximately identical in the cortical bone in the area of the middle[16] and the anterior implant[26].

On implant - The highest values of maximum v. Mises stress are on the loading side, which are most pronounced in the middle (angled) implant[15] - 36.5 MPa and in the anterior implant[25] - 34.8 MPa. The distal implant[5] on the same side has values twice lower - 15.7 Mpa.

For implants on the opposite, the non-loading side, the obtained values of the maximum v. Mises stress are highest in the distal implant[6] of 2.07 Mpa. In the middle[16] and the anterior implant[26], the values for maximum v. Mises stress are identical, 1.23 Mpa.

In cortical bone - the values of maximum v. Mises stress are higher on the loading side. The highest value, of 15.2 MPa, is in the middle implant[15], then in the anterior[25], with a value of 12.3 MPa, and the lowest 9.32 MPa is in the distal implant[5].

On the non-loading side, the approximate values of maximum v. Mises stress are around the middle/angled implant[16] and the anterior implant[26], (2.06 and 2.13 MPa), and the values around the distal implant are almost twice as lower[6], 1.14 MPa.

In trabecular bone - Approximately close values of maximum v. Mises stress are present in the middle/angled implant[15] - 0.66 MPa and the anterior implant[25] - 0.638 MPa. While in the distal implant[5] the maximum v. Mises stress is one third lower, with value of 0.432 MPa.

On the non-loading side, the values for maximum v. Mises stress in the middle/angled1[6] and the distal implant[6] are approximately close, 0.14 and 0.12 MPa and are higher in the anterior implant[26], 0.23 MPa.

2. *Comparison of the results from the research on All-on-6 model with Corona/Implant ratio 1/1*

A comparison of the research results in Figure 1 - 4 shows that higher values of von Mises stress on the ver-

tical and oblique loading forces of the implants, the trabecular and cortical bone, are on the loading side.

In implants - The highest values of maximum strains for vertical forces, measured by von Mises stress, are on the anterior implant[25], 31.1 MPa, and for oblique forces, the highest values are on middle/angled implant[15], 36.5 MPa.

The greatest differences are in the distal implant[5], approximately 1:3. The difference between the middle[15] and the anterior implant[25] is about 5 MPa.

On the non-loading side, the values of maximum von Mises stress for vertical and oblique forces are approximately equal, and are in the range from 1.13 to 2.81 MPa.

In cortical bone – Also, in cortical bone on the loading side, the values of maximum von Mises stress are greater for oblique forces in the zone of all implants. The differences are approximately 1/3 between distal implants 5 and 6, and approximately half between middle implants 15 and 16, and anterior implants 25 and 26.

On the non-loading side, the values of maximum von Mises stress in the distal implant 6 are 2.81 MPa for vertical forces, which are close to the values of middle implant 16 and anterior implant 26 (2.06 and 2.13 MPa) for oblique forces.

In trabecular bone - the maximum von Mises stress, for vertical and oblique forces are very close in middle and anterior implants, i.e. with values lower than one MPa (from 0.124 to 0.757MPa). The highest values of maximum stress are in distal implant 5 on the loading side (0.432 MPa), and the lowest are in distal implant 6 on the opposite side (0.124 MPa).

On the non-loading side in trabecular bone, the values of maximum strains in middle implants have close values (1.99 and 1.38 MPa). Distal implant 6 has the lowest value, 1.14 MPa, on oblique forces, with a ratio greater than 1:3 in relation to the vertical forces (0.124: 0.408 MPa).

The results obtained for the values of maximum strains, measured by von Mises stress, are close to a large number of published results from other studies.

The loading forces in the study are within the results for masticatory force, published by Hattori et al., according to which the average value of masticatory force in patients treated with implants is 50 N, and the maximum value is 150 N[29].

Higher values on the loading side are confirmed in findings of Hong et al (2012), Liu (2013), Bilhan (2013 and 2015), Ozan (2015)[38, 39, 40, 41, 42].

Higher values for von Mises stress in implant, cortical and trabecular bone, on oblique forces load, are equivalent to the findings of Macedo (2019) and Vijapure (2020)[34,35].

We have obtained higher values of maximum von Mises stress in the zone of all implants in the cortical bone than in the trabecular bone, on both, vertical and horizontal forces. These results are in accordance with the findings of Pessoa (2010), Macedo (2019), Pommer (2019) and Vijapure (2020)[30, 31, 32, 33, 34, 22].

The obtained results for the values of maximum von Mises stress are compared with the functional values of bone tissue tolerance, presented by Turner, (2001), Vincent (2013), Bayraktar (2004), Baggi (2008), Shikha (2019), and Macedo (2019). They are within the presented values and do not exceed the limits of implants, cortical and trabecular bone[30, 31, 32, 33, 34, 22].

However, in order not to overload the suprastructure or the implants with all the mechanical or biological consequences in the bone tissue, these results should be used with caution, as they are obtained only for vertical forces of 100N and only for oblique forces of 35N with an angle of 45 degrees. Literature data and findings indicate that von Mises stress strains, are increasing approximately linearly by increasing the loading force and this should be respected.

On the other hand, the load is not the only factor in implant stability. Other factors that affect the stability of implants must be considered in planning implant-prosthetic treatment.

Conclusion

The analysis of the results from the research, and their comparison with relevant researches by other authors, indicate that the model can be used as a benchmark for future research.

Reference

1. Gomez-Polo M, Bartens F, Sala L, Tamini F,Celemin A, del Rio J. The correlation betweencrown-implant ratios and marginal bone resorption:A preliminary clinical study. Int J Prosthodont. 2010;23:33-37
2. Dr.Bini K Ravi1, Dr.Harshakumar K2, Dr.Prasanth V3, Dr.Kavitha Janardanan4. Dental Implants and Osseoperception: A Systematic Review. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS). 2020: 19(1): 55-60.
3. Luigi Svezia1, Filippo Casotto2. Short Dental Implants (6 mm) Versus Standard Dental Implants (10 mm) Supporting Single Crowns in the Posterior Maxilla and/or Mandible: 2-Year Results from a Prospective Cohort Comparative Trial. J Oral Maxillofac Res 2018 (Jul-Sep) | vol. 9 | No 3 | e4 | p.1 (page number not for citation purposes
4. Asawa N1, Bulbule N2, Kakade D3, Shah R1.Angulated implants: an alternative to bone augmentation and sinus lift procedure: systematic review.J Clin Diagn Res. 2015 Mar; 9(3):ZE10-3.
6. Bhering, C.L.B. & Henriques, S.E. & Girundi, Francisco & Miranda, Milton & Vasconcellos, Andréa. (2017). Full arch implant supported oral rehabilitation to reestablish esthetic and function. International Journal of Clinical Dentistry. 10. 25-33.

7. Elsayed MD. Biomechanical Factors That Influence the Bone-Implant-Interface. Res Rep Oral Maxillofac Surg 2017; 3:023
5. David Soto-Peñaloza 1 , Regino Zaragozí-Alonso 2 , María Peñarrocha-Diago 3 , Miguel Peñarrocha-Diago 4. The all-on-four treatment concept: Systematic review. J Clin Exp Dent. 2017; 9(3):e474-88.
8. Su, K., Yuan, L., Yang, J. et al. Numerical Simulation of Mandible Bone Remodeling under Tooth Loading: A Parametric Study. Sci Rep 9, 14887 (2019)
9. Irandoust, S., Müftü, S. The interplay between bone healing and remodeling around dental implants. Sci Rep 10, 4335 (2020).
10. Gurnero P, Szulic DA. Bone remodeling: cellular activities in bone. In: Orwoll E, Bilezikian JP, Vanderschueren D, eds. Osteoporosis in men: the effects of gender on skeletal health. 2nd ed. London, United Kingdom: Elsevier; 2010;15–24.
11. Deguchi T, Takano-Yamamoto T, Yabuuchi T, Ando R, Roberts WE, Garetto LP. Histomorphometric evaluation of alveolar bone turnover between the maxilla and the mandible during experimental tooth movement in dogs. Am J Orthod Dentofacial Orthop. 2008; 133:889–897
12. B. G. Röhlig, "The Use of Angulated Implants in the Maxillary Tuberosity Region, A- Dimensional Finite Element Analysis," Doctoral Thesis, The Philipps University of Marburg, Germany, 2004.
13. Forna Norina Consuela1, Agop Forna Doriana2, Butnaru Moldoveanu3, Anca Sînziana3. Current Status of Finite Element Analysis Based Studies on Optimal Dental Implant Length and Diameter in the Posterior Mandible Bone: A Review of the Literature. J Dent Res Prac 2019; 1(1): 2 - 1.
14. Raaj G1, Manimaran P2, Kumar CD2, Sadan DS2, Abirami M2.Comparative Evaluation of Implant Designs: Influence of Diameter, Length, and Taper on Stress and Strain in the Mandibular Segment-A Three-Dimensional Finite Element Analysis. J Pharm Bioallied Sci. 2019 May; 11(Suppl 2):S347-S354.
15. Ishak M.I., Abdul Kadir M. (2013) Biomechanical Considerations. In: Biomechanics in Dentistry: Evaluation of Different Surgical Approaches to Treat Atrophic Maxilla Patients. SpringerBriefs in Applied Sciences and Technology. Springer, Berlin, Heidelberg
16. Cicciù M., Beretta M., Risitano G., Maiorana C. Cemented-retained vs screw-retained implant restorations: an investigation on 1939 dental implants. Minerva Stomatologica. 2008;57(4):167–179.
17. Cicciu M., Bramanti E., Matacena G., Guglielmino E., Risitano G. FEM evaluation of cemented-retained versus screw-retained dental implant single-tooth crown prosthesis.International Journal of Clinical and Experimental Medicine. 2014;7(4):817–825.
18. Kong l., Gu Z., Li T., et al. Biomechanical optimization of implant diameter and length for imeddiate loading: a nonlinear finite element analysis. The International Journal of Prosthodontics. 2009;22(6):607–615.
19. Ding X., Zhu X.-H., Liao S.-H., Zhang X.-H., Chen H. Implant-bone interface stress distribution in immediately loaded implants of different diameters: a three-dimensional finite element analysis. Journal of Prosthodontics. 2009;18(5):393–402.
20. Mahajan A., Kadam K.N., The Influence of Mechanical Loads on the Biomechanics of Dental Implant. Int J Sci Res. 2014;3(11):1085–90.
21. Sedat Guven,1 Koksal Beydemir,1 Serkan Dundar,2 and Veysel Eratilla3. Evaluation of stress distributions in peri-implant and periodontal bone tissues in 3- and 5-unit tooth and implant-supported fixed zirconia restorations by finite elements analysis. Eur J Dent. 2015 Jul-Sep; 9(3): 329–339.
22. Shikha Joshi1, Sandeep Kumar2, Shashikala Jain3, Rajnish Aggarwal4, Sunita Choudhary5, Nandalur K Reddy6. 3D Finite Element Analysis to Assess the Stress Distribution Pattern in Mandibular Implant-supported Overdenture with Different Bar Heights. The Journal of Contemporary Dental Practice (2019): 10.5005/jp-journals-10024-2599
23. Akyuz E, Braun JT, Brown NA, Bachus KN. Static versus dynamic loading in the mechanical modulation of vertebral growth. Spine, 2006;31:952-958.
24. Solberg, K.; Heinemann, F.; Pellikaan, P.; Keilig, L.; Stark, H.; Bourauel, C.; Hasan, I. Finite element analysis of different loading conditions for implant-supported overdentures supported by conventional or mini implants. Comput. Methods Biomech. Biomed. Eng. 2017, 20, 770–782
25. Avram Manea et al. New Dental Implant with 3D Shock Absorbers and Tooth-Like Mobility—Prototype Development, Finite Element Analysis (FEA), and Mechanical Testing. Materials 2019, 12(20), 3444;
26. Zieliński, R.; Kozakiewicz, M.; Świniarski, J. Comparison of Titanium and Bioresorbable Plates in "A" Shape Plate Properties-Finite Element Analysis. Materials (Basel) 2019, 12, 1110.
27. Reddy MS, Sundram R, Eid Abdemagyd HAApplication of Finite Element Model in Implant Dentistry: A Systematic Review..J Pharm Bioallied Sci. 2019 May; 11(Suppl 2):S85-S91.
28. Nordendale, N.A., Heard, W.F., Sherburn, J.A. et al. A comparison of finite element analysis to smooth particle hydrodynamics for application to projectile impact on cementitious material. Comp. Part. Mech. 3, 53–68 (2016).
29. Hattori Y, Satoh C, Kunieda T, Endoh R, Hisamatsu H, Watanabe M (2009) Bite forces and their resultants during forceful intercuspal clenching in humans. J Biomech 42(10):1533– 1538
30. Vincent, Kevin. "Topic 3: Structure and Mechanical Properties of Bone". BENG 112A Biomechanics, Winter Quarter, 2013. Department of Bioengineering, University of California
31. Turner, C.H.; Wang, T.; Burr, D.B. (2001). "Shear Strength and Fatigue Properties of Human Cortical Bone Determined from Pure Shear Tests". Calcified Tissue International. 69 (6): 373–378.
32. Bayraktar et al. Comparison of the elastic and yield properties of human femoral trabecular and cortical bone tissue. J Biomech 37 (2004): 27-35
33. Baggi et. all. The influence of implant diameter and length on stress distribution of osseointegrated implants related to crestal bone geometry: a three-dimensional finite element analysis. J Prosthet Dent [Internet]. 2008:100(6):422–31.
34. Macedo et al. Finite element analysis of peri-implant bone volume affected by stresses around Morse taper implants: effects of implant positioning to the bone crest. Computer Methods in Biomechanics and Biomedical Engineering. 2019: 21. 10.1080/10255842.2018.1507025
35. Vijapureet al. Comparison of Stress In Peri-Implant Bone of Anterior Maxilla on Loading of Straight and Angulated Platform Switched Implant Abutments - A 3D Finite Element Analysis. Archives of Clinical and Medical Case Reports 4 (2020): 030-043
36. Pessoa RS, Vaz LG, Marcantonio E Jr, Vander Sloten J, Duyck J, Jaecques SV. Biomechanical evaluation of platform switching in different implant protocols: computed tomography-based three-dimensional finite element analysis. Int J Oral Maxillofac Implants. 2010 Sep-Oct;25(5):911-9. PMID: 20862404.
37. Pommer L.;, B.; Hunger, S.; Stehrer, R.; Watzek, G.; Insua, A. Influence of Implant Length and Associated Parameters Upon Biomechanical Forces in Finite Element Analyses. Implant. Dent. 2019, 28, 296–305.
38. Hong et al. Effect of implant position, angulation, and attachment height on peri-implant bone stress associated with mandibular two-implant overdentures: a finite element analysis. Int J Oral Maxillofac Implants. 2012; 27: e69–e76
39. Bilhan et al. Baykasoglu Effect of attachment types and number of implants supporting mandibular overdentures on stress distribu-

tion: a computed tomography-based 3D finite element analysis. J Biomech. 2015; 48: 130–137
40. Arat Bilhan et al. The influence of the attachment type and implant number supporting mandibular overdentures on stress distribution: an in vitro study, part I. Implant Dent. 2013 Feb;22(1):39-48
41. Ozan O, Ramoglu S. Effect of Implant Height Differences on Different Attachment Types and Peri-Implant Bone in Mandibular Two-Implant Overdentures: 3D Finite Element Study. J Oral Implantol. 2015 Jun; 41(3):e50-9.
42. Liu J, Pan S, Dong J, Mo Z, Fan Y, Feng H. Influence of implant number on the biomechanical behaviour of mandibular implant-retained/supported overdentures: a three-dimensional finite element analysis. J Dent. 2013 Mar;41(3):241-9.
43. Ozdemir Dogan D, Polat NT, Polat S, Seker E, Gul EB. Evaluation of ‘‘all-on-four’’ concept and alternative designs with 3D finite element analysis method. Clin Implant Dent Relat Res. 2014; 16:501–510.
44. Chang H-S, Chen Y-C, Hsieh Y-D, Hsu M-L. Stress distribution of two commercial dental implant systems: a three-dimensional finite element analysis. J Dent Sci. 2013; 8:261–271.

UDK: 616.316–008.8:616.314.17–008.1

THE ROLE OF SALIVARY ANTIOXIDANTS IN THE PROTECTION OF ORAL TISSUES

УЛОГАТА НА САЛИВАРНИТЕ АНТИОКСИДАНСИ ВО ЗАШТИТАТА НА ОРАЛНИТЕ ТКИВА

Dirjanska K., Ivanovski K., Poposki B., Micevski B., Gligurova I., Asani R.

Department of Oral and Periodontal Diseases, Ss. Cyril and Methodius University in Skopje, Faculty of Dentistry - Skopje, Republic of North Macedonia

Abstract

As a secrete, saliva comes into direct contact with all oral structures in the oral cavity. Antioxidants are essential for the protection of oral tissues. Antioxidants play an important role in the pathogenesis of inflammatory processes such as periodontal disease. Saliva contains enzymatic antioxidants such as glutathione peroxidase (GPx), superoxide dismutase (SOD), etc., as well as non-enzymatic antioxidants such as uric acid, albumin, etc. According to the findings of the literature and some of our studies, a lower concentration of antioxidants in saliva has been found in patients with chronic periodontitis. Following the causal treatment, a correlation was established between the clinical parameters for the condition of the periodontium and the level of antioxidants in saliva. The importance of these studies is that they demonstrate the possibility of using saliva as a valid diagnostic tool in the monitoring of periodontitis and other inflammatory diseases. The non-invasive determination of antioxidants in saliva allows for analysis of the results and the generation of useful recommendations for the development and monitoring of new treatment strategies, as well as the prevention of many pathological conditions and the prevention of inflammatory diseases in the oral cavity. **Key words:** saliva, antioxidants, periodontitis.

Апстракт

Плунката како секрет е во непосреден контакт со сите орални структури во усната празнина. Во заштита на оралните ткива значајна улога имаат антиоксидантите. Антиоксидантите играат важна улога во патогенезата на воспалителните процеси, вклучувајќи ја и пародонталната болест. Плунката содржи ензимски антиоксиданси, какошто се глутатион пероксидаза (GPx), супероксид дисмутаза (SOD) итн., неензимски антиоксиданси и тоа мочна киселина, албумини и др. Според наодите од литературата и од некои наши истражувања утврдена е намалена концентрација на антиоксидантите во плунка кај пациенти со хронична пародонтопатија. По спроведениот каузален третман воспоставена е корелација помеѓу клиничките параметри за состојбата на пародонциумот и нивото на антиоксиданси во плунка. Важноста на овие студии е да се прикаже можноста за употреба на плунката како валиден дијагностички медиум во следењето на пародонтопатијата и другите инфламаторни заболувања. Со неинвазивното определување на антиоксидантите во плунка се овозможува анализа на постигнатите резултати и се добиваат корисни препораки за развој и следење на нови стратегии за третман и можност да се спречат многу патолошки состојби и да се овозможи превентивно делување на инфламаторните заболувања во усната празнина. **Клучни зборови:** плунка, антиоксиданси, пародонтопатија.

Introduction

Saliva as an oral cavity secrete, is produced by the large and small mucous glands and comes into direct contact with all oral structures[1]. It is made up of 99% water, and the rest is made up of organic and inorganic substances. The biochemical composition of saliva enables numerous functions in the oral environment[2]. Saliva plays the most important role in maintaining oral homeostasis, self-cleansing of the mouth from leftover food particles, maintaining physiological pH values, maintaining the integrity of hard and soft tissues, and providing specific and non-specific antimicrobial and antioxidant protection. Saliva, with its multifunctional role in the oral cavity, is an important component of oral health maintenance[3].

Antioxidants play an important role in protecting oral tissues from the harmful effects of free radicals[4].

The history of free radicals began when McCordKelle and Fridovich discovered the enzyme superoxide dismutase, which catalyzes the decomposition of the superoxide anion created by the uniform reduction of oxygen[5].

Free radicals are highly reactive transient chemicals (atoms, ions, or molecules) with one or more electrons in their structure[6]. Once created, a free radical can cause a series of chain reactions and then react with less reactive molecules. This chain reaction is interrupted by the action of non-enzymatic antioxidants and enzyme mechanisms[7].

The most well-known are the free radicals of the oxygen-superoxide anion O^2; perhydroxy anion - HOO; hydrogen peroxide - H_2O_2; hydroxyl radical – OH, and so on.

Increased production of these radicals may be associated with increased activity of inflammatory cells and polymorphonuclear leukocytes present in the gingival epithelium in aggressive and chronic forms of periodontitis[8].

In recent years, in the pathogenesis of many inflammatory diseases, including chronic periodontitis, free radicals and antioxidants have received special attention. Numerous studies have been conducted to examine free radicals and antioxidants in serum and gingival tissue. In the examination of our material, an increase in the value of free radicals in serum and gingival tissue was observed with the progression of the clinical stage of periodontitis in non-smokers. In the second and third clinical stages of chronic periodontitis, patients with antioxidant stress have lower antioxidant levels[9].

In recent decades, analysis of the biochemical composition of saliva has been used as an additional diagnostic test. Numerous biochemical parameters of pathological processes in the oral cavity can be determined in the saliva.

Aim of the study

The aim of this study is to highlight the role of antioxidants in saliva in the protection of oral tissues.

Material and methods

Data from published scientific and scientific-professional journals and books were used to achieve the aim of this study, Electronic journal data from the ISSN database was also used. This paper examines foreign and domestic journals and books from 1992 to 2021.

All data is displayed according to the set goal.

We explained the obtained data for using the analysis of the biochemical composition of saliva as an additional diagnostic test that can demonstrate a number of biochemical parameters of pathological processes in the oral cavity. The topic of research in a number of studies is the analysis of the total antioxidant capacity in saliva and its significance for the occurrence of oral diseases. Studies have highlighted the link between salivary antioxidants and chronic periodontal disease.

Results and discussion

Antioxidants and saliva (Biochemical properties of antioxidants in saliva)

During the course of growth and development of the human body, a specific defense system, namely an antioxidant system, is established to protect the body from the harmful effects of free radicals. There is a balance between ROC (reactive oxygen compounds) and antioxidants in physiological states. Oxidative stress occurs only when the antioxidant defense system cannot neutralize the increased ROC production. According to the mode of action, antioxidants are divided into two groups: enzymatic and non-enzymatic antioxidants.

Superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), oral peroxidase (OP) are among the first group od enzyme antioxidants. Non-enzymatic antioxidants in the second group include ascorbic acid (Vitamin C), retinol (Vitamin A), alpha-tocopherol (Vitamin E), uric acid, glutathione reductase, polyphenols and albumin.

Superoxide dismutase (SOD) is an enzyme that catalyzes the dismutation of the superoxide anion into hydrogen peroxide and oxygen.

There are more isoform forms of superoxide dismutase in humans. Copper, zinc and manganese-dependent extra cellular superoxide dismutase are the three forms.

Studies have shown increased SOD activity in saliva in patients with recurrent aphthous stomatitis relative to the control group. The authors believe that the increased activity of this antioxidant enzyme is a host adaptation mechanism as a result of the increased production of free radicals by the defense cells[10,11].

Oral peroxidase (OP) is a salivary enzyme that contains two peroxidase enzymes, salivary peroxidase (80%) and myeloperoxidase (20%).

Salivary peroxidase (SP) is mostly secreted by the parotid salivary glands. This enzyme contains selenium in its composition. The most important function of salivary peroxidase is to reduce hydrogen peroxide in the presence of thiocyanate ions. These ions are produced by tobacco smoke during liver detoxification, and are then transported through the blood to the salivary glands and reach the saliva by ultrafiltration. SP catalyzes the reaction of hydrogen peroxide and thiocyanate ions. Hypothiocyanate acid and hypothiocyanate ions are obtained as a result of this reaction,. Thus, this enzyme participates in the non-specific antibacterial protection and in the efficient removal of hydrogen peroxide from the oral environment[12].

In some studies, the activity of SP in cigarette smokers has been studied in terms of the occurrence of oral cancer. Cigarette smoking is one of the risk factors for developing this malignant disease. In smokers, SP activity is significantly reduced. Incomplete elimination of hydrogen peroxide occurs, and in reaction with other free radicals, more reactive radicals are formed, causing oxidative damage to biomolecules and this leads to malignant transformation and the appearance of oral cancer[13].

Myeloperoxidase (MPO) is a HEM-dependent enzyme found in neutrophil leukocytes and monocytes. In the presence of hydrogen peroxide, a complex is formed that has the ability to oxidize iodides and chlorides, creating toxic products. The chlorine ion is distributed in biological systems and its oxidation produces hypochlorous acid. This acid has oxidative properties, resulting in active forms of oxygen that participate in the breakdown of toxins, inflammatory regulators and other compounds[11].

In some studies, some authors have noted increased MPO activity in saliva during inflammatory processes in the oral cavity[11].

Among the enzymatic antioxidants found in saliva is catalase, which is a tetramer in structure and contains HEM in each subunit. This enzyme inhibits the formation of more hydrogen peroxide and catalyzes its breakdown into water and molecular oxygen[14].

Uric acid (acidum uricum) is the most important non-enzymatic antioxidant followed by albumin, and other non-enzymatic antioxidants that are found in small concentrations in saliva.

Uric acid is the end product of purine nucleotide metabolism. It is found in higher concentrations in the blood plasma, because it is not degraded due to a lack of the enzyme uricase. It is present in saliva in lower concentrations as uric acid salts (urates) and enters[4] through passive diffusion from the circulation. In patients with oral cancer who smoke, a reduced concentration of uric acid is observed compared to the control group, as a result of its consumption, because it participates in the neutralization of the increased concentration of free radicals[15].

Albumins are plasma proteins that are synthesized in the liver. In addition to participating in antioxidant protection, they also play a role in regulating blood pH, transporting various substances and arriving in saliva from the blood by ultrafiltration[16].

Glutathione reductase is a tetrapeptide and consists of glutamic acid, cysteine and glycine. It facilitates the activity of the antioxidant enzyme - glutathione peroxidase[16.]

The effects of the antioxidant system depend on the intake of vitamins and micronutrients through diet, as well as the synthesis of antioxidant enzymes, which can be influenced by physical activity, nutrition, and genetic predisposition[17,18].

Antioxidants in saliva and periodontitis

A number of studies have been conducted to examine the total antioxidant capacity in saliva and its significance in the occurrence of oral diseases.

Studies have been performed with meta-analysis of antioxidants in saliva in patients with oral lichen planus (OLP), which is a type of premalignant disease. The authors noted a reduced antioxidant capacity compared to the control group[19].

Many studies have examined the association between antioxidants in saliva and periodontal disease.

Many authors compare antioxidant levels in saliva in patients with chronic periodontitis and individuals with clinically healthy periodontitis[20]. Other studies have determined the level of antioxidants in saliva in patients with chronic periodontitis before and after causal therapy[21].

Canacki et al.[22] in their study on 30 patients with chronic periodontitis and 30 individuals in the control group, obtained results indicating lower levels of superoxide dismutase (SOD) and glutathione peroxidase (GPx) in saliva. Other authors conducted studies with the same number of patients with chronic periodontitis and control group, and found lower activity of the enzyme antioxidants SOD, GPx and catalase (CAT) in saliva, which is negatively correlated with the clinical parameters of periodontitis[23]. Other studies have found a significant negative correlation between the antioxidant enzymes SOD, CAT and glutathione reductase activity and periodontal parameters in patients with periodontal disease[24]. A group of authors[25] found lower values of GPx and the non-enzymatic antioxidant uric acid in patients with chronic periodontitis,. Uric acid activity in saliva is reduced in patients with periodontitis and has a negative correlation with bone resorption biomarkers such as collagen C-terminal telopeptide type 1 and matrix metalloproteinases 8 (MMP-8)[26].

In contrast, some authors[27] studied saliva in 43 patients with chronic periodontal disease who had received periodontal treatment. They received higher values for SOD, GPx, as well as for the albumins. Other studies found the opposite results for SOD after periodontal treatment compared to the previous authors but increased values for GPx, albumin and uric acid[28]. Other authors show increased concentration of antioxidants in saliva (uric acid, total antioxidant status, SOD and GPx) after causal therapy, as well as a positive correlation with clinical parameters of the periodontal condition (gingival index, plaque index and gingival bleeding)[29].

A number of studies[30] have examined the correlation between GPx activity in gingival fluid and clinical signs of the periodontal tissue (gingival index, plaque index, bleeding index, periodontal pocket depth, and loss of epithelial attachment) in patients and individuals with a clinically healthy periodontium. A positive correlation was found between GPx and the noted clinical parameters, as well as higher GPx activity in the gingival fluid relative to saliva.

The SOD activity was reduced following periodontal treatment. Bacterial polysaccharides stimulate the release of oxygen from fibroblasts during inflammation. Increased oxygen release may lead to increased SOD activity in order to balance oxidative stress with antioxidant protection. Increased SOD activity allows for increased activity of GPx, which removes hydrogen peroxide. Following the analyses, a progressive reduction of the SOD activity was observed with the increase of the depth of the periodontal pockets.

The differences in the results obtained for the enzyme antioxidants in saliva presented in the studies are due to how the mixed unstimulated saliva is collected and stored.

The SOD and CAT activity has also been determined in gingival tissue in patients with periodontal disease, and their reduced activity has been observed with increasing depth of periodontal pockets[31].

A group of authors suggests that non-enzyme antioxidants in saliva such as vitamin C, vitamin E, and glutathione reductase have decreased activity in patients with periodontitis, whereas enzyme antioxidants such as SOD and GPx have increased activity[32].

The opposite results between periodontal status and antioxidant protection have been obtained from the conducted researches. Some studies performed with meta-analyzes have obtained results for SOD levels that indicate insignificant differences between patients with periodontitis and the control group[33]. Studies of non-enzymatic antioxidants in saliva have shown a greater association between clinical parameters of periodontitis and decreased activity of non-enzymatic antioxidants.

Conclusion

The significance of these studies is that they indicate that saliva can be used as a valid diagnostic medium. Saliva is in constant and direct contact with the tissues in the oral environment and thus can follow physiological conditions, pathological changes and changes at the cellular molecular level. Non-invasive determination of antioxidants in saliva allows for analysis of the achieved results and the generation of useful recommendations for development and monitoring of new treatment strategies, as well as the possibility of preventing many pathological conditions and preventing inflammatory diseases in the oral cavity.

Reference

1. Lima DP., Diniz DG.,Moimaz SA.,Sumida DH., Okamoto AC. Saliva: reflection of the body. Int. J. Infect Dis. 2010:14,184-8.
2. Mandel ID. Acontemporary view of salivary research.Crit Rev.Oral.Biol.Med.1993:4:599-604.
3. Amerongen AV.,Veerman EC. Saliva the defender of the oral cavity. Oral Dis:2002;8:12-22.
4. Battino M., Ferreiro MS., Gallardo I.,Nesviluon HN., Bullonn P. The antioxidant capacity of saliva J. Clin. Periodontal 2002;29(3):189-94.
5. Chapple ILC. The role of free radicals and antioxidants in the pathogenesis of the inflammatory periodontal diseases Mol. Pathol 1996; 49;247-55.
6. Halliwell B. Gutteridge J.M.C. .& Cross C.E. Free radicals,antioxidants and human disease, where are we now? Journal of Laboratory and Clinical Medicine1992;119;598-620.
7. Chapple ILC., Matthews JB. The role of reactive oxygen and antioxidant species in periodontal tissue destruction. Periodontology 2000:43 2007:160-232.
8. Krol K. Reactive oxygen species and antioxidant mechanisms in pathogenesis of periodontitis. Ann Acad Med Stetin 2004:50 (2): 135-48.
9. Катарина Дирјанска Улогата на слободните радикали во патогенетските механизми на пародонталната болест. Докторска дисертација , Скопје 2009.
10. Brock GR., Butherworth CJ., Mathews JB., Chapple IL. Local and systemic total antioxidant capacity in periodontitis and health. J. Clin. Periodontal 2004;31(7):515-21.
11. Rezmick AZ., Klein I., Eiserich JP., Cross CE., Nagler RM. Inhibition bof oral peroxidase activity by cigarette smoke: in vivo and in vitro studies. Free Radic Biol Med 2003; 34 (3):377-84.
12. Орална биохемија и физиологија, К. Ивановски, С. Пешевска, К. Дирјанска, С. Ристоска, Скопје 2021.
13. Ozmeric N. Advences in periodontal disease markers. Clin. Chim. Acta 2004;343(1-2):1-16.
14. Karincaoglu Y., Bacioglu K., Erden T., Esrefoglu M., Genc M. The levels of plasma and salivary antioxidants in the patient with recurrent aphthous stomatitis. J.Oral Pathol Med 2005;34 (1):7-12.
15. Mandic B., Todorovic T. Antioxidant status in oral cancer patients. Oral Oncology 2002;8:38-42.
16. Djordjevic V., Pavlovic D., Kocic G. Biochemistry of free radicals ist ed Nis: Sirius Print;2000.
17. Nagler RM., Klein I., Zarzhevsky N., Drigues N., Reznick AZ. Characterizization of the differentiated antioxidant profile of human saliva. Free radical Biol. Med. 2002; 32:269-77.
18. Sugiura K., Nagal T.,Nakano M.,Ichinose H.,Nakabayashi T. et al. Redox sensor proteins for highly sensitive direct imaging of intracellular redox state. Biochem Biophys Res Commun 2015; 457:242-248.
19. Wang J.,Yang J., Wang C., Jhao Z., Fan Y. Systematic review and Meta- analysis of oxidative stress and antioxidant markers in oral lichen planus. Meta Analysis Oxid. Med. Cell Longev 2021;9914652.
20. Baser U., Gamsiz- Isik H., Cifcibasi E., Ademoglu E., Yalcin F. Plasma and salivary total antioxidant capacity in healthy controls compared with aggressive and chronic periodontitis patients. Saudi Ned. 2015;36:856-861.
21. Lisuman S.,Vihalem T.,Salum O.,Zillmer K.,Fiscer K.,Zilmer M. Characterization of the antioxidant profile of human saliva in periimplant health and disease. Clin Oral Implants Res. 2007;18:27-33.
22. Canacki C.F. Cicek Y., Yildirim A., Sezar U., Canacki V. Increased levels of 8-hydroxydeoxygansione and malondialdehyde and relationship with antioxidant enzymes in saliva of periodontitis patients.Eur. J. Dent.2009;3:100-106.
23. Panjamurthy K.,Manoharan S., Ramchandran C.R..Lipid peroxidation and antioxidant status in patients with periodontitis. Cell. Mol. Biol. 2005;10:255-264.
24. Triverdi S., Lain N., Mahdi A.A., Singh B., Pandey S. Association of salivary lipid peroxidation levels, antioxidant enzymes and chronic periodontitis. J. Period. Restorat Dent. 2015;35 14-19.
25. Novakovic N., Todorovic T., Ronic M., Milinkovic I., Dozic I.,

Jankovic S. et al. Salivary antioxidants as periodontal biomarkers in evaluation of tissus status and treatment outcome. J. Periodont. Res. 2014;49:129-136.
26. Miricesu D., Totan A., Calenic B., Mocanu B., Didilescu A., Mohora M. et al. Salivary biomarkers : relationship between oxidative stress and alveolar bone loss in chronic periodontitis. Acta Odontol Scand. 2014;72:42-47.
27. Novakovic N., Cakic S., Todorovic T., Andelski- Radicevic B., et al. Antioxidative status of saliva before and after non-surgical periodontal treatment. Srpski arhiv Celok. Lek. 2013 ;141 (3-4):163-168.
28. Brink R., Rosen I., Savulescu D., Borovol I., Gavish M.,et al. Salivary antioxidants and metalloproteinases in juvenile idiopatic arthritis. Mol. Med. 2010;16:122-128.
29. Akalin FA., Toklu E., Renda N. Analysis of superoxide dismutase activity levels in gingiva and gingival crevicular fluid in patients with chronic periodontitis and periodontally healthy control. J. Clin . Periodontol. 2005;32:238-43.
30. Wei PF.,Ho KY., Ho YP.,Wu Ym., Yang YH.,Tsai CC. The investigation of glutathione peroxidase, lactoferrin, myeloperoxidase and interleukin-1beta in gingival crevicular fluid: imlications for oxidative stress in human periodontal diseases. J. Periodontal Res. 2004; 39:287-93.
31. Elis SD., Tucci MA., Serio FG., Johnson RB. Factors for progression of periodontal diseases. J. Oral. Pathol. Med. 1998;27:101-5.
32. Jentsch H., Sievert Y., Gocke R. Lactoferin and other markers from gingival crevicular fluid and saliva before and after periodontal treatment. J. Clin. Periodontology 2004;7:511-4.
33. Minic I et al. Antioxidant role of saliva. Journal of Otolaryngology Research 2019;2(1):124.

UDK: 616.314.17-008.1:616.716.1/.4-018.2/.4-003.93

SURGICAL TREATMENT OF PERIODONTAL POCKET WITH GUIDED BONE AND SOFT TISSUE REGENERATION

ХИРУРШКИ ТРЕТМАН НА ПАРОДОНТАЛЕН ЏЕБ СО ВОДЕНА КОСКЕНА И МЕКОТКИВНА РЕГЕНЕРАЦИЈА

Evrosimovska B.[1], Pop Janeva I.[2], Pop Janeva B.[2]

[1]Department of Oral Surgery and Implantology, University Dental Clinical Centre "St. Pantelejmon", Faculty of Dentistry, Skopje, [2]Private practice Pop Janevi – Skopje

Abstract

Periodontal disease is defined as a complex, multifactorial disease characterized by the loss of connective tissue attachment with destruction of periodontal tissues. The aim of periodontal therapy is to eliminate the inflammatory process, prevent the progression of periodontal disease and also to regenerate the lost periodontal tissues. Loss of bone support by creating a periodontal pocket is one of the most common causes of tooth extraction. Their treatment can be conservative and surgical. The purpose of this paper is to demonstrate the treatment of infrabony periodontal defects with bone and soft tissue regeneration. On periodontal examination and radiographic evaluation, a female 56-year-old patient presented with an infrabony defect extending up to the apical third of the mesial side of the right maxillary second molar with a probing depth of 8 mm. After conservative periodontal treatment, oral surgical intervention was performed including open flap debridement and filling the defect with xenograft and plasma rich fibrin. The application of xenograft and Plasma rich fibrin resulted in bone regeneration of the defect and successful fixed prosthodontic solution. Guided bone and soft tissue regeneration using xenograft and fibrin-rich plasma gives successful radiological and clinical signs of bone augmentation and consolidation of defects caused by loss of tooth attachment. **Key words:** periodontal pocket, xenograft, PRF.

Апстракт

Пародонталната болест е дефинирана како комплексна мултифакторијална болест што се карактеризира со губиток на сврзно-ткивниот атачмент. Пародонтолната терапија има за цел да го елиминира инфламаторниот процес, да ја превенира прогресијата на периодонталната болест и да стимулира регенерација на изгубеното периодонтално ткиво. Губитокот на потпорниот апарат на забите со создавање на пародонтален џеб е една од најчестите причини за екстракција на забот. Терапијата на истите може да биде конзервативна и хируршка. Целта на овој труд е да се прикаже третман на инфракоскен пародонтален џеб на максиларниот втор десен молар со водена коскена и мекоткивна регенерација. Кај пациент од женски пол на 56-годишна возраст, после периодонтални и радилошки иследувања, детектирано е присуство на клинест коскен дефект од мезијалнатастрана на вториот максиларен молар. По конзервативниот третман (обработка на пародонтален џеб) спроведена е регенеративна -хируршка процедура , вклучувајќи open flap debridement исполнување на дефектот со ксенографт и втора генерација на тромбоцитно збогатен фибрин. По период на констатирана коскена регенерација на дефектот следуваше последователна успешна изработка на фиксно-протетски надоместок. Водената коскена и мекоткивна регенерација со употреба на ксенографт и плазма богата со фибрин дава успешни радиолошки и клинички знаци на коскена аугументација и консолидација на дефектите кои се предизвикани од губиток на припојот на забот. **Клучни зборови:** пародонтален џеб, ксенографт, PRF.

Introduction

Periodontal disease is a chronic infection of the periodontium that affects the soft and mineralized tissues surrounding the teeth (Hajishengallis and Lambris, 2012). The extent and the severity of alveolar bone loss in the dentition are usually assessed by a combination of radiographic and clinical means and are important adjuncts to the clinician in the diagnosis, treatment planning, and assessment of prognosis of the periodontal patient.[1] Classically, periodontal defects have been differentiated based on bone resorption patterns into "supraosseous" ("suprabony") and "infraosseous" ("infrabony") (Goldman&Cohen, 1958)[1]. These authors defined

suprabony defects as those where the base of the pocket is located coronal to the alveolar crest. On the other hand, infrabony defects are those with apical location of the base of the pocket relative to the bone crest.

New attachment of periodontal tissues can be obtained following surgical treatment of intrabony pockets. There are several available surgical treatments for infrabony defects, including: 1. open flap debridement in which the gum is lifted back surgically in order to clean the deep tartar; 2. bone graft in which a portion of natural or synthetic bone is placed in the area of bone loss; 3. guided tissue regeneration in which a small piece of membrane-like material is placed between the bone and gum tissue in order to keep the gum tissue from growing into the area where the bone should be; and 4. use of enamel matrix derivative, a gel-like material which is placed in the area where bone loss has occurred and promotes its regeneration[2]. In order to accelerate the healing process, autologous platelet concentrates have been used recently. A large number of studies have evaluated the effect of periodontal regeneration for infrabony defects and have shown positive clinical and radiographic outcomes, as well as histological evidence of new cementum, periodontal ligament and alveolar bone regeneration. Today, flap procedures with complete surgical opening to the defect and removal of all soft material from the intrabony lesion, often followed by bone transplantation, constitute the accepted approach to obtain a new connective tissue attachment [3]. Recent approaches for treatment of infrabony defects combine advanced surgical techniques with platelet-derived growth factors[3]. With the advancements made in platelet formulations over the past decade, PRF has recently been introduced and utilized as a supra-physiological concentration of autologous growth factors without necessitating the use of anticoagulants. The additional fibrin network has further been shown to serve as a space-making provisional matrix supporting angiogenesis and blood clot formation within periodontal pockets. Platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) are autologous platelet concentrates prepared from patient's own blood. Platelet-rich fibrin (PRF) is a second-generation platelet concentrate which contains platelets and growth factors in the form of fibrin membranes prepared from the patient's own blood free of any anticoagulant or other artificial biochemical modifications[4]. The PRF clot forms a strong natural fibrin matrix, which concentrates almost all the platelets and growth factors of the blood harvest, and shows a complex architecture as a healing matrix with unique mechanical properties which makes it distinct from other platelet concentrates[4]. PRF enhances wound healing and regeneration and several studies have shown rapid and accelerated woundhealing with the use of PRF than without it[5]. It showed that the GTR combined with bone grafting was better than bone grafting alone in improving the aesthetics of the patients' gums, which might be related to its promotion of soft tissue healing and good integration of soft tissues[6].

Case report

The female 56-year-old patient was admitted to the University dental clinical center "St. Panteleimon", Skopje, at the Department of oral surgery and implantology, with no signs of acute infection and no luxation changes. On examination, the patient was systemically healthy and had not taken any long-term anti-inflammatory medications or antibiotics.

On periodontal examination and radiographic evaluation, the patient showed an infrabony defect extending up to the apical third of the mesial side of the right maxillary second molar with a probing depth of 8 mm. (Figure 1)

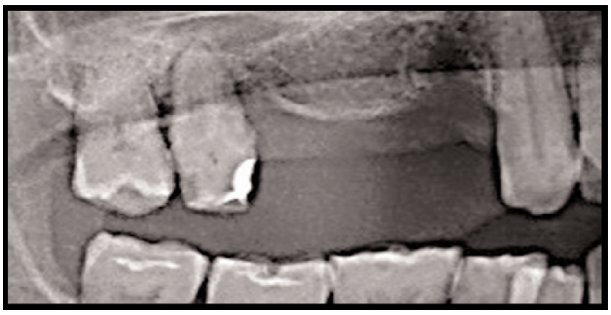


Figure 1. *X-ray of the infrabony defect*

This tooth was crucial because of the unique ability to make fixed prosthetic replacement with patient's natural teeth. Surgical treatment was performed including open flap debridement. Local infiltrative anesthesia using Scandonest 3% was applied.

The first incision was intrasulcular incision that is carried around each tooth, between the hard structure and the gingiva, beyond the base of the pocket and extending to the apical extent of the pocket epithelium.

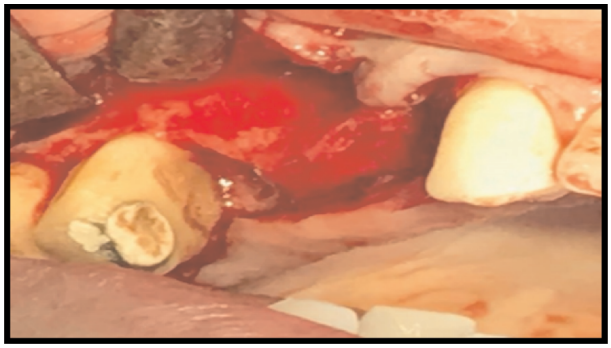


Figure 2. *Infrabony defect of 2nd maxillar molar*

The final incision was horizontal, to release the pocket tissues sharply and atraumatically. aAsmall elevator is used to reflect a full thickness flap, as atraumatically as possible. (Figure 2)

The soft tissue and all of the granulation tissue within the pocket are thereby removed using fine curettes and ultrasonic instruments. Systematic root cleaning and planing was performed with repeated rinsing (NaCl 0.9 %).

Blood sample was taken just before the surgery according to the Choukroun`s PRF protocol. With venipuncture the blood sample was taken from the patient in 10 ml glass tubes without an anti-coagulant and immediately centrifuged at 3000 rpm for 12 min.

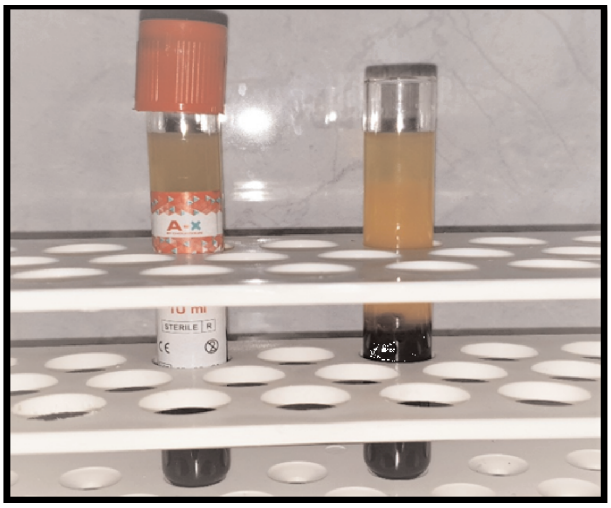


Figure 3. *Tubes containing plasma rich protein*

A fibrin clot was formed in the middle of the tube, whereas the upper part contained cellular plasma, and the bottom part contained red corpuscles. (Figure 3) The fibrin clot was easily separated from the lower part of the centrifuged blood. (Figure 4)

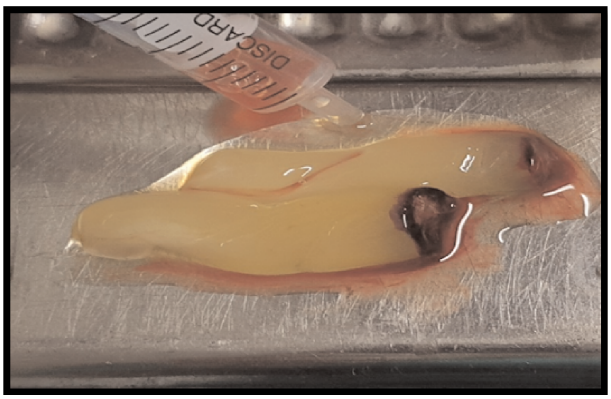


Figure 4. *PRF membranes*

One of the PRF membranes was cut in pieces and was mixed with xenograft (Bio-Oss™, 0,25mg). Also, PRF exudate which accumulated at the bottom of the box during the squeezing of the membrane was put in this mixture and "sticky" bone made from all this was applied to the defect walls and root surfaces. (Figure 5 a, b). With the other PRF membrane applied "sticky" bone was covered. The flap was repositioned to their presurgical level and sutured with atraumatic suture utilizing an interrupted technique.

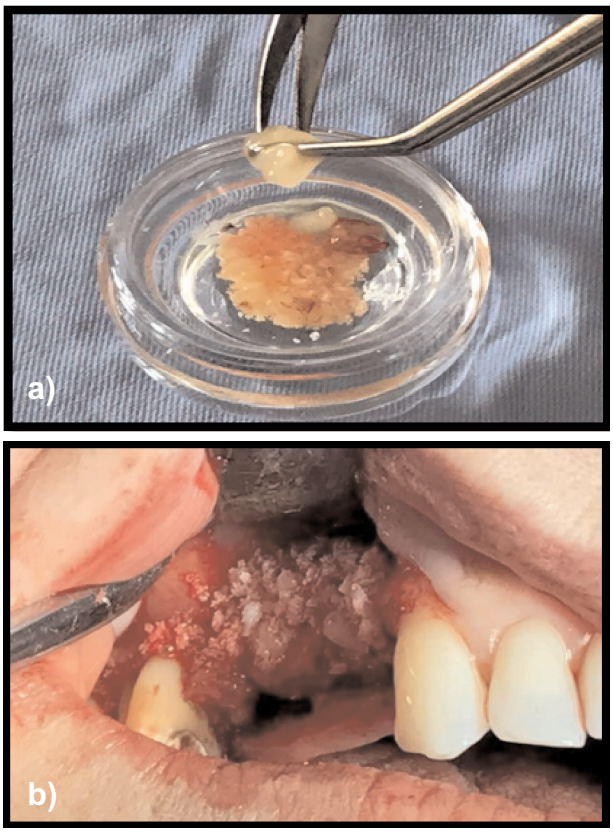


Figure 5. *a) "Sticky" bone, b) Applied xenograft with PRF in the infrabony defect*

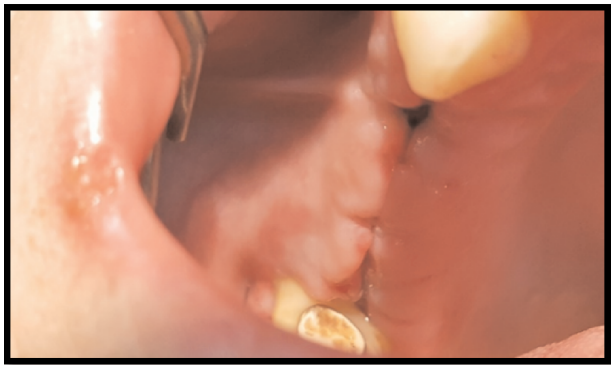


Figure 7. *Follow up after one week*

After the operation, the patient was ordinated systemic antibiotics (Amoxicline with clavulanic acid for 7 days), Vitamin D (2000 I.E per day), Vitamin C (1000 mg per day) and natrium chloride solution for mouth wash (twice a day for 2 weeks).

The patient was examined the next day, and after 1 week, 2 weeks, 1 month, 3 and 6 months. (Figure 7)

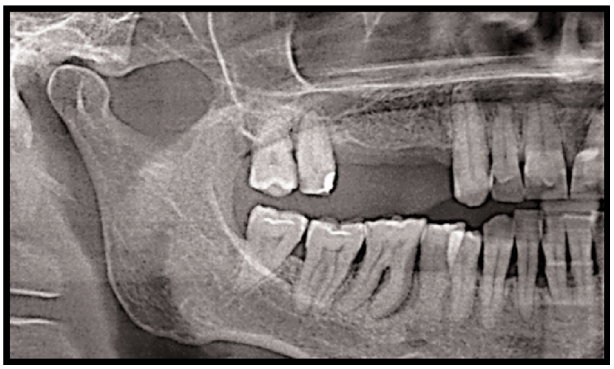


Figure 8. *X-Ray after two months*

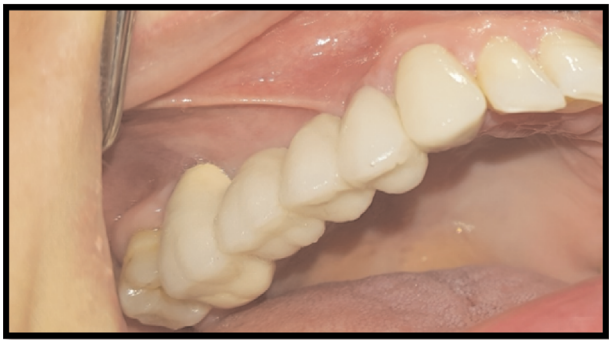


Figure 9. *Fixed prosthodontic solution*

Panoramic radiography was performed. (Figure 8) In this case report, reduction of pocket depth and gain of clinical attachment were found after 6 months of follow-up which ended with successful prosthodontic solution. (Figure 9)

Discussion

Gingival disease and chronic periodontitis are both periodontal diseases with a high incidence, which can be manifested as gingival swelling and bleeding, and are also one of the important reasons for periodontal intraosseous defect[8]. The aim of periodontal and surgical therapy is to arrest and control periodontal infection and ultimately regenerate lost periodontal structures. Newer approaches to periodontal therapy include regenerative procedures that aim to restore lost periodontal ligament, bone, cementum, and connective tissue.

With the development of new materials on how to promote the regeneration of periodontal tissue, restoring the function of periodontal tissue, giving attention to gingival aesthetics, and eliminating the symptoms of infection and destruction on the basis of simple bone grafting has become a new direction for clinical treatment of periodontal intraosseous defect[7]. PRF is a second generation platelet concentrate which can enhance both soft and hard tissue healing[4]. Its advantages over platelet-rich plasma include ease of preparation, ease of application, minimal expense, and lack of biochemical modification (no bovine thrombin or anticoagulant is required). This considerably reduces the biochemical handling of blood as well as risks associated with the use of bovine-derived thrombin. PRF also contains physiologically available thrombin that results in slow polymerization of fibrinogen into fibrin which results in a physiologic architecture that is favorable to wound healing.. At the same time due to its material characteristics, weak mechanical strength, it is prone to collapse, which affects the space of the osteogenic area and leads to insufficient bone formation[8]. Combined with bone transplantation, the bone substitutes were implanted into bone defects to promote blood vessel regeneration and guide attachment of periodontal precursor cells[9,10].

In this case report, the decision to utilize PRF as defect fillers in combination with xenograft was made because of its easy manipulation and delivery to the surgical site. The intended role of the PRF in the intrabony defect was to deliver the growth factors in the early phase of healing.

It has been reported that the combination of a mineralized, rigid bone mineral, with a semi-fluid, non-rigid agent, such as EMD, significantly enhanced the clinical outcome of intrabony defects other than treated without the addition of bone mineral[11]. In another study, PRF in combination with bone mineral had ability in increasing the regenerative effects in intrabony defects. For that reason, we chose xenograft (Bio-Oss™), hypothesizing that it could enhance the effect of PRF by maintaining the space for tissue regeneration to occur. Amorphous PRF, when used along bio-oss for augmentation in maxillary atrophic cases, showed reduced healing time and favorable bone regeneration[12].

In this case report, the reduction in pocket depth and gain in clinical attachment were found after 6 months of follow-up. These are the important clinical outcomes for any periodontal regenerative procedures. Radiographs revealed significant bone fill in the intrabony defect compared to measurements at baseline.

Conclusion

Guided bone and soft tissue regeneration using xenograft and platelet rich fibrin gives successful radiological and clinical signs of bone augmentation and consolidation of defects caused by loss of tooth attachment.

Reference

1. EF Corbet, DKL Ho, Radiographs in periodontal disease diagnosis and managementFirst published: 03 September 2009 https://doi.org/10.1111/j.1834-7819.2009.01141.x Citations: 38
2. Del Fabbro M, Karanxha L, Saurav P, Bucchi C, Doraiswamy J N, Sankari M, Ramamoorthi S, Varghese S, Taschieri S. Autologous platelet concentrates for treating periodontal infrabony defects. Cochrane Database of Systematic Reviews 2018, Issue 11. Art. No.: CD011423. doi: 10.1002/14651858.CD011423.
3. Andrea Pilloni, Mariana A. Rojas, Lorenzo Marini, Paola Russo, Yoshinori Shirakata, Anton Sculean,3 and Roberta Iacono1 : Healing of intrabony defects following regenerative surgery by means of single-flap approach in conjunction with either hyaluronic acid or an enamel matrix derivative: a 24-month randomized controlled clinical trial;Published online 2021 Feb 10. doi: 10.1007/s00784-021-03822-x
4. Preeja C, Arun S Platelet-rich fibrin: Its role in periodontal regeneration, King Saud University Journal of Dental Sciences (2013), http://dx.doi.org/10.1016/j.ksujds.2013.09.001
5. Balaram Naik, P Karunakar, M Jayadev, and V Rahul Marshal : Role of Platelet rich fibrin in wound healing: A critical review ; J Conserv Dent. 2013 Jul-Aug; 16(4): 284–293.doi: 10.4103/0972-0707.114344
6. Yongping Yuan, Jiajia Zhao, and Nv He Observation on the Effect of Bone Grafting Alone and Guided Tissue Regeneration Combined with Bone Grafting to Repair Periodontal Intraosseous Defects ; Evid Based Complement Alternat Med. 2021; 2021: 1743677. Published online 2021 Oct 12. doi: 10.1155/2021/1743677
7. M. Siaili, D. Chatzopoulou, and D.G. Gillam? An overview of periodontal regenerative procedures for the general dental practitioner ; Saudi Dent J. 2018 Jan; 30(1): 26–37. Published online 2017 Nov 14. doi: 10.1016/j.sdentj.2017.11.001
8. N.H. Hart, S. Nimphius, T. Rantalainen, A. Ireland,A. Siafarikas, and R.U. Newton1: Mechanical basis of bone strength: influence of bone material, bone structure and muscle action;J Musculoskelet Neuronal Interact. 2017 Sep; 17(3): 114–139.
9. Petsos H., Ratka-Krüger P., Neukranz E., Raetzke P., Eickholz P., Nickles K. Infrabony defects 20 years after open flap debridement and guided tissue regeneration. Journal of Clinical Periodontology. 2019;46(5):552–563. doi: 10.1111/jcpe.13110. [PubMed] [CrossRef] [Google Scholar]
10. Geão C., Costa-Pinto A. R., Cunha-Reis C., et al. Thermal annealed silk fibroin membranes for periodontal guided tissue regeneration. Journal of Materials Science: Materials in Medicine. 2019;30(2):p. 27. doi: 10.1007/s10856-019-6225-y. [PubMed] [CrossRef] [Google Scholar]
11. Lekovic V, Camargo PM, Weinlaender M, Nedic M, Aleksic Z, Kenney EB. A comparison between enamel matrix proteins used alone or in combination with bovine porous bone mineral in the treatment of intrabony periodontal defects in humans. J Periodontol. 2000; 71:1110–6.
12. Tatullo M, Marrelli M, Cassetta M, Pacifici A, Stefanelli LV, Scacco S, et al. Platelet Rich Fibrin in reconstructive surgery of atrophied maxillary bones: Clinical and histological evaluations. Int J Med Sci. 2012;9:872–80.

UDK: 616.314–007–053.5

AESTHETIC CHANGES IN PATIENTS WITH CLASS II DEVISION 1 MALOCCLUSION

ПРОМЕНИ ВО ЛИЦЕВАТА ЕСТЕТИКА КАЈ ПАЦИЕНТИ СО МАЛОКЛУЗИЈА II КЛАСА 1-ВО ОДДЕЛЕНИЕ

Gavrilovikj I., Kurcieva Chuckova G., Bajraktarova Misevska C., Maneva Ristovska M., Mitikj K.

Ss. Cyril and Methodius University in Skopje, Faculty of Dentistry - Skopje, Republic of North Macedonia

Abstract

Malocclusions are manifested with changes in the teeth position, different position of the bones of maxilla and mandible are often accompanied by soft tissue changes. Orthodontic treatment also affects the changes of soft tissue structures, and improves the facial aesthetics of the patients. In order to see the benefits of orthodontic therapy in Class II/1 malocclusion, an analysis of the changes that occur in the soft tissues and lips in patients before and after, was performed. For this purpose, 7 soft tissue parameters of the lips were analyzed in 30 patients with Class II Division 1 malocclusion, before and after orthodontic treatment, and in 30 patients with normal occlusion. The results indicate that after orthodontic treatment in patients with Class II/1 malocclusion, there are significant changes in the upper smile line, the height of the upper lip at rest position and during the smile and for the intercommissural length. From the analysis it can be concluded that the soft tissues follow the changes that occur with orthodontic treatment, which positively affects the aesthetics of the lips and the smile. **Key words:** Class II Division 1 malocclusion, aesthetics, smile aesthetics, lip position.

Апстракт

Малоклузиите се манифестираат со промени на поставеноста на забите, дентоалвеоларните и коскените структури, а често се пропратени и со промени на меките ткива. Ортодонтскиот третман влијае и на промените на меките структури и на подобрување на лицевата естетика на пациентите. Со цел да се согледаат придобивките од ортодонтската терапија кај малоклузија од II/1, направена е анализа на промените кои настануваат на меките ткива, на усните кај пациенти пред и после ортодонтската терапија. За таа цел анализирани се 7 параметри на усните кај 30 пациенти со малоклузија II класа 1-во одделение, пред и после ортодонтската терапија, и кај 30 пациенти со нормална оклузија. Резултатите укажуваат дека после ортодонтскта терапија кај пациенти со малоклузија II/1, има сигнификанти промени во горната линија на насмевка, во висината на горната усна при мирување и при насмевка и во интеркомисуралната должина. Од направената анализа може да се заклучи дека меките ткива ги следат промените кои настануваат со ортодонтскиот третман, кои позитивно влијаат на естетиката на усните и насмевката. **Клучни зборови:** малоклузија II класа 1-во одделение, естетика, естетика на насмевка, поставеност на усните.

Introduction

Malocclusions, in addition to altering the position of the teeth and occlusion, also affect the extraoral appearance of patients.

Class II / 1 malocclusion is characterized by protrusion of the maxillary incisors, the same can be manifested on face appearance also, therefore the upper lip only partially covers the incisors and these patients have incompetent lips. Hypotonia of the lip muscles is often present. Due to hypotonia, very often it is possible for gingiva to be exposed above the maxillary incisors during smiling, known as "gingival smile"[1]. These patients have a convex profile and the upper and lower lip touch or cross the aesthetic line.

Sometimes even modest inconsistencies in the face configuration cause a feeling of dissatisfaction and concern in the individual[2, 3]. The configuration and expression of the face, depend of the structure and position of the bones of the face, the position of the upper and lower jaw in relation to the cranial base and their mutual relation, the ratio of hard and soft tissues that cover the whole facial skeleton, forehead, nose, chin and lips[4, 5].

Arnett, Bergman, Proffit[6] emphasized the importance of perceiving aesthetics from a frontal point of view. The dynamic of the lip muscles during conversation and smiling in patients should also be analyzed.

Dejanovski[7] examining the length of the upper lip and the visibility of the incisions concludes that the visibility of the teeth is inversely proportional to the length of the upper

lip and in terms of gender, females have a shorter lip and greater visibility of the incisions.

Mackley[8] says that it is very important for orthodontists to make an effort to create a harmonious balance, which will produce an attractive smile in every orthodontically treated individual.

Utley[8, 9] indicates that facial aesthetics are not static. The orthodontist must know the proper vertical ratios of the dentition and the soft tissue.

Rafiqul et al.[10] examined lip changes in patients with class II/1 malocclusion, and in patients with normal occlusion at rest position and when smiling. Twenty patients were examined, 17 of them were treated without extraction, while 3 were treated with extraction. They found that in patients with class II/1 malocclusion, before treatment, both lips were placed facing down, when smiling. There is an improvement in the smile after the orthodontic treatment, but it takes time for the soft tissues to adapt to a new position.

Utley[8,9] examined patients before and after fixed orthodontic treatment and concluded that, in all treated patients, the torque of the maxillary incision had not been improved. There is a correction of the protrusion of the maxillary incisors and improvement of the smile before and after the orthodontic treatment.

Ackerman et al.[11] examined the size of the interlabial gap, the intercommissural length, and the length of the incisions in posted smile and speech. Patients were suggested to say "cheese," and videos were made, which were later used for analysis. The obtained results indicate that in posted smile there is greater display of incisions and a greater width of the smile. While in relation to the interlabial gap, no significant changes were found in a posted smile and during speaking. When planning the vertical placement of the maxillary incisions with orthodontic treatment, the orthodontist should account for the visibility of the incisions in rest position, when talking and when smiling.

An aesthetically pleasing smile usually shows symmetry between teeth, gingiva and lips. In some people, a smile shows the gingiva above the maxillary front teeth. This anatomical feature is defined as gingival line of a smile[12].

Ackerman et al.[11] took digital photographs of 50 patients (27 male and 23 female) who said "cheese" while smiling. From the photographs, the following were measured: the intercommissural length in mm, the interlabial space in mm, the visibility of the incisors below the commissure line, and the maximum visibility of the incisors in mm. The obtained results indicate that the visibility of the incisors is different when talking and smiling. Therefore, during orthodontic treatment, it is important to plan the vertical placement of the incisors.

Aim of the study

Purpose of these study is to see the benefits of orthodontic therapy in patients with Class II/1 malocclusion thought the analysis of the changes that occur in the soft tissues and lips in patients before and after orthodontic therapy. Because very often soft tissue changes occur during orthodontic treatment and have their impact in approving esthetic appearance of the face of the patients.

Material and methods

The aesthetic components of extraoral changes in patients with Class II/1 malocclusion were examined in this research. 30 subjects had Class II/1 malocclusion, before and after orthodontic treatment, and 30 subjects had normal occlusion.

The following extraoral parameters measured on the teeth and lips were used for analysis, measured extraorally (Figure 1):

1. Length of permanent left maxillary incisior (21) - from the incisal edge of the maxillary incisior to the highest point of the marginal edge of the crown,
2. Top smile line during maximum smile - the horizontal line that passes through the cervical edge of the maxillary central incisors is the zero point. It imagines a normal, passing through the middle of the face, graduated in mm. Measure the distance from the zero axis to the lower edge of the upper lip during maximum smile. This distance is "+" when the lip is above the zero axis and "-" when the lip is below it,
3. Upper lip at rest position - when the mandible is at physiological rest position and the distance from Sn to the lower edge of the upper lip (mm) is measured,
4. Upper lip height during maximum smile,

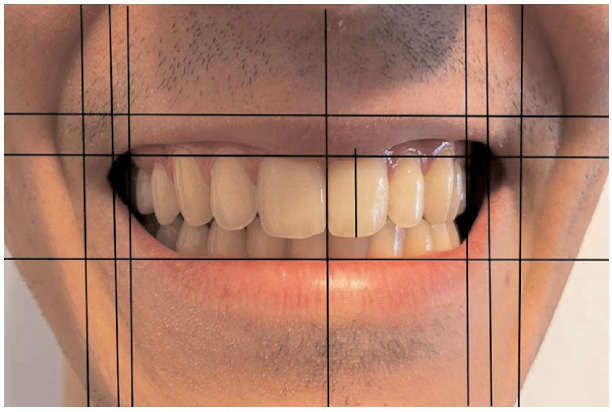


Figure 1. *Teeth and lip position during smile*

5. Distance between the lower edge of the upper lip and the incisal edge of the upper maxillary incisor during smile,
6. Intercommissural length - distance between the commissures of the lips during maximum smile,
7. Interlabial space (gap) - distance between the lower edge of the upper lip and the upper edge of the lower lip during maximum smile.

All examined patients were from 12 to 18 years of age.

Statistical processing of results

During the analysis of the obtained results from the examined groups, the following statistical parameters were applied and processed:

- Arithmetic mean
- Standard deviation
- Standard error
- Minimum
- Maximum
- Student "t" test for significance of differences

p> 0.05 (-) has no significance
0.05> p> 0.01 (*) has significance
0.01> p> 0.001 (**) high significance
p <0.001 (***) expressed significance

Purpose of the study

Purpose of these study is to see the benefits of orthodontic therapy in patients with Class II/1 malocclusion thought the analysis of the changes that occur in the soft tissues and lips in patients before and after orthodontic therapy. Because very often soft tissue changes occur during orthodontic treatment and have their impact in approving esthetic appearance of the face of the patients.

Results

Table no. 1 shows the values for t - test between patients with normal occlusion and patients with Class II/1 malocclusion before orthodontic treatment. Significant changes were found for the height of the upper lip at rest position and during smiling. We found significant changes for intercommissural length, interlabial gap and upper smile line.

In table no. 2 are given the values for t - test between patients with normal occlusion and patients with Class II/1 malocclusion after orthodontic treatment. The obtained values indicate significantly significant changes for the intercommissural length. Highly significant changes were found in both values, the value for the

Table 1. Differences (t-test) of extraoral parameters in patients with normal occlusion and Class II/1 malocclusion before treatment

	Normal occlusion		**Class II/1 before treatment**			
	X	SD	X	SD	t-test	P
Length of 21	9.73	1.24	9.63	0.95	0.73088	p > 0.05
Top smile line	-0.30	2.08	0.43	1.65	0.01425	0.05 > p > 0.01*
Upper lip height at rest position	21.83	2.21	17.17	2.16	0.00000	p < 0.001***
Upper lip height at max smile	17.93	2.37	13.67	2.45	0.00000	p < 0.001***
The lower edge of the upper lip and the incisal edge of 21 during a smile	8.00	2.32	9.10	2.49	0.08761	p > 0.05
Intercommissural length	66.00	4.51	58.53	4.45	0.00000	p < 0.001***
Interlabial space (gap)	8.97	2.65	12.83	3.51	0.00001	p < 0.001***

Table 2. Differences (t-test) of extraoral parameters in patients with normal occlusion and Class II/1 malocclusion class after orthodontic treatment

	Normal occlusion		Class II/1 before treatment			
	X	SD	X	SD	t-test	P
Length of 21	9.73	1.24	9.70	0.90	0.90697	p> 0.05
Top smile line	-0.30	2.08	0.13	1.06	0.03220	0.05 > p > 0.01*
Upper lip height at rest position	21.83	2.21	20.30	1.99	0.00730	0.01>p>0.001 **
Upper lip height at max smile	17.93	2.37	16.50	1.84	0.01257	0.05 > p>0.01*
The lower edge of the upper lip and the incisal edge of 21 during a smile	8.00	2.32	9.30	1.35	0.01159	0.05 > p>0.01*
Intercommissural length	66.00	4.51	61.10	4.17	0.00007	p<0.001***
Interlabial space (gap)	8.97	2.65	11.60	3.50	0.00204	0.01>p>0.001 **

Table 3. Differences (t-test) of extraoral parameters of patients with Class II/1 malocclusion before and after treatment

	Normal occlusion		Class II/1 before treatment			
	X	SD	X	SD	t-test	P
Length of 21	9.63	0.95	9.70	0.90	0.78458	p> 0.05
Top smile line	-0.43	1.65	0.13	1.06	0.041233	0.05 > p > 0.01*
Upper lip height at rest position	17.17	2.16	20.30	1.99	0.00000	p<0.001***
Upper lip height at max smile	13.67	2.45	16.50	1.84	0.00001	p<0.001***
The lower edge of the upper lip and the incisal edge of 21 during a smile	9.10	2.49	9.30	1.35	0.70534	p>0.05
Intercommissural length	58.53	4.45	61.10	4.17	0.02720	0.05 >p>0.01*
Interlabial space (gap)	12.83	3.51	11.60	3.50	0.18558	p>0.05

size of the interlabial space and the height of the upper lip at rest position. Significant changes were found for the values of the upper lip height at maximum smile, for the value from the lower edge of the upper lip to the incisal edge of the maxillary left central incisor (21), and for the top smile line.

In table no. 3, we can see that there is a significant difference in the height of the upper lip at rest position and in a maximum smile, in the examined group with Class II/1 malocclusion, before and after treatment. There is a significant change for the intercommissural length, and for the value of the top smile line.

Discussion

In order to achieve the maximum benefits from the orthodontic treatment of malocclusions, it should have a positive impact on the aesthetic characteristics of the face. This can be achieved if the therapy plan is aimed at improving the relationship between the maxillary incisors and the smile line.

A study by Terpsithe et al.[13] who searched 5 electronic databases and selected 814 papers, based on how orthodontic treatment affects smile aesthetics in relation to the three dimensions, found that tooth extraction did not affect smile width and the width of the buccal corridor, but orthodontic treatment improves these smile components.

In our examination we found that the height of the upper lip in patients with normal occlusion, at rest position is 21.83 mm, while during a smile there is a significant shortening of the upper lip and its values is 17.93 mm, which matches the data obtained by Desai[14], with a value of 21.58 mm for the same parameter. During a smiling, the length of the upper lip is shortened, and its value is 17.93 mm, while Desai[14] gets a slightly lower value than ours, 16.84 mm. Examinations show significant changes in the upper lip in patients with Class II/1 malocclusion before and after treatment, at rest position and during a smile. An increase in the height of the upper lip at rest from 17.17 mm to 20.30 mm after treatment, indicates a significant elongation of the upper lip, which results of the retraction of the maxillary incisors and lowering of the upper lip, as a result of which the lip muscles are not pressured from the maxillary incisions proclination.

There are also changes for value of the height of the upper lip during a smile from 13.67 mm before treatment to 16.50 mm after treatment, which favors less exposure of the gingiva above the maxillary incisors, during a smile.

The results show that patients with class II/1 malocclusion have a shorter upper lip. This shorter upper lip may be the result of hypotension of the lip muscles. This results in greater exposure of the incisors, not only during a smile but also at rest position. After treatment in patients with Class II/1 malocclusion there is an increase in the height of the upper lip length.

Bisson et al.[15] in the analysis of individuals who are photo models and those who are not, found that full lips are aesthetically more beautiful and more desired by patients.

The upper line of the smile at maximum smile, depends on the height of the upper lip relative to the maxillary incisor.

Gerona[1] did a photo examination to determine the aesthetics of the smile when talking and smiling and to define whether the display of gingival tissue is more or less aesthetic. She defined that the most attractive is the smile where the upper lip is in the zero position, up to 2 mm to cover the crowns of the maxillary central incisors. The smile is considered unattractive when the crowns of the mandibular central incisors are fully exposed. Unattractive are those smiles where a smile shows more than 1.5 mm of the gingiva. A study by Van der Gelda et al.[16] found that smiles were less aesthetically pleasing when the upper smile line covered the maxillary incisors similar as smiles where gingival tissue was overexposed during a smiling.

Peck et al.[17] found that the lower smile line is characteristic for males, while the upper smile line predominates in females. They found that maxillary anterior teeth are more exposed in females, while males are more likely to show mandibular incisors. The findings show that if the gingiva is seen more than 1 mm when smiling, the smile is considered unaesthetic. While the exposure of the mandibular incisors and their gingiva are signs of the aging process.

Our findings coincide with the findings of Gerona[1] and indicate that in patients with Class II/1 malocclusion before treatment, the upper smile line is 43.4 mm, and after treatment is 0.13 mm, while in patients with normal occlusion the value is - 0.30 mm. Our values are slightly lower than the values defined by McLeoda et al.[18] in their study of the Canadian population. The ideal value of gingival exposure is considered to be 2.7 mm, the minimum tolerable value is 2.7 mm and maximum is -2.52 mm. For the American population they found that an ideal value is 2.1 mm, a minimum tolerance value is 4mm, and a maximum tolerance value is -3.6 mm. Kokich et al.[19] suggest that an acceptable tolerance threshold is ± 4 mm.

We can notice that the upper line of the smile in patients with Class II/1 malocclusion is above the zero position, i.e. it is above the cervical edge of the maxillary incisors. It occurs as a result of protrusion of the

maxillary incisors. When the position of the upper lip in patients with class II/1 malocclusion is below zero, it is as a result of greater mobility of the lip muscles and soft tissue compensation to mask the orthodontic anomaly. It can be seen that after the therapy, the upper line of the smile passes below the zero position, which is a positive and desired effect of the treatment. By retrusion of the maxillary incisors, the lips follow the movements of the hard tissues, descending; the gingival exposure, which was present before therapy, is lost. With this we can say that the orthodontic treatment is satisfied with the aesthetic component of the smile.

Rafiqul et al.[10] evaluated the morphological changes of the lips in patients with class II/1 malocclusion, before and after orthodontic treatment, compared with patients with normal occlusion, and determined the degree of improvement of the smile after orthodontic treatment. They concluded that after the treatment, when smiling, the corners of the lips are wider and closer to the control group. The lips of the treated group are not under tension during a smile. This is probably due to the fact that the lips cannot immediately adapt to the new position and it takes more time for that. Perhaps the orthodontic treatment of wearing braces for a period of 2 years interferes with the normal movement of the lips.

The size of the clinical crown of the maxillary incisors, their color and placement play an important role in creating a smile. In our study, the value for this parameter in patients with normal occlusion is 9.73 mm. Our findings are consistent with the findings of Peck et al.[17] which indicate a value of 9.8 mm for the crown of the maxillary incisor (21). No difference was found in the size of the maxillary incisions before and after orthodontic treatment. This indicates that the changes that occur during treatment do not refer to excessive extrusion or intrusion of the maxillary incisors, but rather to the teeth movement; there are more changes in the tooth torque and their labio-palatal displacement.

The value of the lower edge of the upper lip and the incisal edge of the maxillary incisors (21) when smiling i.e. the maximum exposure of incisions during a smile, in the examined patients with normal occlusion, is 8.00mm. Our obtained values do not match (are higher) the values obtained by Ackerman et al.[20] who obtained a value of 6.47 mm, while they match the values obtained by Desai[21, 22] with a value of 8.76 mm. Our data do not match the data obtained from Peck et al.[17] who has obtained larger values of 10.2 mm for the same parameter for the examined patients.

The value obtained for the interlabial space is 8.96 mm in patients with normal occlusion and match the values of Ackerman et al.[11,19] who obtained a value of 8.41 mm, and do not match with the findings by Desai[21,22] with a value of 12.00 mm. For the same examined parameter, we found an increased value (12.83 mm) in patients with Class II/1 malocclusion before treatment. After treatment the value is 11.60 mm. Our findings are consistent with those of Maganzini (Anthony et al.)[23].

The enlarged interlabial gap is due to protrusion of the maxillary incisors in patients with class II / 1 malocclusion, weaker perioral muscles, and a shorter, hypotonic upper lip.

The intecommissural length actually shows the length of the smile itself. The value we obtained for this parameter is 66.00 mm in individuals with normal occlusion. Ackerman et al.[11,19] got a lower value than ours, 49.39 mm. Our values match the values obtained by these authors.

In our study we found that the examined group with normal occlusion (66.00 mm) has a longer smile length compared to the patients with Class II/1 malocclusion before treatment, where it is 58.53 mm. After the treatment, the width of the smile increases, which is due to the expansion of the maxilla, the correction of the protrusion and we can say that the lips muscles are strengthened. The value of this parameter in patients with Class II/1 malocclusion after orthodontic treatment is 61.10 mm. Soft tissues also have a positive effect on therapy and follow the changes in dentoalveolar structures. Our values do not match the values obtained by Ackerman et al.[11,19] but match the values of Jannathul et al.[24] who found that after orthodontic treatment there are large changes in the lips during a smile which affects the aesthetic and emotional changes in patients.

Conclusion

The values obtained from the examined soft tissue parameters lead to the following conclusions: the length of the left maxillary incisor (21) remains unchanged before and after orthodontic treatment. The size of the maxillary incision (21) is the same in both patients with normal occlusion and patients with class II/1 malocclusion before and after treatment. The value obtained for the top smile line in patients with Class II/1 malocclusion is 0.43 mm, before therapy, indicates full exposure of the maxillary incisors when smiling, but that value is not so high and does not indicate the appearance of a gingival smile. After the treatment, there is a slight lowering of the upper line of the smile, which indicates that after orthodontic treatment and retraction of the maxillary incisions, the slight lowering of the upper line of the smile meets the required aesthetic criteria. The height of the upper lip at rest position is longer in individuals with normal occlusion than in patients with Class II/1 malocclusion before treatment. There are significant changes

in the height of the upper lip at rest position and when smiling in patients with Class II/1 malocclusion, before and after therapy. This indicates that with orthodontic treatment we do not only act on the dentoalveolar structures, but there are also changes in the soft tissues. No significant changes were found in relation to the lower edge of the upper lip and the incisal edge of the maxillary incisor (21) during a smile, in none of the examined groups. Changes in intercommissural length are significant in patients before and after orthodontic treatment. After orthodontic treatment there is an increase of the intercommissural length. There is a significant change in the size of the interlabial space. The group with normal occlusion (8.97 mm) has a lower value compared to the value found in patients with Class II/1 malocclusion before (12.83 mm) and after orthodontic therapy (11.60 mm).

Facial and dental harmony depend on the mutual position of the maxilla and the mandible, their placement relative to the anterior cranial base, and the placement of the incisions relative to their reference planes and their mutual position. Correction of malocclusions is followed by soft tissue changes, and meeting functional and aesthetic criteria.

Properly planned and implemented orthodontic treatment will enable achievement of the desired results, i.e. correction of malocclusion that is present in patients, and meeting all criteria from a functional and aesthetic point of view.

Reference

1. Gerona, S., Wasserstein, A. Influence of Sex on the Perception of Oral and Smile Esthetics with Different Gingival Display and Incisal Plane Inclination. Angle Orthodontist. 2005; 75(5):778-84.
2. Chaconas, J. S., Jack, D. B. Prediction of Normal Soft Tissue Facial Changes. The Angle Orthodontist. 1975;45 (1):12-25.
3. Aboucaya, W. A. Le sourire: classification et criteres, applications en esthetique faciale. Nouv Presse Med. 1973;39: 26611-2616.
4. Janson, I., Hasund, A. Cephalometric guidance for the positioning of the lower incisors. European Journal of Orthodontics. 1981;3(4):237-240.
5. Kasai, K. Soft tissue adaptability to hard tissues in facial profile. Am I Orthod Dentofacial Orthop. 1998;113(6): 674-80
6. II–Hyung, Y., Dong-Seog, N., Seung- Hak, B. Which Hard and Soft Tissue Factors Relate with the Amount of Buccal Corridor Space during Smiling?. Angle Orthodontist. 2008; 78 (1):5-11.
7. Dejanovski, K. Somatometriski aspekt na odnosot na dolzinata na gornata usna i vidlivosta na centralnite maksilarni incizivi Maked Stomatol Pregl. 1988; XII (1-2):47-50.
8. Mackley, R. J. "Animated" Orthodontic treatment planning. JCO. 1993; 27: 361-364.
9. Mackley, R.J. An evaluation of smiles before and after orthodontic treatment. The Angle Orthodontists. 1993; 63 (3):183-9.
10. Rafiqul, I., Toru, K., Lutfun, N., Atsushi, H., Akihiko, N. Lip Morphological Changes in Orthodontic Treatment. Class II Division 1 Malocclusion and Normal Occlusion at Rest and On Smiling. Angle Orthodontist. 2009; 79 (2):256-64.
11. Ackerman, B., M., Colleen, B., J, Richard, L. An Evaluation of Dynamic Lip-Tooth Characteristics During Speech and Smile in Adolescents. Angle Orthodontist.2004; 74(1):43-50.
12. Isaacson, J., R. Smile, Face and Straith Teeth. Angle Orthodontist. 2002; 72 (4):282.
13. Terpsithea, C., Anna, B., Najd, A., Dorithy, O., Chung, H., K. Clinical effectiveness of orthodontic treatment on smile esthetic: systematic review. Clin Cosmet Investing Dent. 2019; 2(11):89-101.
14. Desai, S., G. Dynamic Smile Analysis: Changes with Age. University of Connecticut. Healt Center. Master Thesis. 2008.
15. Bisson, M., Adriaan, O., G. The Esthetic Properties of Lips: A Comparation of Models and Nonmodels. Angle Orthodontist. 2004; 74(2):162-6.
16. Piter Van del Geld, Paul, O., Guus Van Hek, Anne Marie, K-J. Smile attractiveness. Self-perception and influence on Personality. Angle Ortodontist. 2007; 77 (5): 759-65
17. Peck, S., Peck, L., Kataja M. The gingival smile line. Angle Orthodontist. 1993; 62 (2): 91-100.
18. Mc Leod C., Fields, H., V. Esthetics and smile characteristics evaluated by laypersons: A comparation of Canadian and US data. Angle Orthodontist. 2011; 81 (2):198-205.
19. Vincent, O Kokich., Vincent, G Kokich., Asuman, K., H. Perception of dental professionals and laypersons to altered dental esthetic: asymmetric and symmetric situations. Am I Orthod Dentofacial Orthop. 2006; 130(2):141-51.
20. Ackerman, B, M., Ackerman, J., L. Smile Analysis and Design in the Digital Era. I Clinic Orthodontist.2002; 36(4): 221-36.
21. Desai, S., Madhur, U., Nanda, R. Dynamic smile analysis: Changes with age. Am I Orthod Dentifacial Orthoped. 2009; 136 (3):310-1.
22. Desai, S., G. Dynamic Smile Analysis: Changes with Age. University of Connecticut. Healt Center. Master Thesis. 2008.
23. Maganzini, A., L., Schroetter, S., B., Freeman, K. Improvement in smile esthetics following orthodontic treatment: A retrospective study utilizing standardized smile analysis. Angle Orthodontist. 2014; 84(3):492-9.
24. Jannathul, F., K., Rengalakshimi, S. Analysing the smile arc in Class 2 patients before and after orthodontic treatment. International Journal of Scientific Development and Research. 2020; 5 (1):70-4.

UDK: 616.311.2–002:618.19–006.6–085.357.651.1

EFFECTS OF TAMOXIFEN ON PERIODONTAL STATUS

ЕФЕКТОТ НА ТАМОКСИФЕН ВРЗ ПАРОДОНТАЛНИОТ СТАТУС

Gjorgievska Jovanovska S.[1], Georgieva S.[1], Pesevska S.[1], Markovic S.[1], Vasev N.[1], Simonova D.[1]

[1]PHI University Dental Clinical Center ,,St. Panteleimon"- Skopje, Clinic for Oral and Periodontal Diseases Markovic S - PHI University Clinic for Endocrinology, diabetes and metabolic diseases Vasev N, Simonova D - PHI University Clinic for radiotherapy and oncology - Skopje

Abstract

Tamoxifen is a selective estrogen receptor modulator (SERM) or a partial estrogen receptor (ER) agonist. It has mixed estrogenic and antiestrogenic activity, with a profile of effects that differ by tissue. For example, tamoxifen has predominantly antiestrogenic effects in the breast, but predominantly estrogenic effects in other tissues where it has an estrogen receptor. In breast tissue, tamoxifen acts as an ER antagonist by inhibiting the transcription of estrogen-responsive genes. **Aim:** The purpose of this study was to follow the effects of tamoxifen therapy on periodontal disease on oncological patients (Carcinoma Mammae). **Material and method:** In order to achieve the goal of the study, 75 examinees were included. All examinees were divided into four groups. The subjects who were involved in the research signed a written consent, which enabled us to use the obtained data for scientific and research purposes. The first three groups were subjects with Ca Mammae who completed the appropriate therapy and started receiving tamoxifen. The fourth group (control) were healthy subjects who did not receive tamoxifen. **Results:** For 75 subjects included in the examination, the index of gingival inflammation varies in the interval 0.87 ± 0.99; ± 95.00% CI: 0.64-1.09; the minimum value is 0.00 and the maximum 3.00. **Conclusion:** Our research has shown that in patients with breast cancer treatment with tamoxifen for more than two years leads to reduction of inflammatory processes in the periodontium. **Key words:** gingival inflammation, tamoxifen, breast cancer, oral health, chemotherapy.

Апстракт

Тамоксифен делува како селективен модулатор на естрогенски рецептори (SERM) или како делумен агонист на естрогенските рецептори (ЕР). Има мешана естрогена и антиестрогена активност, со профил на ефекти кои се разликуваат по ткиво. На пример, тамоксифен има претежно антиестрогени ефекти во градите, но претежно естрогени ефекти во другите ткива каде што има естрогенски рецептор. Во ткивото на градите, тамоксифен делува како антагонист на ЕР така што е инхибирана транскрипцијата на гените кои одговараат на естрогенот. **Цел на трудот:** Целта на овој труд беше преку клинички испитувања да се проследат ефектите од терапијата со тамоксифен врз пародонтот кај онколошките пациенти (Ca Mammae). **Материјал и метод:** За реализација на поставената цел во истражувањето беа вклучени 75 испитаници поделени во четири групи. Испитаниците кои беа вклучени во истражувањето потпишаа писмена согласност, со што ни беше овозможено добиените податоци да ги искористиме во научно-истражувачки цели. Првите три групи беа испитаници со Ca Mammae кои ја завршиле соодветната терапија и започнале со примање на тамоксифен. Четвртата група (контролна) ја сочинуваа здрави испитаници кои не примаат тамоксифен. **Резултати:** Кај 75 испитаници вклучени во испитувањето индексот на гингивална инфламација варира во интервалот 0,87±0,99; ±95,00%CI:0,64-1,09; минималната вредност изнесува 0,00 а максималната 3,00. **Заклучок:** Нашето истражување покажа дека кај пациентите со рак на дојка третирани со терапија со тамоксифен повеќе од две години доведува до намалување на воспалителните процеси на пародонтот. **Клучни зборови:** гингивална инфламација, тамоксифен, рак на дојка, орално здравје, хемотерапија.

Introduction

Tamoxifen (TAM) has been the drug of choice in breast cancer treatment for more than 20 years. In fact, this synthetic non-steroidal compound inhibits the binding of natural estrogen to its receptors, therefore inhibiting the proliferation of tumor cells dependent on it. Its effect is specific and has no affinity for the progesterone receptor or other steroids; it has antitumor and cytostatic use[1], it is also used as a therapy for other cancers[2]. Tamoxifen is usually taken orally (per os) every day for five years for breast cancer[3]. It is a selective estrogen receptor modulator (SERM) and reduces the growth of breast cancer cells[3,4]. It is a member of the group of triphenylethylene compounds[5].

Tamoxifen is currently used to treat early and advanced estrogen receptor-positive (ER-positive or ER +) breast cancer in pre- and postmenopausal women[6].

A beneficial effect of tamoxifen is that it prevents bone loss by acting as an estrogen receptor agonist (i.e., mimicking the effects of estrogen) in this type of cell. Therefore, by inhibiting osteoclasts, it prevents osteoporo-

sis[7,8]. Estrogen receptors are located in all layers of the gingival epithelium, buccal mucosa, and salivary glands, it's the effect of tamoxifen on oral health. Estrogen receptors exist as two subtypes, the estrogen receptor alpha (EPα) and the estrogen receptor beta (EPβ)[9]. Some research articles have shown that ERa was completely undetected in oral tissues, whereas ERb was expressed in high levels in oral epithelium and salivary glands[10, 11]. The differential expression of ERb in these tissues may account for the conflicting results in estrogen receptor expression in earlier studies. In this study, the results show that a tissue-specific subtype distribution is also observed in oral tissues with ERb but not ERa. ERa is usually expressed in classic target tissues, such as breast tissue. The identification of ERb in these tissues has significant clinical importance and suggests a direct role for estrogen in the physiology of the oral mucosa and salivary gland function[10].

Tamoxifen is a selective estrogen receptor modulator (SERM) or a partial estrogen receptor (ER) agonist. It has mixed estrogenic and antiestrogenic activity, with a profile of effects that differ by tissue. For example, tamoxifen has predominantly antiestrogenic effects in the breast, but predominantly estrogenic effects in other tissues where it has an estrogen receptor. In breast tissue, tamoxifen acts as an ER antagonist by inhibiting the transcription of estrogen-responsive genes[12].

Aim of the study

The aim of this study was to follow the effects of tamoxifen therapy on periodontal status of oncological patients with Carcinoma Mammae.

Material and method

In order to achieve the goal in the survey, 75 examinees were included. All examinees were divided into four groups. The subjects who were involved in the research signed a written consent, which enabled us to use the obtained data for scientific and research purposes. The first three groups were subjects with Carcinoma Mammae who completed the appropriate therapy and started receiving tamoxifen. The fourth group (control) were healthy subjects who did not receive tamoxifen.

- Group 1 - 15 patients with diagnosed breast cancer, treated with TAM for 1 month to 2 years.
- Group 2 - 15 patients with diagnosed breast cancer, treated with TAM for 2-5 years.
- Group 3 - 15 patients with diagnosed breast cancer, who have finished their treatment with TAM (after 5 years).
- Group 4 (control) - 30 healthy patients who did not receive TAM.

All data obtained from clinical trials were noted in a card prepared for that purpose for each patient separately. The card contained generalities of the examinee, anamnestic data about the disease, this part of the card was filled only for the examinees from the first three groups. For determining the condition of the gingiva, we used the index (Silness&Loe) according to the following index values: 0 = absence of inflammation - normal gingiva, 1= slight inflammation, slight discoloration, slight edema, no bleeding during probing, 2 = moderate inflammation moderate redness, swelling, bleeding when probing, hypertrophy and 3 = severe inflammation redness and hypertrophy, ulceration, tendency to spontaneous bleeding.

STATISTICAL ANALYSIS

The data analysis was performed in a statistical program STATISTICA 8.0 and SPSS Statistics 23.0

Results

Descriptive statistics on gingival inflammation (Silness&Loe index) is shown in Table 1.

In the four groups the gingival inflammation index varies in the range 0.87±0.99; ±95.00% CI: 0.64-1.09; the minimum value is 0.00 and the maximum value is 3.00.

In the control group, healthy patients who did not receive TAM, the value of gingival inflammation in the Silness &Loe index varies in the interval 1,100±0.99. In the first group, patients treated with tamoxifen for 1

Table 1. Gingival inflammation (Silness &Loe index)

Variable	Valid N	Mean	Confidence -95,00%	Confidence +95,00	Minimum	Maximum	Std. Dev.
Gingival inflammation Silness&Loe index	75	0.87	0.64	1.09	0.00	3.00	0.99

month to 2 years, the value of gingival inflammation in the Silness &Loe index varies in the interval 1.067±1.01. In the second group, patients treated with tamoxifen for 2 to 5 years, the value of gingival inflammation in the Silness &Loe index varies in the interval 0.667±0.98. In the third group, patients who have finished their treatment with tamoxifen after 5 years, the value of gingival inflammation in the Silness &Loe index varies in the interval 0.400±0.83. (Table 1.1).

For Kruskal-Wallis ANOVA by Ranks=6,44 и p>0,05(p=0,09) values of gingival inflammation between the examinees from the four groups, no statistically significant difference was found. (Table 1.2)

The results shown in Figure 1. refer to the investigated relationship between the treatment with tamoxifen and the index of gingival inflammation following Silness&Loe. For Spearman Rank Order R=-0.27 (p<0.05) a moderately strong negative significant correlation was found. With the increase of treatment with tamoxifen over time, the index of gingival inflammation significantly decreases.

The results shown in Table 1.3 refer to the multiple regression refer to the investigated relationship between

Table 1.1 Breakdown Table of Descriptive Statistics / Gingival inflammation (Silness &Loe index)

Tamoxifen	Gingival inflammation Means	Gingival inflammation N	Gingival inflammation Std.Dev.
Healthy patients who did not receive TAM	1,100	30	0.99
Treated with TAM for 1 month to 2 years	1,067	15	1.03
Treated with TAM for 2-5 years	0,667	15	0.98
Finished their treatment with TAM (after 5 years)	0,400	15	0.83
All Grps	0,867	75	0.99

Table 1.2. Gingival inflammation (Silness &Loe index)/ Kruskal-Wallis ANOVA by Ranks

Gingival inflammation (Silness&Loe)	Code	Valid N	Sum of Ranks
Healthy patients who did not receive TAM	0	30	1276,50
Treated with TAM for 1 month to 2 years	1	15	631,50
Treated with TAM for 2-5 years	2	15	510,00
Finished their treatment with TAM (after 5 years)	3	15	432,00

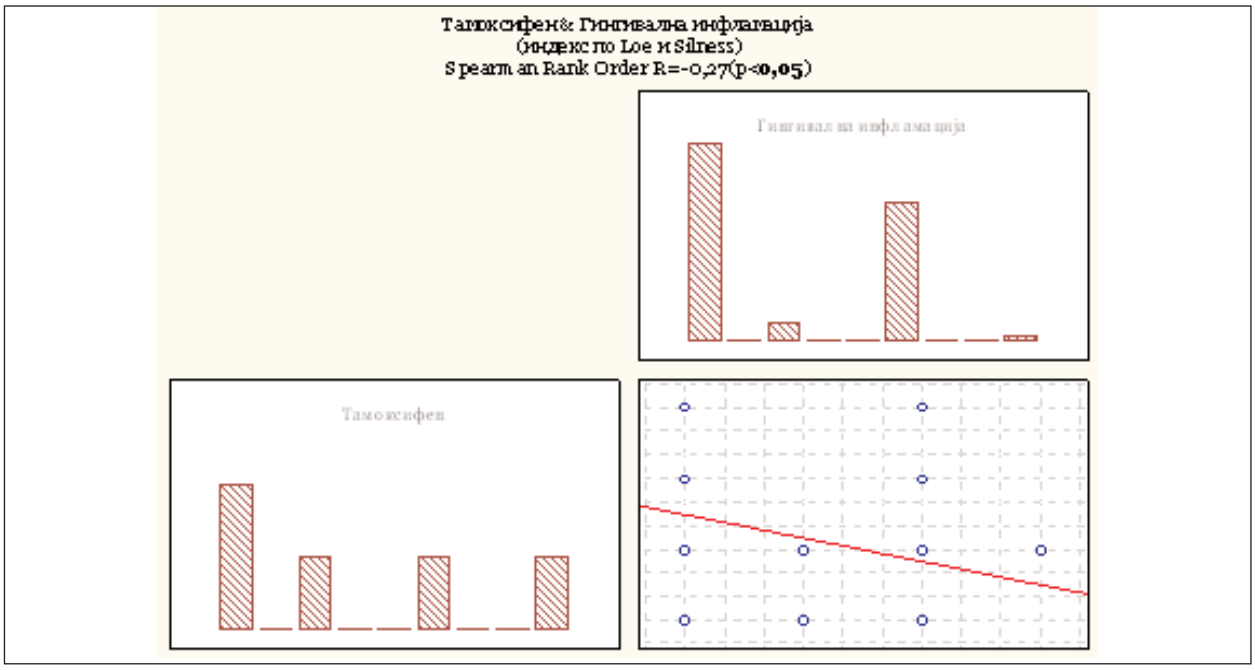


Figure 1

Table 1.3. Gingival inflammation (Silness &Loe index) / Treatment with tamoxifen

Regression Summary for Dependent Variable: Gingival inflammation (Sillnes&Loe index); R= 0,29; F=2,17 and p=0,099						
N=75	Beta	Std.Err. of Beta	B	Std.Err. of B	t(71)	p-level
Intercept			1,10	0,18	6,22	0,000
Treated with TAM for 1 month to 2 years	-0,01	0,12	-0,03	0,31	-0,11	0,91
Treated with TAM for 2-5 years	-0,18	0,12	-0,43	0,31	-1,42	0,16
Finished their treatment with TAM (after 5 years)	-0,28	0,12	-0,70	0,31	-2,29	**0,03**

the index of gingival inflammation following Silness&Loe as a dependent variable and during time of treatment with tamoxifen.

Healthy patients who did not receive tamoxifen were taken as a reference category (control group).

For R=0.29 (F=2.17 and p=0.099) a moderately strong correlation was determined.

The greatest impact on gingival inflammation has treatment with tamoxifen for more than 5 years (Beta=-0.28 (p<0.05), followed by treatment with tamoxifen for 2 to 5 years (Beta=-0.18 (p>0.05)), while the weakest effect of tamoxifen treatment is from 1 month to 2 years (Beta =-0.01 (p>0.05).

Examinees treated with tamoxifen for more than 5 years had an average of -0.70 (p <0.05/p=0.03) significantly lower values of gingival inflammation compared to healthy subjects who did not receive tamoxifen.

Examinees treated with tamoxifen for 2 to 5 years had an average of -0.43 (p> 0.05 / p=0.16) slightly lower val-

ues of gingival inflammation compared to healthy subjects who did not receive tamoxifen.

Examinees treated with tamoxifen from 1 month to 2 years had an average of -0.03 ($p>0.05$ / $p=0.91$) slightly lower values of gingival inflammation compared to healthy subjects who did not receive tamoxifen.

Discussion

If the gingival inflammation (gingivitis) is treated, the condition is reversible without lasting consequences. On the other hand, untreated cases can lead to more complex and destructive changes that result in chronic periodontal disease, with ultimate consequences – premature decomposition and loss of teeth.

Estrogen plays a regulatory role in maintaining the balance between osteoblast production and osteoclast production. Several studies suggest that osteoporosis is a risk factor for periodontal disease and loss of teeth[13,14,15,16,17]

The results obtained from the clinical examination included the determination of the index values for determining the condition of the gingival inflammation among our examinees which varied in the interval 0.87 ± 0.99; ± 95.00% CI: 0.64-1.09; the minimum value is 0.00 and the maximum value is 3.00. (shown in Table 1.) Table 1.2 shows the values of gingival inflammation between the examinees from the four groups and no statistically significant difference was found.

The results acquired for the relationship between duration of the treatment with tamoxifen and gingival inflammation shown in Figure 1 show moderately strong negative significant difference $R=-0.27$ ($p<0.05$). Patients with diagnosed breast cancer, who have been treated with tamoxifen for many years, have a reduction in inflammatory changes in the periodontium, and improvement in periodontal health. Our results are consistent with the results of Milagros et al., a long time of tamoxifen consumption there has a growing trend towards gingival health[18].

Conclusion

Chronic treatment with tamoxifen has a tendency to revert periodontal disease in patients suffering from breast cancer. At longer time of tamoxifen consumption has a growing trend towards gingival health.

Reference

1. Kevin E, Levin R, Actis A. Clave en el tratamiento del c´ancer de mama. LevinE (Ed.).Fundaci´on oncol´ogica Encuentro, Buenos Aires, Argentina, 71 (2003).
2. "Tamoxifen Citrate". NCI. August 26, 2015. Archived from the original on 4 January 2016. Retrieved 28 November 2015.
3. "Tamoxifen Citrate". The American Society of Health-System Pharmacists. Archived from the original on 2014-01-04. Retrieved 27 Nov 2015.
4. "Selective estrogen receptor modulators". Archived from the original on 9 December 2013. Retrieved 28 November 2015.
5. Cano A, Calaf i Alsina J, Duenas-Diez JL, eds. (2006). Selective Estrogen Receptor Modulators a New Brand of Multitarget Drugs. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg. p. 52. ISBN 9783540347422.
6. Jordan VC (October 1993). "Fourteenth Gaddum Memorial Lecture. A current view of tamoxifen for the treatment and prevention of breast cancer". British Journal of Pharmacology. 110 (2): 507–17. doi:10.1111/j.1476-5381.1993.tb13840.x. PMC 2175926. PMID 8242225.
7. Nakamura T, Imai Y, Matsumoto T, Sato S, Takeuchi K, Igarashi K, et al. (September 2007). "Estrogen prevents bone loss via estrogen receptor alpha and induction of Fas ligand in osteoclasts". Cell. 130 (5): 811–23. doi: 10.1016/j.cell.2007.07.025. PMID 17803905. S2CID 17177462.
8. Krum SA, Miranda-Carboni GA, Hauschka PV, Carroll JS, Lane TF, Freedman LP, Brown M (February 2008). "Estrogen protects bone by inducing Fas ligand in osteoblasts to regulate osteoclast survival". The EMBO Journal. 27 (3): 535–45. doi:10.1038/sj.emboj.7601984. PMC 2241656. PMID 18219273.
9. Valimaa H, Savolainen S, Soukka T, Silvoniemi P, Makela S, Kujari H, Gustafsson JA, Laine M. Estrogen receptor beta is the predominant estrogen receptor subtype in human oral epithelium and salivary glands. J Endocrinology 2004; 180:55-56.
10. Pan F, Zhang R, Wang G, Ding Y. Estrogen receptors are involved in the osteogenic differentiation of periodontal ligament stem cells. Biosci Rep 2011; 31:117-124.
11. Nebel D, Bratthall G, Ekblad E, Norderyd O, Nilsson BO. Oestrogen regulates D.N.A. synthesis in human gingival epithelial cells displaying strong estrogen receptor beta immunoreactivity. J Periodontal Res Oct 201146(5):622-8.
12. Wang DY, Fulthorpe R, Liss SN, Edwards EA (February 2004). "Identification of estrogen-responsive genes by complementary deoxyribonucleic acid microarray and characterization of a novel early estrogen-induced gene: EEIG1". Molecular Endocrinology. 18 (2): 402–11. doi:10.1210/me.2003-0202. PMID 14605097.
13. Meurman JH, Tarkkila L, Tiltinen A. The menopause and oral health. Maturitas May 2009;63(1):56-62.
14. Valimaa H, Savolainen S, Soukka T, Silvoniemi P, Makela S, Kujari H, Gustafsson JA, Laine M. Estrogen receptor beta is the predominant estrogen receptor subtype in human oral epithelium and salivary glands. J Endocrinology 2004; 180:55-56.
15. Pan F, Zhang R, Wang G, Ding Y. Estrogen receptors are involved in the osteogenic differ entiation of periodontal ligament stem cells. Biosci Rep 2011; 31:117-124.
16. Nebel D, Bratthall G, Ekblad E, Norderyd O, Nilsson BO. Oestrogen regulates D.N.A. syn thesis in human gingival epithelial cells displaying strong estrogen receptor beta immuno reactivity. J Periodontal Res Oct 201146(5):622-8
17. Liang L, Yu JF, Wang G, Ding Y. Effect of estrogen receptor beta on the osteoblastic dif ferentiation function of human periodontal ligament cells. Archives of Oral Biology June, 2008;53(6):553-557.
18. Milagros Muthular, Fernanda Bálsamo, Pablo Passero, Virginia Jewtuchowicz, Valeria Miozza, Marcelo Blanco Villalba, María Isabel Brusca, Cristina Pérez. Effects of tamoxifen on periodontal disease and Candida albicans of patients with breast cancer and other pathologies. Future Microbiol.2019 Jan;14:129-137.

UDK: 616.31–089.5

UPDATES IN ARTICAINE USE IN DENTISTRY

АРТИКАИН ВО СТОМАТОЛОГИЈАТА - НОВИ СОЗНАНИЈА

Lameski M.[1], Veleska Stevkovska D.[2], Josifov D.[3], Trajculeski S.[3], Bajrami M.[3], Gjurceski J.[4], Lameski M.[5]

[1]Private Dental Office Apolonia – Dent , Kavadarci, [2]Department of Implantology, Ss. Cyril and Methodius University in Skopje, Faculty of Dentistry - Skopje, Republic of North Macedonia, , [3]University Clinic of Oral Surgery, Dental Clinical Center St.Pantelejmon, Skopje, [4]Faculty of Dentistry – European University; PHO "UDCC Ph.D. Bojo Andreski', Skopje, [5]Resident at Department of Microbiology and Parasitology, Ss. Cyril and Methodius University in Skopje, Faculty of Dentistry - Skopje, Republic of North Macedonia,

Abstract

Introduction: Most dental procedures require local anesthesia. Today, a variety of commercially available anesthetics are used in dental practice. One of the reasons science is constantly striving to improve these chemicals in terms of their effectiveness and safety is that an ideal local anesthetic has yet to be discovered. Articaine 4% solution is one of the newer amide anesthetics with an ester bond. Its popularity among dentists is growing rapidly, despite the fact that its the effectiveness and safety in comparison to other anesthetics is still unproven according to some authors. **The aim** of this paper is to summarize the current knowledge about articaine and to compare its potency, efficacy, and safety in use. **Material and method:** Existing works were researched using PubMed as our main source, as well as Web of Science and Google Scholar. We used the following keywords to search for the effectiveness and potency of articaine: "articaine and (comparative or compare or efficacy or potency)"; this yielded 145 results from papers published in the last 5 years. For the safety analysis, keywords were: "articaine and (safety or safe or toxic or toxicity or paresthesia or dysesthesia)", and 75 results were found from publications in the last 10 years. Our research also includes clinical trials and reviews from Google Scholar that do not have specific keywords and time frames. **Results:** The efficacy and safety of using 4% articaine are satisfactory, according to the summarized information from the existing literature. In comparison to other local anesthetics, articaine is a superior anesthetic. Its metabolic and pharmacokinetic properties improve performance in terms of anesthesia effectiveness, and duration, which is especially important in elderly and medically compromised patients. **Conclusion:** Articaine is widely used in surgical and non-surgical dental procedures, as well as in dental surgery, and its use has been extensively researched. Every clinician is free to use articaine or another local anesthetic, based on their own personal preference and experiences, as well as the most recent updates on articaine safety, potency and efficacy presented in this review. **Key words:** articaine, anesthesia, safety, potency, efficacy

Апстракт

Вовед: Локалната анестезија е неодвоива од најголем број од стоматолошките процедури. Во денешно време постојат голем број на комерцијално достапни анестетици кои се користат во денталната пракса. Фактот дека сеуште не е пронајден идеален локален анестетик, е една од причините што науката постојано се залага за унапредување на овие хемикалии во смисла на нивна ефикасност но и безбедност во исто време. Артикаинот како 4% раствор е еден од поновите амидни анестетици кој во себе содржи и естерска врска. Неговата популарност забрзано расте кај стоматолозите, иако ефикасноста и безбедноста во споредба со другите анестетици е според некои автори сеуште недокажана. **Целта** на трудот е сумирање на досегашните сознанија во врска со артикаинот и неговите компаративни анализи во однос на потентноста, ефикасноста и безбедноста при користење. **Материјал и метод:** Истражување на постоечките трудови на PubMed, како наш главен извор, Web of Science и Google Scholar. При пребарување за ефикасноста и потентноста на артикаинот ги користаевме следниве клучни зборови: "articaine and (comparative or compare or efficacy or potency)"; што покажа вкупно 145 резултати од трудови објавени во последните 5 години. За анализа на безбедноста при користење клучни зборови беа: "articaine and (safety or safe or toxic or toxicity or paresthesia or dysesthesia)", со пронајдени 75 резултати од објавите во последните 10 години. Во нашето истражување земени се предвид и клинички студии од Google Scholar без посебни клучни зборови и временски рамки. **Резултати:** Според сумираните информации од постоечката литература, ефикасноста и безбедноста при употребата на 4% артикаин се на задоволително ниво. Во споредба со другите локални анестетици, артикаинот може да се смета за супериорен анестетик. Неговите метаболички и фармакокинетски својства даваат подобри перформанси во однос на ефективноста и времетраењето на анестезијата и се особено важни кога станува збор за постари и медицински компромитирани пациенти. **Заклучок:** Артикаинот е широко користен во хируршки и нехируршки стоматолошки процедури, а неговата употреба е опширно испитувана. Секој клиничар има право да избере дали да користи артикаин или друг локален анестетик, врз основа на неговите лични преференци и искуства како и на најновите ажурирања за безбедноста, моќта и ефикасноста на артикаинот претставени во овој преглед. **Клучни зборови:** артикаин, анестезија, безбедност, потентност, ефикасност.

Introduction

Local anesthesia is the foundation of pain management in dental procedures. If used properly, local anesthetics are one of the safest and most effective drugs for the management of perioperative and post-operative pain[1]. Local anesthetics are one of the most commonly used substances in dentistry. Pain relief makes the patient more comfortable,

allowing the dentist to concentrate and work more efficiently. The normal sensation returns after a short period of time[2] Local anesthetics have been used since 1860, when cocaine was discovered. The Production of Lignocaine/Lidocaine significantly improves the local anesthesia procedure and quickly becomes the gold standard, against which all other new local anesthetics are compared[1]. Etidocaine, Bupivacaine, Mepivacaine, Articaine and other drugs were later discovered. Rusching discovered Carticaine in 1969, and the name was changed to Articaine in 1976 in Germany[3]. Its use gradually spread throughout the world. North America and Canada in 19834, the United Kingdom in 1998, and the United States and Australia in 2000 and 2005. Articaine is the first and only local anesthetic designed specifically for use in dentistry. Articaine is classified as an amide local anesthetic, but it has chemical properties of both the amide and ester groups. Wherever it has been made available, it has become an extremely popular local anesthetic. It was the second most commonly used local anesthetic in the United States (after lidocaine) in 2014[5]. Articaine is used by 70% of dentists in Australia[6]. Articaine was used by 97% of dental professionals in Germany in 2012[7] Articaine's use is rapidly increasing as it becomes one of the world's most popular local anesthetics[8].

The main benefits of articaine are its pharmacological properties. Its molecular structure contains an ester group, making it the only local anesthetic with both amide and ester groups, allowing the drug to be metabolized by plasma esterase and by microsomal enzymes in the liver. Numerous studies have been conducted since its discovery to compare articaine with various anesthetic agents.

Aim

The aim of this paper is to summarize current knowledge about articaine and to compare its potency efficacy, and safety in use. In everyday practice, summarizing this information can help you choose a local anesthetic.

Material and methods

To achieve our goal, we reviewed existing papers in the PubMed medical database, as our main source, as well as Web of Science, and Google Scholar search which cover a broader range of publications and provide easier access to full text documents. For each section of our research, we used a different search query. To compare the potency and efficacy of articaine with other local anesthetics we used the following search query: "articaine and (comparative or compare or efficacy or potency)", which yielded 145 results, with the only filter applied: "in the last 5 years". We searched for "articaine and (safety or safe or toxic or toxicity or paresthesia or dysesthesia)" to assess the safety of using articaine in our practice. We discovered 75 paper by, searching for studies published in the last 10 years. In our research on Google Scholar and other databases, there was no specific search query or time period.

Results and discussion

Potency and efficacy of articaine

Local anesthetics relieve pain by interfering with the propagation of peripheral nerve impulses,thereby inhibiting the generation and the conduction of action potentials. When the nerve membrane is at its normal resting potential, local anesthetics have no effect on it.

Articaine binds to the α-subunit of the sodium channels, preventing nerve conduction. As a result of the sodium influx not reaching the threshold potential, nerve conduction ceases. The action of binding with sodium channels to block conduction is state dependent, with the highest affinity for the open state, intermediate for the inactivated state, and lowest affinity for the resting state[9].

The diameter of the nerve has a significant impact on the degree of neuronal block. Fibers with larger diameter (usually for pressure, touch, motor) require higher anesthetic concentrations than small, myelinated fibers (pain conduction)[10].

The efficacy and potency of local anesthetics are affected by several factors, including fiber type and size, ion balance, myelination, vasoconstrictor or vasodilator properties (vascular uptake), pH (lower pH causes greater ionization, which reduces efficacy), frequency of nerve stimulation, electrolyte concentration (hypercalcemia and hypokalemia can reduce nerve block), and other factors that are not directly related to the chemical composition of the anesthetic solution but to the overall condition of the organism, anatomical and morphological properties or the use or non-use of a vasoconstrictor with the anesthetic solution. Lipid solubility, protein binding affinity and vasodilator activity are the main factors that affect the potency and efficacy of local anesthetics and are dependent on their chemical structure and are frequently used to compare different local anesthetics. The lipid solubility of the molecules determines their ability to penetrate the nerve membranes[11].

The potency of local anesthetics is affected by lipid solubility. Because 90% of the membrane is lipid, increasing lipid solubility allows the anesthetic to penetrate the nerve membrane more easily[11]. Articaine has a different chemical structure than all other amide local

anesthetics.. It is based on thiophene. So, its molecule contains thiophene ring rather than a benzene ring, which is a structural component of other anesthetics. As a result, the molecule is more lipid soluble and can easily pass through lipid barriers, such as the nerve membrane[12].

Duration is affected by protein binding. When the protein binding ability is increased, the cations of the anesthetic can become more firmly attached to the proteins at the receptor sites, extending the duration of action. Articaine has remarkable ability to bind proteins. Vasodilator activity has a significant impact on the potency and duration of local anesthetics. When vasodilator activity is high, blood flow to a region increases, anesthetic molecules are quickly removed from the injection site. This is the cause of decreased anesthetic potency and duration. If both lidocaine and articaine are used without vasoconstrictor, they would be ineffective and more toxic because of their vasodilator activity. Adrenaline, a vasoconstrictor, is added to increase both the duration and safety.

According to some early studies, the potency of analgesia or relative analgesic potency of articaine is intermediate whencompared to lidocaine[13-15].

The high efficacy might be one of the main reasons why articaine became so popular in many countries. Dentists who use articaine for local anesthesia claim that they rarely miss with the IANB (inferior alveolar nerve block), and that maxillary buccal infiltration often is sufficient for extraction of a molar, because of articaine's excellent bone penetration properties. Many dentists from around the world report about the excellent efficacy of articaine, based on their clinical practice and experience. They claim that articaine works better and faster, that they do not miss as many times and can easily numb patients when other anesthetics fail[16,17].

However, the research findings concerning the reported advantage of 4% articaine over other anesthetics (often compared to 2% lignocaine) appear to be conflicting. In a clinical trial, it is difficult to demonstrate statistically significant superiority (evidence-based medicine) of 4% articaine over any other amide local anesthetic[16,17].

The methods used to compare two or more substances, such as articaine and lidocaine, are a critical issue. To obtain statistically significant data, we need a sample size with a sufficient number of subjects. It is possible that some studies cannot show significant differences because of this issue. That could be one of the reasons why articaine in several studies is slightly more effective than lidocaine, but the difference is not statistically significant.

Normally, the next step is to find literature support for some of these clinical findings. In one study, conducted by Malamed et al. (2001), they compared the efficacy of 2% lidocaine and 4 % articaine with adrenaline 1:100 000[18]. Articaine was injected in 882 subjects, and lidocaine in 443. For the determination of the efficacy a visual analog scale was used (VAS). There were no significant differences[18]. Similar findings were obtained by Vehetalo & al.[19].

Other studies also compared articaine to different anesthetics, such as the one conducted by Haas et al[20], who compared articaine with adrenaline 1:200 000 to prilocaine with same adrenaline concentration. The aim of their study was to test the claims that labial injection of articaine is enough to provide anesthesia for mandibular teeth (pulpal anesthesia) as well as lingual and palatal soft tissue. The determination was made by measuring sensation to electrical stimulation at the teeth, lingual and labial soft tissue for canines and second molars. There were no statistically significant differences[20].

On the other hand, in contrast to previously mentioned studies, Ruprecht & al. (1991) demonstrated the superiority of articaine by comparing equimolar concentrations of lidocaine and articaine, demonstrating significantly longer duration of pulpal anesthesia, regardless of the vasoconstrictor content[21].

An older study conducted by Winther & Nathalang (1972) found that articaine was significantly superior to lidocaine in terms of extent, frequency, and duration of analgesia[22]. Concentration of adrenaline is another critical issue. According to Tofoli & al. (2003), the anesthetic effects gained by 4% articaine with 1:100 000 or 1:200 000 adrenaline used for inferior alveolar nerve blocks are the same[23]. As a result, 1:200 000 is the recommended adrenaline concentration of local anesthetics for dental procedures (Jacob 1989)[24], with the exception of some other procedures (e.g., surgical interventions) that require larger degree of hemostasis. In these cases, according to some authors, the recommended adrenaline concentration is 1:50 000 (Buckley & al. 1984) or 1:80 000 as used in Scandinavia[25]. However, 4% articaine and 2% lignocaine both with 1:100 000 adrenaline demonstrated similar properties when used in surgery and a good tolerance and safety profile[26].

Articaine with adrenaline (1:100 000), used for buccal infiltration of mandibular molars, showed a higher success rate than lignocaine with same adrenaline concentration[27,28], but failed to anaesthetize teeth with irreversible pulpitis[29]. Comparable efficacy was demonstrated using 4% articaine with 1:100,000 adrenaline and 2% lignocaine with 1:100,000 adrenaline for intra-ligamentary injections[30]. In the attempt to anesthetize mandibular teeth with irreversible pulpitis using inferior alveolar nerve block injection, articaine and lidocaine had similar effects[31-33].

Some studies concluded that 4% articaine outperforms 2% lidocaine in terms of latency and duration of the local anesthetic effect, but did not show significant differences in anaesthetic efficacy[34]. Similar results were found when the success of inferior alveolar nerve blocks were compared. So, in case of inferior alveolar nerve block, articaine and lignocaine performed similarly[35]. In comparison to lidocaine infiltration, articaine infiltration produced a faster onset and longer duration of pulpal anaesthesia[36]. Supplemental vestibular (buccal) infiltration with articaine in an attempt to anesthetize mandibular molars with irreversible pulpitis, was more effective than lignocaine[37], which could be due to a concentration effect or the greater ability of articaine to diffuse through the bone.When their efficacy in maxillary buccal infiltrations in patients with irreversible pulpitis was compared, articaine had a statistically significant advantage over lidocaine[38]. This high success of articaine injections may be due to the higher lipid solubility and more molecules/ml injected when compared with lignocaine[39]. When used for periodontal surgery, 4% articaine mixed with 1:100 000 or 1:200 000 adrenaline provides excellent surgical pain control[40].

In a systematic review, articaine was found to be more effective than lignocaine, in providing local anesthesia in the first molar region, with similar adverse effects[41,42]. The conclusion of another meta-analysis study was that articaine had a higher probability of achieving local anaesthetic success than lignocaine[43], especially for infiltration, with an odds ratio of 3.81 (95 % CI, 2.71-5.36; P<0.00001), and although weaker, but still significant, for mandibular block anesthesia, with an odds ratio of 1.57 (95% CI, 1.12-2.21; P =0.009)[43].

Clinical trials comparing articaine to other local anesthetics have varied in study design and site of action comparing articaine with lidocaine in most of the cases, with lidocaine being known as the current standard for comparing all new local anesthetics[44]. In his report, Cowan revealed satisfactory clinical properties of articaine, but also a variable onset time and poor predictability for profound anaesthesia[45]. Maxillary teeth anesthesia has yielded varying results; articaine may have a significantly shorter latency and longer duration of anesthesia of the pulp than lignocaine in posterior teeth36 but not in anterior teeth[46]. Articaine showed better properties in maxillary lateral incisors than lidocaine but not in maxillary first molar[47]. There were no significant differences between articaine and prilocaine in anaesthetic duration and onset time[48], nor in the ability of these local anesthetics to induce pulpal anesthesia, buccal or palatal tissue anaesthesia in maxillary second molars[49] or canines.

No significant difference was found in the anesthetic success rate in some trials where articaine and prilocaine were used for mandibular buccal infiltrations comparing pulpal, buccal or lingual anesthesia for mandibular canines or second molars[49], or when buccal injections were compared to buccal and lingual injection of articaine in mandibular first molars. Articaine buccal infiltrations have significantly higher anaesthetic success rates than lidocaine in lower first molars[50,51], premolars and molars and in the mental nerve block for mandibular premolars, canines and lateral incisors[52] .

There were no significant differences in the ability of articaine and lignocaine to achieve pulpal anaesthesia when a periodontal ligament injection was used in mandibular first molars[49]. If we want to provide a pulpal anesthesia for mandibular teeth, we usually use the inferior alveolar nerve block, but in 15 to 20% of the cases, adequate anesthesia is not provided. Lignocaine and Articaine had comparable success rates when used for inferior alveolar nerve block[53].

An additional buccal injection of articaine adjacent to a mandibular molar after an inferior alveolar nerve block has been shown to have a significantly higher success rate than lidocaine in mandibular posterior[54] and anterior teeth[55]. Some reports concluded that there is no significant increase of the effect of anesthesia of mandibular teeth when lignocaine is injected as a supplemental buccal or lingual infiltration[56] or mylohyoid nerve block after an inferior alveolar nerve block[57]. In one study, articaine was used for an inferior alveolar nerve block and buccal infiltration, both injections showed similar success rates in providing pulpal anesthesia for mandibular first molar; however, the buccal infiltration had a faster latency[58].

If articaine is used to extract impacted mandibular third molars, the period of postoperative anesthesia and duration of analgetic effects is significantly longer than when mepivacaine[59] and lignocaine are used. Articaine provided comparable duration of postoperative analgesia to bupivacaine[60], but had a significantly shorter duration and latency of soft tissue anesthesia.

When maxillary teeth must be extracted, palatal injection may not be necessary if articaine is injected in a buccal infiltration[61-63]. It is possible that most of the impacted maxillary third molar extractions can be performed without palatal anesthesia if articaine is used as the anesthetic of choice[64]. These results back up the findings of Badcock et al.[65]. They used lignocaine for buccal and placebo saline for palatal infiltrations in the extraction of maxillary third molars. The conclusion is that when lignocaine is infiltrated buccaly, a palatal injection may not be necessary. On the other hand, when the palatal diffusion of articaine in the maxillary first premolar and molar region was evaluated in clinical and magnetic resonance imaging study, there was no evidence of anesthesia following needle prick stimulation or articaine in the palatal tissues[66].

Safety

If we want to put a new local anesthetic on the market, it must go through various testing procedures such as in vitro studies, testing on animals and clinical testing. Some local anesthetics, such as lidocaine, are well known and their effects and side effects are documented. Articaine, on the other hand, is not as old as lidocaine, although it has been used for 30 years in some European countries.

The possibility of intravascular injection of local anesthetic in oral cavity is not so remote because of high vascularization in this area. The symptoms and signs of toxicity are commonly associated with the cardiovascular system and CNS. CNS intoxication causes disorientation, dizziness, anxiety, visual and auditory signs, muscular tremor etc. According to some studies, intravascular injection of lidocaine causes CNS toxicity more frequently and to a greater extent than articaine[67]. Other concluded that intravascular injection of 80mg 4% articaine (one cartridge) causes no signs of toxicity in healthy patients, which is confirmed by LD50, 37mg/kg for articaine and 33.2 mg/kg for lidocaine[68]. LD50 denotes lethal dose for 50% of the defined population.

Articaine has very low immunogenic potential. The frequency of allergic-type reactions is comparable to that of lidocaine, although there are several factors that alter the predictability such as age, genetics, frequency, and route of administration, etc.[69]

Patients that might be allergic to articaine may also be allergic to lidocaine or other amide local anesthetics. In the formulation of articaine, there is a vasoconstrictor preservative, sodium metabisulphite, which may cause allergic reactions in patients with sulphite sensitivity, such as some people with allergic-type asthma[18]. It is claimed that both articaine and prilocaine can cause methemoglobinemia. This type of side effect is very unlikely, when used in dental practice. No cases of methemoglobinemia have been reported when anesthetics are used at the recommended dosages[12]. Earlier formulations of articaine and other local anesthetics contained a bacteriostatic, antifungal and antioxidant preservative for the local anesthetic itself, called methylparaben, which is allergenic. It was part of articaine until the mid-1990`s.

All anaesthetics have the potential to be dangerous, causing different adverse effects such as symptoms of dizziness, disorientation, tremors, convulsions, seizures, and cardiac and respiratory depression[70,71]. Articaine might be one of the safer anaesthetics because of its rapid metabolism into an inactive metabolite, lowering the risk of systemic complications, even after repeated injection.

Some early studies on articaine from 100 injections in 211 paediatric patients reported no toxix reactions[72] and lower adverse events when compared to lidocaine. Some studies reported different adverse reactions to articaine such as ophthalmologic complications, hypersensitivity, chills and arthralgia, ischemic skin necrosis and fever[73-76]. Based on four retrospective reports, there is some controversy regarding the safety of using articaine, in non-surgical dental procedures with an inferior alveolar nerve block, in which articaine has a higher incidence of paraesthesia[77-80]. Articaine is the local anesthetic most commonly associated with paraesthesia (34–60%), the majority of cases involved the lingual nerve (71–93%) and no nerves in the maxilla were affected[77-80]. Prior to the release of articaine in the United States, similar studies revealed that the lingual nerve was mostly involved with similar incidence of involvement (71–83%) and lignocaine as the most commonly used local anesthetic (67%)[81,82]. Some later studies contradicted these early findings, with lignocaine still being the most used local anesthetic (35%), than articaine and prilocaine (30% each)[83]. However, according to one retrospective study from 2010, 4% solutions of local anesthetics (articaine and prilocaine) were more associated with cases of paraesthesia than local anesthetics with a lower concentration. Only one case of paraesthesia was linked to a Gow-Gates[8], with the rest being linked to an inferior alveolar nerve block.

Studies that have documented paresthesia after inferior alveolar nerve block included only non-surgical procedures, except for one, which included one simple dental extraction and another in which 64% of their sample were cases with unknown procedural details. When the methodology of data recruitment is not carefully examined and referral after paresthesia is not compulsory, then the collected data cannot be considered a representative sample, because this has the potential for underreporting, which certainly exists and can change the distribution and incidence of nerves affected and local anesthetic agents used.

Paresthesia as a complication of non-surgical dental procedures is extremely rare and its mechanism is unknown; however, there are few theories regarding susceptibility of the lingual nerve damage: direct needle trauma, local anesthetic toxicity, intraneural hematoma formation, and the fascicular pattern[85]. Incidences of lingual nerve damage caused by mandibular block anesthesia for non-surgical dental procedures have been reported to be between 0.15%[86] and 0.54%[87] and gross estimations of the incidence of paresthesia after inferior alveolar nerve block administration for non-surgical procedures range from 1:26,762 to 1:785,000, assuming that half of all injections involve inferior alveolar nerve injections[77].

There is only one report in the literature of maxillary paresthesia after articaine injection, following an extraction[88], and one report of maxillary non-surgical paresthesia, with lignocaine and mepivacaine[89]. According to the available literature, it is evident that paresthesia is an extremely rare occurrence that occurs regardless of the local anesthetic.

Most of the non-surgical paresthesia cases affect the lingual nerve after inferior alveolar nerve block. According to some reports, the concentration of the local anesthetic is more closely related to complications such as paresthesia than the anesthetic agent itself[90]. Although there have been some in vitro animal studies linking increased anesthetic concentration and neurotoxicity[91], this still does not explain the preferentially involvement of the lingual nerve. There is no scientific evidence to support the claim that articaine is more associated with paraesthesia than the other anesthetics[92,93] and there is still no clear causal relationship in the literature between anesthetic agent and paresthesia[94].

All of the studies that suggest that using articaine has an increased risk of neurotoxicity are retrospective and biased in data recruitment, lack high level evidence and consequently are unsuitable for strong recommendations[95]. In order to prove claims of increased paresthesia, the current incidence of paresthesia associated with other anesthetics needs to be clearly established and further studies are needed to demonstrate a notable increase in paresthesia associated with articaine. These claims should be randomized controlled trials that will contribute to the highest level of evidence, and their design can maximize control over the environment while providing convincing causal relationship[96]. According to Gaffen and Haas, it would take an unrealistically large trial to detect statistically significant differences for an event as rare as nonsurgical paresthesia and in reference to the current data on randomized controlled trials using articaine, they advocate that no conclusions regarding permanent paraesthesia should be drawn from these particular studies. To date there has only been one randomized controlled trial comparing articaine to other local anesthetics that has reported adverse outcomes. The comparation of 4% Articaine and 2% Lidocaine for various types of dental procedures, with respective samples of 882 and 443, did not offer any association of articaine with an increased risk of paresthesia. Considering this evidence, as well as efficacy studies comparing inferior alveolar nerve blocks of articaine with other local anesthetics in sound teeth and teeth with irreversible pulpitis[97,98], the literature demonstrates that there is neither clinical advantage nor higher risk of paresthesia when using articaine instead of lignocaine for inferior alveolar nerve block. Therefore, there is no scientific evidence from the current available literature demonstrating that articaine as a 4% solution is neurotoxic or unsafe to use in any aspect of clinical dentistry.

Articaine has been widely used in non-surgical dental procedures and dental surgery since aroud 1977, and its use has been extensively researched. In the clinical trials, articaine is usually compared with lidocaine. All these studies have varied in terms of study design and site of action. There are many controversial data regarding the association of articaine with neurotoxicity like paresthesia or prolonged numbness after dental procedures. Based on an excellent review of the dental literature, the authors[99], concluded that articaine is a safe and effective local anesthetic in all aspects of clinical dentistry for all patients of various ages, with suitable properties, comparable to other common local anesthetics. Although there could be some controversy about its safety and advantages over other local anesthetics, there is no convincing evidence demonstrating the connection with neurotoxicity or some significantly superior anesthetic properties of articaine over the other local anesthetic drugs for surgical or non-surgical dental procedures. Currently, articaine is available as a 4% solution containing 1:100,000 or 1:200,000 epinephrine. Although clinical trials have not found significant advantage of 4% anesthetic solutions (like articaine) over the other (2%) local anesthetics100, the number of dental practitioners who use 4% articaine is growing, and they feel more comfortable practicing dentistry with this local anesthetic where “chances of failing are lower”. It might be due to its superior diffusion through bony tissue or grater bone penetration. Its higher lipid solubility accelerates diffusion through the nerve membranes, resulting in faster anesthetic effect. Because articaine is hydrolyzed into the blood plasma by the action of nonspecific cholinesterase, it is the preferred anesthetic of choice in patients with impaired liver function. Its metabolic product, articainic acid, is inactive and systemic toxicity has never been observed.

Conclusion

According to the summarized information from the existing literature, it can be concluded that the efficacy and safety of using 4% articaine are at a satisfactory level. Articaine has superior diffusion through bony tissue (grater bone penetration) and greater lipid solubility that accelerates diffusion through the nerve membranes, resulting in faster anesthetic effect. Articaine is hydrolyzed into the blood plasma by the action of nonspecific cholinesterase and is a preffered anesthetic of choice in patients with impared liver function. The presence of an ester group makes articaine much less toxic

and thus an anesthetic of choice in patients with advanced age and chronic diseases. Every clinician is free to use articaine or another local anesthetic, based on their own personal preference, experiences and data from this review.

Reference

1. https://www.oralhealthgroup.com/features/1003919408/
2. Hopman, A. & Baart, J. & Brand, H.. (2017). Articaine and neurotoxicity – a review. British Dental Journal. 223. 10.1038/sj.bdj.2017.782.
3. Muschaweck R, Rippel R. Ein neues Lokalanasthetikum (Carticain) aus der Thiophenreihe [A new local anaesthetic (carticaine) in the thiophene series]. Prakt Anaesth 9(3):135-146, 1974
4. Lemay H; Albert G; Helie P; Dufour L; Gagnon P; Payant L; Laliberte R. Ultracaine en dentisterie operatoire conventionnelle. [Ultracaine in conventional operative dentistry]. J Can Dent As soc. 50(9):703-708, 1984
5. Dental local anesthetic market share, United States, Calendar year–2014, 23 April 2015. Septodont Inc. Lancaster, PA
6. Yapp KE; Hopcraft MS; Parashos P. Dentists' perceptions of a new local anaesthetic drug-articaine. Aust Dent J. 57(1):18-22; quiz 109, 2012
7. Deutcher Dentalmarkt Jahresbericht (DDM) 2010 (German Dental Market Annual Report 2010). GfK HealthCare, Nuremberg, Germany
8. Vree TB; Gielen MJ. Clinical pharmacology and the use of articaine for local and regional anaesthesia. Best Pract Res Clin Anaesthesiol. 19(2):293-308, 2005
9. Wang GK, Calderon J, Jaw SJ, Wang SY. State-dependent block of Na+ channels by articaine via the local anesthetic receptor. J Membr Biol. 2009;229:1–9.
10. Buckenmaier CC, Bleckner LL. Anaesthetic agents for advanced regional anaesthesia: a North American perspective. Drugs. 2005;65:745–759.
11. Malamed SF. Handbook of local anaesthesia. 4th ed. St. Louis, Mosby; 1997.
12. Isen DA. Articaine: Pharmacology and clinical use of a recently approved local anesthetic. Dent Today 2000;19:72-77.
13. Vähätalo K, Antila H, Lehtinen R. Articaine and lidocaine for maxillary infiltration anesthesia. Anesth Prog. 1993;40:114–116.
14. Kaukinen S, Eerola R, Eerola M, Kaukinen L. Comparison of carticaine and lidocaine in spinal anaesthesia. Ann Clin Res. 1978;10:191–194.
15. Syed, Gufaran & Mulay, Sanjyot. (2014). Articaine vs Lidocaine: A review. IOSR Journal of Dental and Medical Sciences. 13. 40-44.
16. Malamed SF. Local anesthetics: dentistry's most important drugs, clinical update 2006. J Calif Dent Assoc [Internet]. 2006;34(12):971-6.
17. Moodley, DS. (2017). Local anaesthetics in dentistry - Part 2: Choice of local anaesthetic agent. South African Dental Journal , 72(3), 128-130.
18. Malamed S F, Gagnon S, Leblanc D. Articaine hydrochloride: a study of the safety of a new amide local anesthetic. J Am Dent Assoc 2001;132:177-184.
19. Vähätalo K, Antila H, Lehtinen R. Articaine and lidocaine for maxillary infiltration anesthesia. Anesth Prog 1993;40:114-116.
20. Haas DA, Harper DG, Saso MA, Young ER. Comparison of articaine and prilocaine anesthesia by infiltration in maxillary and mandibular arches. Anesth Prog 1990;37:230-237.
21. Ruprecht S, Knoll-Køhler E. Vergleichende Untersuchung äquimolarer Lösungen von Lidocain und Articain zur Anästhesie. Schweiz Monatsschr Zahnmed 1991;101:1286-1290.
22. Winther JE, Nathalang B. Effectivity of a new local analgesic Hoe 40 045. Scand J Dent Res. 1972;80:272-278.
23. Tofoli GR, Ramacciato JC, de Oliviera PC, Volpato MC, Groppo FC, Ranali J. Comparison of effectiveness of 4 % articaine associated with 1:100 000 or 1:200 000 epinephrine in inferior alveolar nerve block. Anesth Prog 2003;50:164-168.
24. Jacob W. Local anaesthesia and vasoconstrictive additional components. Newslett Int Fed Dent Anesthesiol Soc 1989;2:1-3.
25. Buckley JA, Ciancio SG, McMullen JA. Efficacy of epinephrine concentration in local aneshesia during periodontal surgery. J Periodontol 1984;55:653-657.
26. Martínez-Rodríguez N, Barona-Dorado C, Martin-Ares M, Cortes-Breton-Brinkman J, Martinez-Gonzallez J-M. Evaluation of the anaesthetic properties and tolerance of 1:100,000 articaine versus 1:100,000 lidocaine. A comparative study in surgery of the lower third molar. Med Oral Patol Oral Cir Bucal. 2012;17(2):345-51.
27. Robertson D, Nusstein J, Reader A, Beck M, McCartney M. The anesthetic efficacy of articaine in buccal infiltration of mandibular posterior teeth. J Am Dent Assoc. 2007;138(8):1104-12.
28. Balto K. Administration of articaine anesthesia may lead to superior profound pulpal anesthesia compared with lidocaine in adult patients. Journal of Evidence-Based Dental Practice. 2011;11:183-4.
29. Ashraf H, Kazem M, Dianat O, Noghrehkar F. Efficacy of articaine versus lidocaine in block and infiltration anesthesia administered in teeth with irreversible pulpitis: A prospective, randomized, double-blind study. J Endod. 2013;39(1):6-10.
30. Berlin J, Nusstein J, Reader A, Beck M, Weaver J. Efficacy of articaine and lidocaine in a primary intraligamentary injection administered with a computer-controlled local anesthetic de livery system. Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology. 2005;99(3):361-6.
31. Bigby J, Reader A, Nusstein J, Beck M. Anesthetic efficacy of lidocaine / meperidine for inferior alveolar nerve blocks in patients with irreversible pulpitis. J Endod. 2007;33:1-4.
32. Argueta-Figueroa L, Arzate-Sosa G, Mendieta-Zeron H. Anesthetic efficacy of articaine for inferior alveolar nerve blocks in patients with symptomatic versus asymptomatic irreversible pulpitis. Gen Dent. 2012;60(1):e39-43.
33. Claffey E, Reader A, Nusstein J, Beck M. Anesthetic efficacy of articaine for inferior alveolar nerve blocks in patients with irreversible pulpitis. J Endod. 2004;30(8):568-71.
34. Sierra Rebolledo A, Delgado Molina E, Berini Aytís L, Gay Escoda C. Comparative study of the anesthetic efficacy of 4% articaine versus 2% lidocaine in inferior alveolar nerve block during surgical extraction of impacted lower third molars. Med Oral Patol Oral Cir Bucal. 2007;12(2) e139-44
35. Corbett IP, Kanaa MD, Whitworth JM, Meechan JG. Articaine infiltration for anesthesia of mandibular first molars. J Endod. 2008;34(5):514-8.
36. Costa CG, Tortamano IP, Rocha RG, Francischone CE, Tortamano N. Onset and duration periods of articaine and lidocaine on maxillary infiltration. J Prosthet Dent. 2005;94(4):381.
37. Rogers BS, Botero TM, McDonald NJ, Gardner RJ, Peters MC. Efficacy of articaine versus lidocaine as a supplemental buccal infiltration in mandibular molars with irreversible pulpitis: A prospective, randomized, double-blind study. J Endod. 2014;40(6):753-8.
38. Srinivasan N, Kavitha M, Loganathan CS, Padmini G. Com parison of anesthetic efficacy of 4% articaine and 2% lidocaine for maxillary buccal infiltration in patients with irreversible pulpitis. Oral Surgery, Oral Med Oral Pathol Oral Radiol Endodontology. 2009;107(1):133-6.
39. Becker DE, Reed KL. Essentials of Local Anesthetic Pharmacology. Anesth Prog. 2006;53:98-109.

40. Moore P, Doll B, Delie R, Hersh E, Korostoff J, Johnson S, et al. Hemostatic and anesthetic efficacy of 4% articaine HCl with 1:200,000 epinephrine and 4% articaine HCl with 1:100,000 epinephrine when administered intraorally for periodontal surgery. J Periodontol [Internet]. 2007;78(2):247-53. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17274713
41. Katyal V. The efficacy and safety of articaine versus lignocaine in dental treatments: A meta-analysis. J Dent. 2010; 38(4):307-17.
42. Powell V. Articaine is superior to lidocaine in providing pulpal anesthesia. J Am Dent Assoc. 2012;143(8):897-8.
43. Brandt RG, Anderson PF, Mcdonald NJ, Sohn W, Peters MC. The pulpal anesthetic efficacy of articaine versus lidocaine in dentistry A meta-analysis. J Am Dent Assoc. 2011;142:493-504
44. Malamed S F. Handbook of local anesthesia. 5th ed. p 71. St Louis: Mosby, 2004.
45. Cowan A. Clinical assessment of a new local anesthetic agent-carticaine. Oral Surg Oral Med Oral Pathol 1977; 43: 174–180.
46. Oliveira P C, Volpato M C, Ramacciato J C, Ranali J . Articaine and lignocaine efficiency in infiltration anaesthesia: a pilot study. Br Dent J 2004; 197: 45–46.
47. Evans G, Nusstein J, Drum M, Reader A, Beck M . A prospective, randomized, double-blind comparison of articaine and lidocaine for maxillary infiltrations. J Endod 2008; 34; 389–393.
48. Donaldson D, James-Perdok L, Craig B J, Derkson G D, Richardson A S . A comparison of Ultracaine DS (Articaine HCl) and Citanest forte (Prilocaine HCl) in maxillary infiltration and mandibular nerve block. J Can Dent Assoc 1987; 53: 38–42.
49. Haas D A, Harper D G, Saso M A, Young E R . Lack of differential effect by Ultracaine (articaine) and Citanest (prilocaine) in infiltration anaesthesia. J Can Dent Assoc 1991; 57; 217–223.
50. Kanaa M D, Whitworth J M, Corbett I P, Meechan J G . Articaine and lidocaine mandibular buccal infiltration anesthesia: a prospective randomized double-blind cross-over study. J Endod 2006; 32: 296–298.
51. Abdulwahab M, Boynes S, Moore P et al. The efficacy of six local anesthetic formulations used for posterior mandibular buccal infiltration anesthesia. J Am Dent Assoc 2009; 140: 1018–1024.
52. Batista da Silva C, Aranha Berto L, Cristina Volpato M et al. Anesthetic efficacy of articaine and lidocaine for incisive/mental nerve block. J Endod 2010; 36; 438–441.
53. Mikesell P, Nusstein J, Reader A, Beck M, Weaver J . A comparison of articaine and lidocaine for inferior alveolar nerve blocks. J Endod 2005; 31: 265–270.
54. Haase A, Reader A, Nusstein J, Beck M, Drum M . Comparing anesthetic efficacy of articaine versus lidocaine as a supplemental buccal infiltration of the mandibular first molar after an inferior alveolar nerve block. J Am Dent Assoc 2008; 139; 1228–1235.
55. Kanaa M D, Whitworth J M, Corbett I P, Meechan J G . Articaine buccal infiltration enhances the effectiveness of lidocaine inferior alveolar nerve block. Int Endod J 2009; 42: 238–246.
56. Foster W, Drum M, Reader A, Beck M . Anesthetic efficacy of buccal and lingual infiltrations of lidocaine following an inferior alveolar nerve block in mandibular posterior teeth. Anesth Prog 2007; 54: 163–169.
57. Clark S, Reader A, Beck M, Meyers W J . Anesthetic efficacy of the mylohyoid nerve block and combination inferior alveolar nerve block/mylohyoid nerve block. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999; 87; 557–563.
58. Jung I Y, Kim J H, Kim E S, Lee C Y, Lee S J . An evaluation of buccal infiltrations and inferior alveolar nerve blocks in pulpal anesthesia for mandibular first molars. J Endod 2008; 34: 11–13.
59. Colombini B L, Modena K C, Calvo A M et al. Articaine and mepivacaine efficacy in postoperative analgesia for lower third molar removal: a double-blind, randomized, crossover study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006; 102: 169–174.
60. Gregorio L V, Giglio F P, Sakai V T et al. A comparison of the clinical anesthetic efficacy of 4% articaine and 0.5% bupivacaine (both with 1:200,000 epinephrine) for lower third molar removal. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008; 106: 19–28.
61. Uckan S, Dayangac E, Araz K . Is permanent maxillary tooth removal without palatal injection possible? Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006; 102; 733–735.
62 Uckan S, Dayangac E, Araz K . Erratum to 'Is permanent maxillary tooth removal without palatal injection possible? Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007; 103: 580.
63. Fan S, Chen W L, Yang Z H, Huang Z Q . Comparison of the efficiencies of permanent maxillary tooth removal performed with single buccal infiltration versus routine buccal and palatal injection. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009; 107: 359–363.
64. Lima-Júnior J L, Dias-Ribeiro E, de Araújo T N et al. Evaluation of the buccal vestibule-palatal diffusion of 4% articaine hydrochloride in impacted maxillary third molar extractions. Med Oral Patol Oral Cir Bucal 2009; 14: E129–132.
65. Badcock M E, Gordon I, McCullough M J . A blinded randomized controlled trial comparing lignocaine and placebo administration to the palate for removal of maxillary third molars. Int J Oral Maxillofac Surg 2007; 36: 1177–1182.
66. Ozeç I, Tasdemir U, Gümüs C, Solak O . Is it possible to anesthetize palatal tissues with buccal 4% articaine injection? J Oral Maxillofac Surg 2010; 68: 1032–1037.
67. Oertel R, Rahn R, Kirch W. Clinical pharmacokinetics of articaine. Clin Pharmacokinet 1997;33:417 -425.
68. Borchard U. Vergleichende pharmacologie der lokalanaesthetica und spezielle pharmakologie von Carticain. Anasthesiol Intensivmed 1978;113:7-11.
69. Maccoll S, Young ER. An allergic reaction following injection of local anesthetic: A case report. J Can Dent 1989;55:981-984.
70. Strichartz GR, Ritchie JM. The action of local anesthetics on ion channels of excitable tissues. Handbook of Experimental Pharmacology, Vol.81. Berlin, Springer-Verlag, 1987.
71. Oertel R, Ebert U, Rahn R, Kirch W . The effect of age on pharmacokinetics of the local anesthetic drug articaine. Reg Anesth Pain Med 1999; 24: 524–528.
72. Wright G Z, Weinberger S J, Marti R, Plotzke O . The effectiveness of infiltration anesthesia in the mandibular primary molar region. Pediatr Dent 1991; 13: 278–283.
73. Magliocca K R, Kessel N C, Cortright G W . Transient diplopia following maxillary local anesthetic injection. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006; 101: 730–733.
74. Kocer B, Ergan S, Nazliel B . Isolated abducens nerve palsy following mandibular block articaine anesthesia, a first manifestation of multiple sclerosis: a case report. Quintessence Int 2009; 40; 251–256.
75. Torrente-Castells E, Gargallo-Albiol J, Rodríguez-Baeza A, Berini-Aytés L, Gay-Escoda C. Necrosis of the skin of the chin: a possible complication of inferior alveolar nerve block injection. J Am Dent Assoc 2008; 139: 1625–1630.
76. Petitpain N, Goffinet L, Cosserat F, Trechot P, Cuny J F . Recurrent fever, chills, and arthralgia with local anesthetics containing epinephrine-metabisulfite. J Clin Anesth 2008; 20: 154.
77. Haas D A, Lennon D . A 21 year retrospective study of reports of paresthesia following local anesthetic administration. J Can Dent Assoc 1995; 61; 319–330.
78. Hillerup S, Jensen R . Nerve injury caused by mandibular block analgesia. Int J Oral Maxillofac Surg 2006; 35: 437–443.
79. Gaffen A S, Haas D A . Retrospective review of voluntary reports of nonsurgical paresthesia in dentistry. J Can Dent Assoc 2009; 75: 579.
80. Garisto G A, Gaffen A S, Lawrence H P, Tenenbaum H C, Haas D

A . Occurrence of paresthesia after dental local anesthetic administration in the United States. J Am Dent Assoc 2010; 141: 836–844.
81. Pogrel M A, Bryan J, Regezi J . Nerve damage associated with inferior alveolar nerve blocks. J Am Dent Assoc 1995; 126; 1150–1155.
82. Pogrel M A, Thamby S . Permanent nerve involvement resulting from inferior alveolar nerve blocks. J Am Dent Assoc 2000; 131: 901–907.
83. Pogrel M A. Permanent nerve damage from inferior alveolar nerve blocks – an update to include articaine. J Calif Dent Assoc 2007; 35; 271–273.
84.- Gow-Gates G A. Mandibular conduction anesthesia: a new technique using extraoral landmarks. Oral Surg Oral Med Oral Pathol 1973; 36: 321–328.
85. Pogrel M A, Schmidt B L, Sambajon V, Jordan R C . Lingual nerve damage due to inferior alveolar nerve blocks: a possible explanation. J Am Dent Assoc 2003; 134; 195–199.
86. Krafft T C, Hickel R . Clinical investigation into the incidence of direct damage to the lingual nerve caused by local anaesthesia. J Craniomaxillofac Surg 1994; 22; 294–296.
87. Harn S D, Durham T M . Incidence of lingual nerve trauma and postinjection complications in conventional mandibular block anesthesia. J Am Dent Assoc 1990; 121; 519–523.
88. Bernsen P L. Peripheral facial nerve paralysis after local upper dental anaesthesia. Eur Neurol 1993; 33: 90–91.
89. Nusstein J, Burns Y, Reader A, Beck M, Weaver J . Injection pain and postinjection pain of the palatal-anterior superior alveolar injection, administered with the Wand Plus system, comparing 2% lidocaine with 1:100,000 epinephrine to 3% mepivacaine. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004; 97; 164–172.
90. Haas D A. Articaine and paresthesia: epidemiological studies. J Am Coll Dent 2006; 73: 5–10.
91. Cornelius C P, Roser M, Wietholter H, Wolburg H . Nerve injection injuries due to local anaesthetics. Experimental work. J Cranio Maxillofac Surg 2000; 28(Suppl 3); 134–135.
92. Malamed S F. Nerve injury caused by mandibular block analgesia. Int J Oral Maxillofac Surg 2006; 35: 876–877, author reply 878.
93. Malamed S F. Articaine versus lidocaine: the author responds. J Calif Dent Assoc 2007; 35; 383–385.
94. Missika P, Khoury G . Paresthesia and local infiltration or block anesthesia. L'Information Dentaire 2005; 87: 2731–2736.
95. Shekelle P G, Woolf S H, Eccles M, Grimshaw J . Clinical guidelines: developing guidelines. BMJ 1999; 318: 593–596.
96. Sathorn C, Parashos P . Questions and answers in evidence-based patient care. Br Dent J 2007; 203: 309–319.
97. Tortamano I P, Siviero M, Costa C G, Buscariolo I A, Armonia P L . A comparison of the anesthetic efficacy of articaine and lidocaine in patients with irreversible pulpitis. J Endod 2009; 35: 165–168.
98. Maniglia-Ferreira C, Almeida-Gomes F, Carvalho-Sousa B et al. Clinical evaluation of the use of three anesthetics in endodontics. Acta Odontol Latinoam 2009; 22: 21–26.
99. Yapp KE, Hopcraft MS, Parashos P. Articaine: a review of the literature. Br Dent J. 2011;210:323–329.
100. Hintze A, Paessler L. Comparative investigations on the efficacy of articaine 4% (epinephrine 1:200,000) and articaine 2% (epinephrine 1:200,000) in local infiltration anaesthesia in dentistry – a randomised double-blind study. Clin Oral Investig. 2006;10:145–150.

UDK: 616.314–77

EVALUATION OF THE MARGINAL FIT IN FIXED PROSTHODONTICS

ПРОЦЕНКА НА МАРГИНАЛНОТО УПАСУВАЊЕ ВО ФИКСНАТА ПРОТЕТИКАТА

Mijoska A.[1]*, Jovanovski S.[1], Pancevska S.[1], Bajraktarova Valjakova E.[1], Jurukovska Sotarovska V.[1], Dastevski B.[1], Petkov M.[1], Naumovski B.[1], Srbinoska D.[2], Trpevska V.[2]

[1]Department of prosthodontics, Ss. Cyril and Methodius University in Skopje, Faculty of Dentistry - Skopje, Republic of North Macedonia,
[2]Department of orthodontics, Ss. Cyril and Methodius University in Skopje, Faculty of Dentistry - Skopje, Republic of North Macedonia,

Abstract

The marginal gap space is frequently responsible for prosthodontic restoration loss, due to specific demineralization process by micro-leakage and bacteria colonization. The aim of the in-vitro study was to evaluate the width of the marginal gap in porcelain fused to metal (PFM) crowns. A light-body silicone was used to measure the marginal gap between the abutment tooth and crown in order to evaluate absolute discrepancy with the replica technique (RT). Twenty PFM crowns were fabricated on premolar die marginal discrepancies ranging from 61.5 to 75.0 microns, mean vertical discrepancies ranging from 22.9 - 46.0 micron and mean horizontal discrepancies ranging from 42.0 to 58.8 micron. Based on selection of 100 microns as limit of clinical acceptability, restoration margins were presented with minimal risk for caries occurrence, and the prostheses demonstrated acceptable marginal adaptation. **Key words:** Secondary caries, abutment, marginal gap.

Апстракт

Маргиналниот простор честопати е одговорен за пропаѓање и загуба на протетската реставрација поради специфичноста на процесот на деминерализација од пропусливоста на коронката и бактериската колонизација. Целта на оваа ин-витро студија беше да се направи проценка на ширината на маргиналниот простор кај метал-керамички коронки. Маргиналниот простор се измери со реплика методата за евалуација на апсолутното растојание со употреба на течна силиконска маса. 20 метал-керамички коронки се изработија на премоларно трупче, а резултатите покажаа средни вредности на просторот 61.5-75.0 микрони, средно вертикално растојание 22.9-46.0 микрони и средно хоризонтално растојание 42.0-58.8 микрони. Според прифатените вредности во студијата на 100 микрони, маргиналните простори преставуваат минимален ризик за појава на кариес, а реставрациите се со прифатлива маргинална адаптација. **Клучни зборови:** секундарен кариес, абатмент, маргинален простор.

Introduction

In fixed prosthodontics, the evaluation of the "marginal gap" is defined as the measurement of the space or internal surface between the casting and the axial wall of the abutment tooth in the margin region[1]. The marginal gap or fit is acceptable when the crown lies or fits well in most various points on the abutment and it presents important factor for prosthetic restoration longevity and clinical success[2,3]. Deficiency in the marginal fit can sometimes cause inflammation of the tooth and the surrounding periodontal tissues as well as the appearance of secondary caries below the crown margin[4]. Dental cements serve to fill the interim space while also fixating and isolating the abutment[5]. However, even if the recommended manufacturing process is followed, the appearance of the marginal discrepancies is unavoidable. Wider marginal gaps cause cement dissolution and washing, saliva propagation, plaque accumulation and secondary caries[6]. The materials and techniques used to make dental crowns, as well as the patient's behavioral and dietary changes, all play a role in reducing or increasing caries risks[7,8].

There is a wide range of data on clinically acceptable width of the marginal gap. Some authors consider acceptable gap to be between 30μm and 200μm, while other clinical studies have found much higher values of the gaps ranging between 70μm and 647μm, but there is no defined or accepted reference value on clinically accepted marginal gap[9,10]. There are also various approaches available in the evaluation and assessment methods used for measuring the marginal gap[11,12]. The problem of determining crown fit under in vivo conditions has yet to be solved[13]. In the patient's mouth, the fit can only be evaluated by subjective methods by an experienced doctor using

visual examination, dental explorers, x-rays etc[14]. In Kerschbaum study, there were no significant differences between the visual examination and the use of the explorer,, whereas in another study radiographically margin discrepancies less than 80µm were difficult to detect[15,16]. Several other methods are presented for evaluation of the marginal gap, including the cross-sectional method (CSM), triple scan method (TSM), micro-computed tomography (MCT), optical coherence tomography (OCT), silicone replica technique (SRT) and others, each with advantages and disadvantages. Although some previous studies have examined the significance of the various assessment methods, comparing them was difficult due to the differences in the experimental condition in each study[17].

The silicone replica technique (SRT) has been widely used for evaluating of the marginal and internal fitting because of its ability to measure the condition of a dental prosthesis without causing any damage. However, due to morphological variations such as rounded margins, the location and number of the several measurement points must sometimes be predetermined.

The aim of this in-vitro study was to compare the marginal gap and fit on the abutment teeth to subjective evaluation using the direct-sight technique.

Material and methods

A light-body silicone was used to measure the marginal gap and fit between the abutment tooth and crown in order to evaluate absolute discrepancy with the silicone replica technique (SRT). It evaluates the thickness of the impression material, as a result of the cementation space of the crowns over copings. Ten anatomical premolar abutments (dies) with dimensions 6.5 mm of height, axial walls 6º tapered and chamfer finish line were made of type IV dental stone as master models (Figure 1). There was no use of die spacing. The models were then sent to the dental laboratory, where 20 porcelain fused to metal crowns (Ni-Cr-Mo alloy, Ugirex III) were fabricated on the premolars casts. They were fabricated conventionally with the wax technique, invested and casted. The investment was removed from the framework and cleaned with 110 µm aluminum oxide sandblasting. Finally the veneering porcelain was manually applied to the frameworks and sintered according to manufacturer's recommendations.

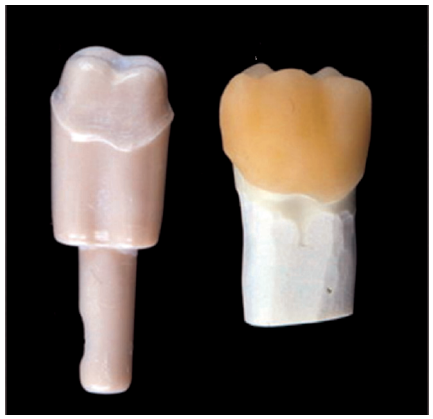


Figure 1. *Premolar stone abutment as master model*

Following that,, the light body polyvinylsiloxane addition silicone impression material (base and catalizator) was mixed with activator and used to fill the discrepancies, or the space between the crowns and abutment teeth, according to manufacturer's recommendations (Figure 2).

Figure 2. *Light body addition silicone immersion material*

The silicone impression material film was used to simulate the position and thickness of the cement layer in order to determine the width of the existing "marginal gap" (Figure 3).

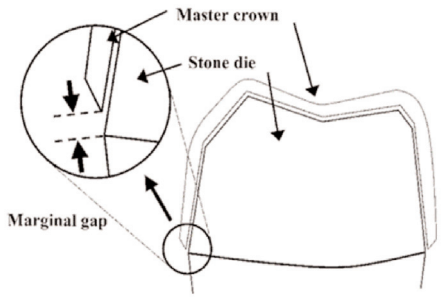


Figure 3. *Marginal gap – schematic presentation*

After the impression material had been set, it was removedfrom the die in one piece (Figure 4.) and the thickness of the layer was measured and evaluated using the direct-sight technique and a microscope at ×4.6 magnification. Each silicon impression film was cut in two

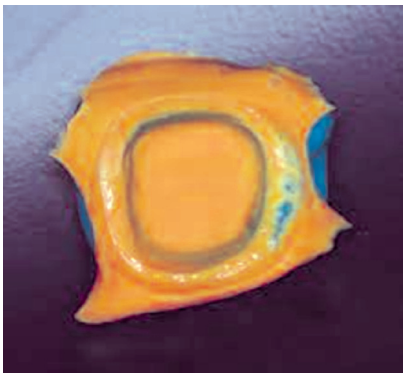


Figure 4. *Silicone impression film after setting and removing from the coping*

directions (buccolingually and mesiodistally) and evaluated at three pre-determined sites. Internal adaptation or the film thickness was measured as the distance between the inner surface of the crown and the outer surface of the prepared tooth at three location points (marginal, occlusal and axial). The fitting of the marginal surface was measured as the distance between the finish surface angle of the prepared tooth and the cervical margin of the crowns.

Results

Statistical analysis was performed using SPSS 11.0 software for Windows. The measurements of the internal fit in the marginal point in crowns revealed mean marginal discrepancies ranging between 61.5 and 75.0 μm. The results of the occlusal points measurements showed mean marginal gaps ranging from 40.9 to 45.3 μm. The results of the axial points measurements indicate vertical discrepancies ranging from 22.9 to 46.0 μm. The measurements in the occlusal points showed mean horizontal discrepancies in the range of 42.0 to 58.8 μm.

Table 1. Mean values of the marginal discrepancy in three measuring points

Measuring Points / 20 crowns	Marginal discrepancy (mean value)
marginal	68.2 μm
occlusal	43.1 μm
axial	34.4 μm

In this study, the largest gaps (mean value) were found at the marginal area 68.2 μm, the internal values showed smallest axial gap 34.4 μm, and the mean occlusal gaps 43.1 μm.

Discussion

In the field of fixed prosthodontics, the best treatment approach has traditionally consisted of a conventional impression technique for the stone casts and fabrication of a porcelain-fused-to-metal restoration. This protocol is regarded as the clinical gold standard for replicating the intraoral situation. In the modern era of digitalization, traditional dentistry and prosthesis have been questioned for their accuracy and precision, and comparative analysis is very common[18]. However, regardless of the manufacturing process, the primary goal of every prosthdontist is to achieve the smallest or acceptable marginal gap value of the restoration[19]. A well-fitting restoration needs to be accurate along its margins as well as its internal surface[20].

Various values and locations on the abutment tooth are usually defined as marginal gap (MG) and marginal discrepancy (MD). Some authors suggested using the term absolute marginal discrepancy (AMD) or the largest measurement of margin space at measurement points[21]. They consider absolute marginal discrepancy to be the most important because it considers both horizontal and vertical directions. AMD is defined as the linear distance between the finish line of the preparation and the margin of the restoration. According to some studies, the maximum opening should not exceed 100 μm, while another study reported that 100 - 200 μm is the clinically acceptable range for long-term success of dental prostheses[22]. In order to obtain accurate and correct values, the number of the measurement points in In-vitro studies must be predetermined and should not be less than 50[23]. In our study, we measured the crown/abutment gaps in our study according to the recommendations.

However, several studies for evaluation of the marginal and internal fit of the crowns using various methods and materials have been published, but there is no standardized measurement methodology and the results obtained from different techniques vary significantly. The replica technique has some limitations as well, such as possibility of tearing the elastomeric film while removing it from the abutment, or errors in cutting and sectioning that may result in higher measurement values.

A few variables control and affect the dimensional changes that occur in the interim spaces between the die and the final casting. It is usually the result of multiple errors during the clinical and laboratory stages of crown fabrication. The preparations of the tooth geometry, finish line type, impression methods, and cementation technique and cement thickness are responsible for the creation of the clinical gap space[25]. The axial gap values from our study were slightly lower than those of some previous studies[26].

When compared to the accepted parameters, the gap in chamfer area of premolar substructure in our study was in the range of 61.5 to 75.0 μm, which is slightly less than the recommended value of 100 μm, and the crowns demonstrated acceptable values of the marginal fit.

The gap space is a determining factor for the long-term integration and failure of a restoration[27,28]. It is critical for tooth and periodontal health to reduce marginal and internal fit inaccuracies. Several techniques, such as overwaxing the margin of wax pattern, removing wax from internal surface of wax pattern, die relief with the application of a die spacer, internal relief of cast restoration by sandblasting, mechanical milling, acid etching, electro-chemical milling, and so on, were presented by various authors.[29,30].

Conclusion

Within the scope of this study, the conventional method of wax pattern fabrication produced copings with good marginal and internal fit, and demonstrated a comparable and acceptable marginal, axial and occlusal fit, all of which were within the range of clinically accepted values.

Within the limitations of this study, it is possible to conclude that the SRT is an accurate and reliable technique for simulating crown gap space after the cementation. The RT is a reliable method for evaluating cement thickness at the marginal and internal gaps.

Reference

1. Boeckler AF., Stadler A., Setz J. The Significance of Marginal Gap and Overextension Measurement in the Evaluation of the Fit of Complete Crowns. The Journal of Contemporary Dental Practice. 2005; 6 (4): 1-12.
2. Bader J, Rozier R, McFall W, et al. Effect of crown margins on periodontal conditions in regulary attending patients. J Prosthet Dent 1991; 65:75.
3. Geurtsen W. The margin of crowns and fillings. Dtsch Zahnaerztl Z. 1990; 45: 380.
4. Felton D, Kenoy B, Bayne S, et al. Effect of in vivo crown margin discrepancies on periodontal health. J Prosthet Dent 1991; 65: 357-364.
5. Young Park J, S Bae, J Lee, Kim J, Kim H, Kim H. Evaluation of the marginal and internal gaps of three different dental prostheses: comparison of the silicone replica technique and three dimensional superimposition analysis. J Adv Prosthodont. 2017; 9: 159-69.
6. Zeynep A, Bicer Y, Unver S. Etiology of Secondary Caries in Prosthodontic Treatments. Dental Caries - Diagnosis, Prevention and Management. IntechOpen, September 2018
7. Paes Leme AF, Koo H, Bellato CM, Bedi G, Cury JA. The role of sucrose in cariogenic dental biofilm formation--new insight. J Dent Res. 2006; 85(10):878-887.
8. Rosen H. Dissolution of cement, root caries, fracture, and retrofit of post and cores. J Prosthet Dent. 1998; 80 (4): 511-3.
9. Kerschbaum T, Porschen C. Marginal gap and quality of cast crowns from five dental laboratories. Deutsch Zahnaerzt.1998; 53: 620-623.
10. K. J. Anusavice, Kunjan Kakar, N. Ferree. Which mechanical and physical testing methods are relevant for predicting the clinical performance of ceramic-based dental prostheses? Clinical oral implant research. 2007; 18 (3): 218-231.
11. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications in fixed prosthodontics. J Prosthet Dent. 2003; 90(1):31-41.
12. Zoellner A, Heuermann M,Weber HP, Gaengler P: Secondary caries in crowned teeth: correlation of clinical and radiographic findings. J Prosthet Dent 2002; 88:314–319.
13. Dedmon HW: Disparity in expert opinions on size of acceptable margin openings. Oper Dent 1982; 7: 97-101
14. Holmes JR, Bayne SC, Holland GA, et al. Considerations in measurement of marginal fit. J Prosthet Dent 1989; 62: 405- 408.
15. Kerschbaum T, Faber F. Marginal fit of crowns from foreign countries. Zahnaerztl Mitt 2001; 91: 44-46.
16. McLean J, von Frauenhofer J. The estimation of cement film thickness by an in vivo technique. Br Dent J 1971; 131: 107-111.
17. Boitelle P, Tapie L, Mawussi B, Fromentin O. Evaluation of the marginal fit of CAD-CAM zirconia copings: Comparison of 2D and 3D measurement methods. J. Prosthet. Dent. 2018, 119, 75–81.
18. Paul N, Raghavendra Swamy KN, Dhakshaini MR, Sowmya S, Ravi MB. Marginal and internal fit evaluation of conventional metal-ceramic versus zirconia CAD/CAM crowns. J Clin Exp Dent. 2020; 12(1): 31-37.
19. Bronson MR, Lindquist TJ, Dawson DV. Clinical acceptability of crown margins versus marginal gaps as determined by pre-doctoral students and prosthodontists. J Prosthodont. 2005; 14(4): 226-32.
20. Quante K, Ludwig K, Kern M. Marginal and internal fit of metal-ceramic crowns fabricated with a new laser melting technology. Dent Mater 2008; 24:1311-5.
21. J. Robert Holmes, Stephen C. Bayne, Gene A. Holland, William D. Sulik, Considerations in measurement of marginal fit, The Journal of Prosthetic Dentistry. 1989; 62 (4): 405-408,
22. Laurent, M.; Scheer, P.; Dejou, J.; Laborde, G. Clinical evaluation of the marginal fit of cast crowns-validation of the silicone replica method. J. Oral Rehabil. 2008, 35, 116–122.
23. Rahme HY, Tehini GE, Adib SM, Ardo AS, Rifai KT. In vitro evaluation of the "replica technique" in the measurement of the fit of Procera crowns. J Contemp Dent Pract. 2008; 9 (2):25-32.
24. Jadhav VD, Motwani BK, Shinde J, Adhapure P. Comparative Evaluation of Conventional and Accelerated Castings on Marginal Fit and Surface Roughness. Contemp Clin Dent. 2017; 8(3):405-410.
25. Cenci MS, Pereira-Cenci T, Cury JA, Cate J. Relationship between gap size and dentine secondary caries formation assessed in a microcosm biofilm model. Caries Res 2009; 43(2):97–102
26. Hasanzade M, Aminikhah M, Afrashtehfar KI, Alikhasi M. Marginal and internal adaptation of single crowns and fixed dental prostheses by using digital and conventional workflows: A systematic review and meta-analysis. J Prosthet Dent. 2021; 126(3):360-368.
27. Askar, H., Krois, J., Göstemeyer, G. et al. Secondary caries: what is it, and how it can be controlled, detected, and managed?. Clin Oral Invest 24, 1869–1876 (2020).
28. Freifrau von Maltzahn N, Bernhard F, Kohorst P. Fitting accuracy of ceramic veneered Co-Cr crowns produced by different manufacturing processes. J Adv Prosthodont. 2020; 12(2): 100-106.
29. Molin M, Karlsson S. The fit of gold inlays and three ceramic inlay systems. A clinical and in vitro study. Acta Odontol Scand. 1993; 51(4):201-6.
30. Beuer F, Aggstaller H, Edelhoff D, Gernet W, Sorensen J. Marginal and internal fits of fixed dental prostheses zirconia retainers. Dent Mater. 2009; 25: 94–102.

UDK: 616.314.17–008.1–089–022.7

BACTERIAL ACCUMULATION ON DIFFERENT TYPES OF SUTURING MATERIALS IN PERIODONTAL SURGERY AND IMPLANTOLOGY - LITERATURE REVIEW

БАКТЕРИСКА АКУМУЛАЦИЈА НА РАЗЛИЧНИ ВИДОВИ НА МАТЕРИЈАЛИ ЗА СУТУРИРАЊЕ ВО ПАРОДОНТАЛНАТА ХИРУРГИЈА И ИМПЛАНТОЛОГИЈА – ПРЕГЛЕД НА ЛИТЕРАТУРА

Mitikj J.[1], Georgieva S.[2], Shushak Z.[3], Mitikj K.[2]

[1]PHI „Guda Dent“ Skopje, Republic of North Macedonia, [2]“Ss. Cyril and Methodius” University in Skopje, Faculty of Dentistry – Skopje, Republic of North Macedonia, [3]PHI “Dentoria-1 - Specialist practice for oral surgery and implantology” Ohrid, Republic of North Macedonia

Abstract

Suturing materials are artificial products used for intimate approximation of the wound margins, until they are capable of self-healing with the help of natural collagen fibers. The ideal suture material must have the following characteristics: strength, knot stability, flexibility, easy handling, minimal tissue response and resistance to infection. There is a wide range of suturing materials and they are used in both periodontal surgery and implantology. Today, the number of alternative products that are used as sutures has increased, as well as synthetically produced products. We mainly classify suturing materials as nonresorbable and resorbable. Furthermore, they can be subclassified as natural and synthetic as well as monofilament or multifilament materials. In this review paper we performed an electronic database search and tracked the inflammatory reactions of tissues when using different types of suturing materials. In the paper we have highlighted the more significant trends in new types of sutures. Tissue reactions vary depending on the surface of the materials and the bacterial adhesion to them. **Key words:** suturing materials, inflammation, bacterial accumulation, periodontal surgery, implantology.

Апстракт

Материјалите за сутурирање се артифициелни производи кои се користат со цел интимно прилепување на рабовите на раната, се додека истите не бидат оспособени за самостојно зараснување со помош на природните колагени влакна. Идеалниот материјал за сутура мора да ги поседува следните карактеристики: цврстина, стабилност на јазолот, флексибилност, лесна манипулација, минимална ткивна реакција и резистентност кон инфекциите. Постои широк спектар на материјали за сутурирање и истите се употребуваат како во пародонталната хирургија, така и во имплантологијата. Зголемен е бројот на алтернативните продукти кои денес се користат како сутури, а исто така и на синтетички произведените продукти. Главно, материјалите за сутурурање ги класифицираме како нересорптивни и ресорптивни. Понатаму, можат да бидат супкласифицирани на природни и синтетички, како и на монофиламентни или мултифиламентни материјали. Во овој ревијален труд извршивме електронско пребарување на базите на податоци и ги проследивме инфламаторните реакции на ткивата при користењето на различни типови на материјали за сутурирање. Во трудот ги нагласивме позначајните трендови кај новите типови на сутури. Реакциите на ткивата се разликуваат во зависност од површината на материјалите и бактериската атхезија кон истите. **Клучни зборови:** материјали за сутурирање, инфламација, бактериска акумулација, пародонтална хирургија, имплантологија.

Introduction

Suturing is the final part of a surgical intervention, used for closure of wound margins, bleeding control, and aims towards a primary wound healing[1]. The suture material is an artificial product used for intimate approximation of wound margins until they can hold sufficiently well by themselves by natural collagen fibers[2].

The first description of suture materials dates back to 3000 years BC, from ancient egyptian literature[3]. The suture materials used in that period included hemp, linen, fiber, grass, reed, and metal wires[4]. Many famous surgeons

such as Sushruta, Galen and Antyllus have described suturing techniques using primitive materials[5]. For centuries, the material of choice was catgut[6]. In the 1800s, Joseph Lister introduced the technique of sterilizing catgut, while in 1906 this technique has been finally perfected[7]. In the early 20th century, synthetic suturing materials were developed such as polyglycolic acid, polyglactin, and polypropylene[8].

The ideal suture material should have great strength, knot stability, flexibility, should be easy to manipulate, should cause minimal tissue reaction and be resistant to infections[9]. Commercially available materials are classified according to different criteria: three-dimensional structure (monofilament, multifilament), tissue stability (resorbable, non-resorbable) and origin of the material (natural, synthetic)[10]. Suturing materials are potential risk factors for wound infection obtained during periodontal surgery, and their success depends on the primary wound healing and the absence of bacteria at the healing site[11,12]. The bacterial accumulation is greater in the oral environment than in other tissue areas, due to differences in the quality of the tissues that are involved, the presence of the saliva, the high vascularity, the functions and the parafunctions[13]. The suture surface provides a conductive environment for growth of microorganisms on surgical sites[14]. The multifilament and the resorbable suturing materials produce a greater inflammatory response[15]. The monofilament materials reduce the number of bacteria, but are difficult to handle, and the patient's discomfort is increased[16].

The studies conducted by Varma et al., Elek and Cohen, Raju et al. specify that a certain number of microorganisms is necessary to cause infection in a clean surgical wound[17]. Kathju et al. in their papers suggest that contamination of sutures with biofilm during implantation requires eventual removal of the infected material[18,19]. It is recommended to monitor the wound healing for early identification of signs and symptoms associated with surgical complications[20]. Landry, Turnbull and Howley[21,22] proposed an index to determine the degree of recovery following a periodontal surgery. Bacterial plaque samples are taken from the sutures using a swab test and are cultured for further microbiological analysis[23]. Suture materials act as a risk factor for infections due to their ability to adhere pathogenic bacteria on the surface and are the focus of infections[24]. Reduction of postoperative bacterial accumulation is a very important segment in regenerative periodontal surgery in order to prevent soft tissue dehiscence and exfoliation of the membrane[25]. In mucogingival surgery, increased bacterial accumulation leads to postoperative gingival recession and aesthetically unacceptable results. The authors recommend using a minimum number of sutures to close the flap, as sutures and knots cause inflammation, and delay the healing of the wound[26].

In our paper we performed a search of available literature data using the following databases: PubMed/MEDLINE, Embase and Cohrane Library. The search was conducted electronically, and we used studies published in English. This review is conducted in accordance with the preferred reporting items for systematic reviews and the declaration standards for meta-analyzes (PRISMA) for systematic reviews.

Discussion

This review paper provides an overview of the most commonly used suture materials in both periodontal surgery and implantology, as well as differences in the bacterial accumulation of appropriate materials. 73 studies of a heterogeneous nature were included in the paper. Numerous suturing materials are available to be used during surgical interventions, but it is essential for periodontists to be aware of the nature of the material, the biological healing process and the interaction of the suturing material with the surrounding tissues.

NON-RESORBABLE SUTURING MATERIALS

Suturing materials that cannot be damaged by living tissues are called non-resorbable and are most commonly used in percutaneous wound closures.

Natural

Silk

The use of silk as a suture material began in 1890. It is a product of the larvae of silkworms[27]. Silk is a non-resorbable, natural, multifilament material that is preferred by many surgeons due to its easy handling, good strength and stability[28]. Wax or silicone coating help reduce friction and capillarity. It is classified as non-resorbable material because a complete degradation occurs after 2 years. They are widely accepted in the closure of mucosal wounds and ligation of blood vessels, because they are affordable[29,30]. Due to their multifilament nature, many species of microorganisms adhere to the suture material and cause inflammation[31]. The research of Selvig et al.[32] between silk and chromed catgut, have shown that bacterial invasion of sutures is a common outcome, but it is more pronounced in silk. However, silk has been the most commonly used natural suture material in the last 100 years[33]. Yaltiriki et al. studied the colonization of various microorganisms over natural materials and noticed that it was more significant in silk[34]. According to the researches by Vishaka et al., the use of silk will increase in the future as the trend changes from synthetic to natural threads to reduce environmen-

tal impacts. Besides that, the material is on its way to bioengineering[35].

Synthetic

Nylon (Polyamide)

Nylon is the first synthetic suturing material produced in 1940. It is available in monofilament and multifilament form and it is composed of long chains of aliphatic polymers of nylon 6[36]. It is characterized by minimal induction of cellular response and prolonged suture stiffness retention[37]. Nylon is extremely inert but elastic and has a biodegradation rate of 20% per year[38]. It is found as a monofilament and multifilament material, and the main disadvantage is the poor reliability of the knot and being more difficult to be manipulated. Several studies have shown that nylon suture gives the best biological results and the least inflammatory response[39,40,41]. Castelli et al. compared the tissue inflammatory response between silk, cotton, and nylon, and the results showed that nylon did not elicit any form of inflammatory response in oral tissues compared to other materials[41].

Polypropylene (Prolene)

Polypropylene was introduced as a suturing material in 1962[42]. It is a synthetic material available in monofilament form that causes a limited allergic reaction and does not adhere to tissues. However, it often results in formation of fistulas, pain, and palpable nodules, and the wound infection rate can be up to 24%[43,44]. The friction strength is higher than in other materials[42]. The manipulation of the material is easy and the knot is stable[45]. In their study, Selvi et al. examined the difference in healing between 4 suture materials, including silk, polypropylene, coated polyglactin 910, and polyglecaprone 25. They concluded that polypropylene was causing a significantly smaller inflammatory reaction in the tissues[46].

RESORBABLE SUTURING MATERIALS

Suturing materials are categorized as resorbable when they lose their hardness 60 days after suturing.

Natural

Catgut

These materials are derived from purified connective tissue (predominantly collagen) from the small intestine of sheep or cattle[47]. It is a monofilament material, absorbed through the mechanism of enzymatic digestion which leads to greater inflammation[48]. It is available in two forms: plain and chromed. Plain catgut is resorbed in 7 days, and the chromed one in a period of 20 to 40 days[49,50]. When catgut is used as a suture material, the risk of infection increases, due to which it has been banned in EU countries and Japan[51]. It is difficult to manipulate with poor knot stability when wet[52]. Clinical studies point to catgut as a material with a higher inflammatory response compared to other materials[53,34]. But Selvig et al.[54] in their study prove that bacterial invasion is greater in silk than in catgut. The results of a study by Fomete et al.[55] show that catgut is resorbed faster than indicated on the package due to enzymes and pH variations in the oral environment.

The use of catgut was highest in the 19th century. In 1868, Joseph Lister was the first to use a catgut coated with an antibacterial agent. Over time, the use of catgut became less popular due to the emergence of more modern synthetic resorbable materials on the market[56].

Synthetic

Polyglycolic acid (Dexon)

The first resorbable suturing materials were manufactured in the United States in 1962, and Dexon was introduced to the market in the late 1960s[57]. Polyglycolic acid (PGA) is a polymer of glycolic acid and it is a synthetic, resorbable, multifilament material[58]. PGA sutures have excellent strength and reduced tissue response. The resorption takes place through the mechanism of biodegradation[59]. On the seventh day it retains 60% of the firmness, 35% on the 14th day, and 5% on the 28th day. A complete resorption occurs within a period from 60 to 90 days. One clinical study showed that PGA sutures showed greater inflammation of the wounds than resorbable monofilament materials[60]. Lilli et al.[61] compared resorbable PGA materials with silk and catgut. The bacterial accumulation was higher in silk and PGA due to their multifilament nature. Modern resorbable synthetic sutures have the opposite effect, and researchers suggest that suture degradation products create an antimicrobial environment that stops the bacterial growth and transport[62].

Polyglactin 910 (Vicril)

Polyglactin 910 (Vicryl) consists of a copolymer of 90% glycolide and 10% l-lactide[63]. It is a resorbable, multifilament synthetic material, and its resorption occurs by hydrolysis[64]. It shows complete resorption between 56 and 70 days and loses 50% of its firmness after 3 weeks[65]. Vicryl Rapide is completely resorbed

after 42 days and loses strength after 14 days[66]. Gamma radiation alters the molecular structure of polyglactin 910 and increases the rate of resorption. Several studies have shown reduced bacterial adhesion to the suture material and improved wound healing with the use of Vicryl Plus antibacterial sutures (polyglactin 910 coated with triclosan)[67,68,69]. In their study, Storch et al.[70] did not show a significant difference in wound healing between the use of Vicryl and Vicryl Plus materials.

Poliglecaprone 25 (Monocryl)

Poliglecaprone 25 (monocryl) was introduced to the market in 1993. 20-30% of the firmness is retained 14 days after suturing, and complete hydrolysis occurs after 90 to 120 days[71]. In a study by Yilmaz et al.[72], proliglecaprone 25 showed positive effects in wound healing compared to other materials. An antibacterial form (Monocryl plus) is also available. Sala-Pérez et al, in their clinical study showed the antibacterial effect of Monocryl Plus sutures on the third day, but this effect was negligible 7 days after surgery[73].

Conclusion

The suturing materials used in periodontal surgery and implantology, despite the advances in science and technology, do not possess all the necessary features that lead to primary wound healing and good postoperative results. Despite the fact that the non-resorbable material "silk" shows poor results in clinical and paraclinical parameters, it still remains the most commonly used suturing material. Materials such as Nylon and Polypropylene are slowly but surely gaining ground for their use as non-resorbable materials, only their high price is a partial barrier to wider application. Catgut material is definitely out of use in periodontal surgical intervention, and in the resorptive range of suturing materials, Vicryl, Monocryl and Polyglycolic acid are the materials of choice that give solid and satisfactory results.

Reference

1. Sekhar A, Abdul Basheer S, NAIR A. (Microbiological evaluation of bacterial plaquein suture material used post-extraction. JCR. 2020; 7(19): 10164-10173.
2. Hassan H K. Dental Suturing Materials and Techniques. Glob J Oto 2017; 12(2): 555833.
3. Kavin T, etal. "Suturing Vs Non-Suturing Techniques in Oral Surgery –A Review ofLiterature". IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), 19(2), 2020, pp. 10-13.
4. Rose J, Tuma F. Sutures And Needles. [Updated 2020 Sep 5]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-.
5. Pillai CK, Sharma CP. Review paper: absorbable polymeric surgical sutures: chemistry, production, properties, biodegradability, and performance. J Biomater Appl. 2010 Nov;25(4):291-366.
6. D Mackenzie. The history of sutures. Med Hist 1973 Apr;17(2):158-168.
7. Worboys, Michael. (2013). JOseph Lister and the performance of antiseptic surgery. Notes and records of the Royal Society of London. 67. 199-209.10.1098/rsnr.2013.0028.
8. Schiappa, Jose & Van Hee, Robrecht. (2012). From Ants to Staples: History and Ideas Concerning Suturing Techniques. Acta chirurgica Belgica. 112. 395-402.
9. Açan, Ahmet & Hapa, Onur & Barber, F.. (2018). Mechanical Properties of Suture Materials. 10.1007/978-3-662-56108-9_3.
10. Etemadi A, Bitaraf T, Amini A, Goudarzi M, Nadafpour N. Bacterial Accumulation on TriclosanCoated and Silk Sutures After Dental Implant Surgery. J Res Dentomaxillofac Sci. 2019;4(3) :1-4
11. Asher R, Chacartchi T, Tandlich M, Shapira L, Polak D. Microbial accumulation on different suture materials following oral surgery: a randomized controlled study. Clin Oral Investig. 2019 Feb;23(2):559-65.
12. Karde PA, Sethi KS, Mahale SA, Mamajiwala AS, Kale AM, Joshi CP. Comparative evaluation of two antibacterial-coated resorbable sutures versus noncoated resorbable sutures in periodontal flap surgery: A clinico-microbiological study. J Indian Soc Periodontol 2019;23:220-5.
13. Banche G, Roana J, Mandras N, Amasio M, Gallesio C, Allizond V, et al. Microbial adherence on various intraoral suture materials in patients undergoing dental surgery. J Oral Maxillofac Surg 2007;65:1503–1507.
14. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Centers for disease control and prevention (CDC) hospital infection control practices advisory committee. Am J Infect Control 1999;27:97?132.
15. Minozzi F, Bollero P, Unfer V, Dolci A, Galli M. The sutures in dentistry. Eur Rev Med Pharmacol Sci. 2009 May-Jun;13(3):217-26.
16. Pons-Vicente O, López-Jiménez L, SánchezGarcés MA, Sala-Pérez S, Gay-Escoda C. A comparative study between two different suture materials in oral implantology. Clin Oral Implants Res. 2011 Mar;22(3):282-8.
17. Mahesh, L., Kumar, V. R., Jain, A., Shukla, S., Aragoneses, J. M., Martínez González, J. M., Fernández-Domínguez, M., & Calvo-Guirado, J. L. (2019). Bacterial Adherence Around Sutures of Different Material at Grafted Site: A Microbiological Analysis. Materials (Basel, Switzerland), 12(18), 2848.
18. Kathju, S.; Nistico, L.; Hall-Stoodley, L.; Post, J.C.; Ehrlich, G.D.; Stoodley, P. Chronic surgical site infection due to suture - associated polymicrobial biofilm. Surg. Infect. 2009, 10, 457–461.
19. Kathju, S.; Lask, L.A.; Nistico, L.; Colella, J.J.; Stoodley, P. Cutaneous fistula from gastric remnant resulting from chronic suture-associated biofilm infection. Obes. Surg. 2010, 20, 251–256.
20. PippiR. Post-Surgical Clinical Monitoring of Soft Tissue Wound Healing in Periodontal and Implant Surgery.Int. J. Med. Sci.2017; 14(8): 721-728.
21. Landry RG, Turnbull RS, Howley T. Effectiveness of benzydamyne HCl in the treatment of periodontal post-surgical patients. Res 1988;10:105-118.
22. Masse JF, Landry RG, Rochette C, et al. Effectiveness of soft laser treatment in periodontal surgery. Int Dent J 1993;43:121-127.
23. Shah M A, Shah B K, Dave D H, Shah S S. Comparative evaluation of microbial colony counts on sutures with and without use of periodontal pack: a split mouth, randomized controlled study. J Integr Health Sci 2013;1:90-4.

24. Singh, P. K., Narayan, S. J., Narayan, T., Yadalam, U., Raghava, V., & Singh, I. (2020). Microbial Adherence of three different suture materials in patients undergoing periodontal flap surgery. A clinical & microbiological study. UNIVERSITY JOURNAL OF DENTAL SCIENCES, 6(2): 282.
25. Selvig KA, Kersten BG, Chamberlain AD, Wikesjo UM, Nilveus RE. Regenerative surgery of intrabony periodontal defects using ePTFE barrier membranes: Scanning electron microscopic evaluation of retrieved membranes versus clinical healing. J Periodontol 1992;63:974978.
26. Velvart P, Peters CI. Soft tissue management in endodontic surgery. J Endod 2005;31:4 –16.
27. Silverstein LH, Kurtzman GM. A review of dental suturing for optimal soft -tissue management. Compend Contin Educat Dent (Jamesburg, NJ: 1995) 2005;26(3):163–166.
28. Baqain ZH, Moqbel WY, Sawair FA. Early dental implant failure: Risk factors. Br J Oral Maxillofac Surg 2012;50(3):239-243.
29. Jo YY, Kweon H, Kim DW, et al. Accelerated biodegradation of silk sutures through matrix metalloproteinase activation by incorporating 4-hexylresorcinol. Sci Rep. 2017;7:42441.
30. Gogoi D. et al.. Development of advanced antimicrobial and sterilized plasma polypropylene grafted muga (antheraea assama) silk as suture biomaterial. Biopolymers 101, 355–365 (2014).
31. Chen X, Hou D, Tang X, Wang L. J Mech Behav Biomed Mater. 2015 Oct; 50():160-70.
32. Selvig KA, Biagiotti GR, Leknes KN, et al. Oral tissue reactions to suture materials. Int J Periodont Res Dent 1998;18: 475-487.
33. Thilagavathi, G. and S. Viju. "Silk as a suture material." (2015).Advances in silk science and technology, 219-232.
34. Yaltirik M, Dedeoglu K, Bilgic B, Koray M, Ersev H, Issever H, et al. 2003. Comparison of four different suture materials in soft tissues of rats. Oral Dis., 9:284-286
35. G V, Vishaka & Rathore, Mahender & Muniyappa, Chandrashekharaiah & Nadaf, Hasansab & Sinha, R. (2019). Studies on Silk as a suture in medical science.
36. Kudur MH, Pai SB, Sripathi H, Prabhu S. Sutures and suturing techniques in skin closure. Indian J DermatolVenereol Leprol 2009;75:425-34.
37. Jamali H, Abuali M, Khalili MR. Clinical Outcomes of Silk versus Nylon Sutures for Suturing of Conjunctival Autograft in Pterygium Surgery. Middle East Afr J Ophthalmol. 2020;27(2):110-116.
38. Goel A. Surgical Sutures - A Review. Delhi JOphthalmol 2016;26:159-62.
39. R. S. Abi Rached, B. E. de Toledo, T. Okamoto et al., "Reactionof the human gingival tissue to different suture materials usedin periodontal surgery," Brazilian Dental Journal, vol. 2, no. 2,pp. 103–113, 1992.
40. Javed F, Al-Askar M, Almas K, Romanos GE, Al-Hezaimi K. Tissue reactions to various suture materials used in oral surgical interventions. ISRN Dent.
41. W. A. Castelli, C. F. Nasjleti, R. Diaz-Perez, and R. G. Caffesse, "Cheek mucosa response to silk, cotton, and nylon suture materials," Oral Surgery Oral Medicine and Oral Pathology, vol. 45, no. 2, pp. 186–189, 1978.
42. Gowtham K, Anandh B, Srinivasan K, Umar M. Suture Materials in Dental Surgeries: A Review. Ann SBV 2020;9(1): 30–32.
43. Aldhabaan S, Hudise J Y, Alqarny M, et al. (August 15, 2020) Catgut Versus Polypropylene Sutures for Transcolumellar Incision Closure in Open Rhinoplasty: A Retrospective Cohort Study.
44. Kiran Shankar H: A comparative study of outcome of the absorbable suture polydioxanone and non-absorbable suture polypropylene in laparotomy wound closure. Int J Res Med Sci. 2016, 4:2084-2088.
45. Seki M, Yamamoto S, Abe H, Fukuchi T. Modified ab externo method for introducing 2 polypropylene loops for scleral suture fixation of intraocular lenses. J Cataract Refract Surg 2013; 39:1291-6.
46. Selvi F, Cakarer S, Can T, et al. Effects of different suture materials on tissue healing. J IstanbUnivFac Dent. 2016;50(1):35-42.
47. Kudur MH, Pai SB, Sripathi H, Prabhu S. Sutures and suturing techniques in skin closure. Indian J DermatolVenereolLeprol 2009;75:425-34.
48. MacLean AB, MacLean SB. Suture materials and subsequent wound strength. J ObstetGynaecol. 2008;28(6):561-562.
49. Dennis C, Sethu S, Nayak S, Mohan L, Morsi Y, Manivasagam G. Suture materials—current and emerging trends. J Biomed Mater Res A 2016;104(6):1544–1559.
50. Sharma, Pramod. (2019). Superiority of absorbable synthetic sutures over catgut suture in obstretic and gynaecology sugeries: evidence based review.
51. Saraí C. Guadarrama-Reyes, Rogelio J. Scougall-Vilchis, Raúl A. Morales-Luckie, Víctor Sánchez-Mendieta and Rafael López-Castañares (March 15th 2018). Antimicrobial Effect of Silk and Catgut Suture Threads Coated with Biogenic Silver Nanoparticles, Silver Nanoparticles - Fabrication, Characterization and Applications, Khan Maaz, IntechOpen.
52. Tan, Rachel & BELL, RJW & DOWLING, BA & Dart, Andrew. (2003). Suture materials: composition and applications in vetern-ary wound repair. Australian Veterinary Journal. 81. 140 - 145. 10.1111/j.1751-0813.2003.tb11075.x.
53. Gazivoda D, et al. A clinical study on the influence of suturing material on oral woundhealing. Vojnosanit Pregl 2015; 72(9): 765–769.
54. Selvig KA, Biagiotti GR, Leknes KN, et al. Oral tissue reactions to suture materials. Int J Periodont Res Dent 1998;18: 475-487.
55. Fomete, Benjamin &Saheeb, Birch &Obiadazie, Athanasius. (2013). A prospective clinical evaluation of the longevity of resorbable sutures in oral surgical procedures. Nigerian journal of clinical practice. 16. 334-8. 10.4103/1119-3077.113457.
56. Gierek M, Kuśnierz K, Lampe P, Ochała G, Kurek J, Hekner B, Merkel K, Majewski J. Absorbable sutures in general surgery - review, available materials, and optimum choices. Pol PrzeglChir. 2018 Apr 30;90(2):34-37.
57. Mackenzie D . The History of Sutures. Med Hist 1973; 17: 158–168.
58. Khiste SV, Ranganath V, Nichani AS. Evaluation of tensile strength of surgical synthetic absorbable suture materials: an in vitro study. J Periodontal Implant Sci. 2013 Jun;43(3):130-5.
59. Moser JB, Lautenschlager EP, Horbal BJ. Mechanical properties of polyglycolic acid sutures in oral surgery. J Dent Res 1974;53:804-8.
60. Chunder A, Devjee J, Khedun SM, Moodley J, Esterhuizen T. A randomised controlled trial on suture materials for skin closure at caesarean section: Do wound infection rates differ? S Afr Med J. 2012;102(6 Pt2):374-376.
61. Lilly GE, Osbon DB, Hutchinson RA, HelfichRH.Clinical and bacteriological aspects of polyglycolicacid sutures. J Oral Surg1973;31:103–105.
62. Geiger, Dieter & Debus, Eike-Sebastian & Ziegler, Ulrich &Larena-Avellaneda, Axel & Frosch, Matthias &Thiede, Arnulf & Dietz, Ulrich. (2005). Capillary Activity of Surgical Sutures and Suture- Dependent Bacterial Transport: A Qualitative Study. Surgical infections. 6. 377-83. 10.1089/sur.2005.6.377.
63. Dixit, Asha & Nadkarni, Purnima & Shah, Viral & Patel, Bhavi&Turiya, Prakash & Thakkar, Ashokkumar. (2018). Evaluation of safety and efficacy of polyglactin 910 suture in surgical incision closure: clinical study protocol for a randomized controlled trial. International Journal of Clinical Trials. 5. 80. 10.18203/2349-3259.ijct20180135.
64. Valle LFC, Mar?ns EA, d'Acampora AJ, Kestering DM, Sakae TM, Russi RF. Estudoda força de ruptura do planomúsculo-

aponeuróco da parede abdominal apóssuturaempontosseparadoscomparandotrêspos deoscirúrgicoemratos Wistar. ACM ArqCatarin Med. 2007;36(1):51-8.
65. Biondo-Simões, Maria & Oda, Marian & Pasqual, Suzane& Robes, Rogério. (2018). Comparative study of polyglactin 910 and simple catgut in the formation of intraperitoneal adhesions. Acta CirurgicaBrasileira. 33. 102-109. 10.1590/s0102-865020180020000001.
66. Odijk, R., Hennipman, B., Rousian, M. et al. The MOVE-trial: Monocryl® vs. VicrylRapide™ for skin repair in mediolateral episiotomies: a randomized controlled trial. BMC Pregnancy Childbirth 17, 355 (2017).
67. Kruthi N, Rajasekhar G, Anuradha B, Krishna Prasad L (2014) Polyglactin 910 vs. Triclosan Coated Polyglactin 910 In Oral Surgery: AComparative In Vivo Study. Dentistry 4: 267.
68. Edmiston CE, Seabrook GR, Goheen MP, Krepel CJ, Johnson CP, Lewis BD, Brown KR, Towne JB. Bacterial adherence to surgical sutures: can antibacterial-coated sutures reduce the risk of microbial contamination? J Am Coll Surg. 2006 Oct;203(4):481-9.
69. Gomez Alonso A, Garcia-Criado FJ, Parreno- Manchado FC, Garcia-Sanchez JE, Garcia-Sanchez E, et al. (2007) Study of the efficacy of coated Vicryl plus antibacterial suture (coated polyglactin 910 suture with triclosan) in two animal models of general surgery. J Infect 54: 82-8.
70. Storch M, Perry LC, Davidson JM, Ward JJ. A 28-day study of the effect of Coated VICRYL* Plus Antibacterial Suture (coated polyglactin 910 suture with triclosan) on wound healing in guinea pig linear incisional skin wounds. Surg Infect (Larchmt). 2002;3 Suppl1:S89-98.
71. Okamoto T, Rosini KS, Miyahara GI, Gabrielli MF. Healing process of the gingival mucosa and dental alveolus following tooth extraction and suture with polyglycolic acid and polyglactin 910 threads. comparative histomorphologic study in rats. Braz Dent J 1994(1):35– 43.
72. Yilmaz N, Inal S, Muglali M, Guvenc¸ T, Bas¸ B. 2010. Effects of polyglecaprone 25, silk and catgut suture materials on oral mucosa wound healing in diabetic rats: an evaluation of nitric oxide dynamics. Med. Oral, PatologiaOral y CirugiaBucal., 15:e526–e530.
73. Sala-Pérez S, López-Ramírez M, Quinteros-Borgarello M, Valmaseda-Castellón E, Gay-Escoda C. Antibacterial suture vs silk for the surgical removal of impacted lower third molars. A randomized clinical study. Med Oral Patol Oral Cir Bucal. 2016 Jan 1;21(1):e95-102.

UDK: 616.314–089.23–053.5

CENTER OF OCCLUSION IN PATIENTS WITH DISTOOCCLUSION, ANGLE CLASS II DIVISION 1 AND ANGLE CLASS II DIVISION 2

ЦЕНТАР НА ОКЛУЗИЈА КАЈ ПАЦИЕНТИ СО ДИСТООКЛУЗИЈА ANGLE КЛАСА II 1 ОДДЕЛЕНИЕ И ANGLE КЛАСА II 2 ОДДЕЛЕНИЕ

Trpevska V.

Department of Orthodontics, University Dental Clinical Center „St.Panteleimon“, Skopje, Republic of North Macedonia

Abstract

Orthodontic malocclusions-distoocclusion, Angle Class II division 1 and Angle Class II division 2 are characterized by certain morphological, functional and aesthetic changes in the orofacial system that result in occlusal disharmony and morphologically and functionally unbalanced bite. We can conclude from the use the of the T-Scan III system in everyday orthodontic clinical practice, examinating the center of occlusion, that there is a positive correlation between morphological and functional occlusal parameters in 60 patients divided into two subgroups of the group.. We concluded that this patients have significant presence of occlusal interferences in the posterior area during mandibular excursions, as well as dislocation of center of occlusal force. **Key words:** orthodontics, occlusion, T-Scan III digital occlusal analyses, malocclusion, center of occlusion.

Апстракт

Ортодонтските малоклузии, втора класа според Angle или дистооклузија се карактеризираат со одредени морфолошки, функционални и естетски промени во орофацијалниот систем кои доведуваат до оклузална дисхармонија и морфолошки и функционално неурамнотежен загриз. Со помош на T-Scan III системот во секојдневната ортодонтска клиничка практика преку испитување на центарот на оклузија го утврдивме соодносот помеѓу морфолошките и функционалните оклузални карактеристики на мастикаторниот апарат и денталниот систем кај 60 испитаници со втора класа според Angle, поделени во две подгрупи. Заклучивме дека кај овие испитаници постои сигнификантно присуство на оклузални интерференции во постериорниот сегмент при мандибуларните движења и истите се карактеризираат со дислокација на центарот на оклузална сила. **Клучни зборови:** ортодонција, оклузија, T-Scan III дигитална оклузална анализа, малоклузија, центар на оклузија.

Introduction

Orthodontic malocclusions-distoocclusion, Angle Class II division 1 and Angle Class II division 2 are characterized by certain morphological, functional and aesthetic changes in the orofacial system that result in occlusal disharmony and morphologically and functionally unbalanced bite. The contacts of the antagonistic occlusal surfaces of the teeth are not in harmony, and there is the presence of interceptive or deflective contacts of the teeth during the eccentric excursions of the mandible[1-4]. These malocclusions are characterized by bilateral asymmetry of the occlusal contacts at maximal intercuspidation, non-simultaneity of the occluding contacts of the antagonistic teeth during eccentric mandibular movements, and dislocation of the center of occlusal force from the occlusal field to the mesial position. The time of occlusion and dislocation during occlusion and articulation is prolonged, and protrusive and balancing occlusal interferences are present[5-10]. We can conclude from the use of the T-Scan III system in everyday orthodontic clinical practice that there is a positive correlation between morphological and functional occlusal parameters between the two subgroups (division 1 and division 2) of the group- distoocclusion, Angle Class II. This supports our research hypotheses that overall occlusion and articulation differ between the examined subgroups of the group. The aim of this study is to examine the center of occlusion to determinate the relationship between morfological and functional occlusal characteristiscs of the masticatory system in orthodontic malocclusions – distoocclusion, Angle Class II division 1 and Angle Class II division 2.

Material and methods

In our study, 60 patients with orthodontic malocclusion-distoocclusion Angle Class II divided into two groups were analysed. The first group included 30 patients with distoocclusion Angle Class II division 1 (Figure 1), and the second group consisted of 30 patients with distoocclusion Angle Class II division 2 (Figure 2).

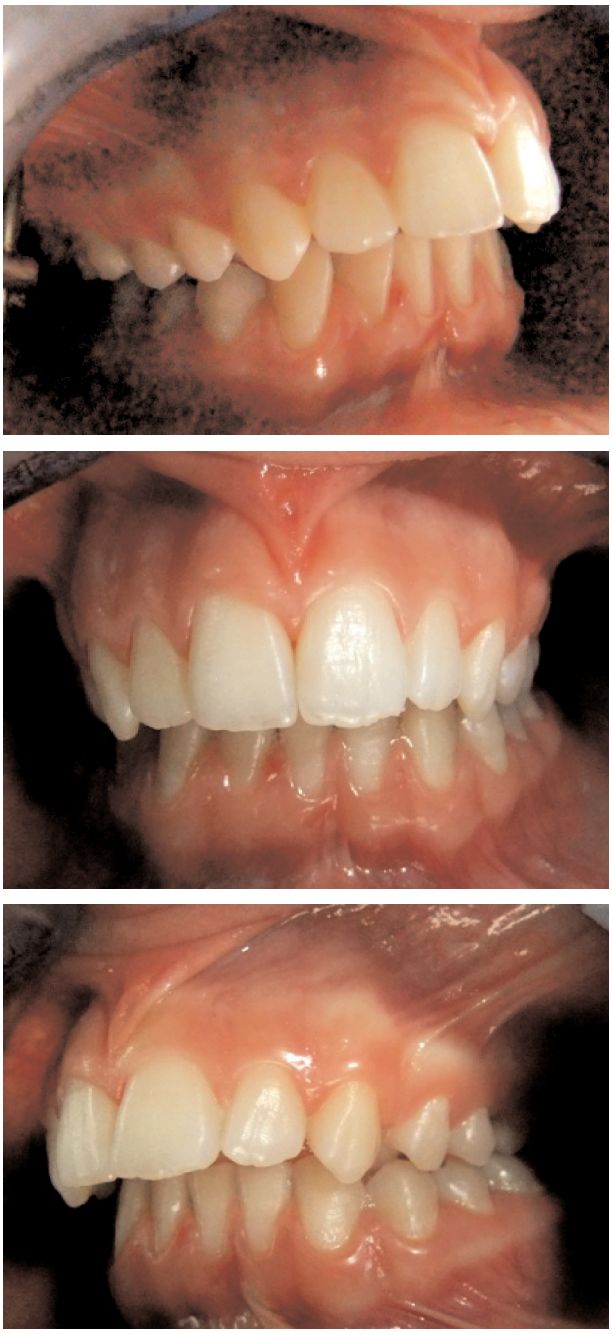


Figure 1. *Intraoral view of distoocclusion Angle Class II division 1.*

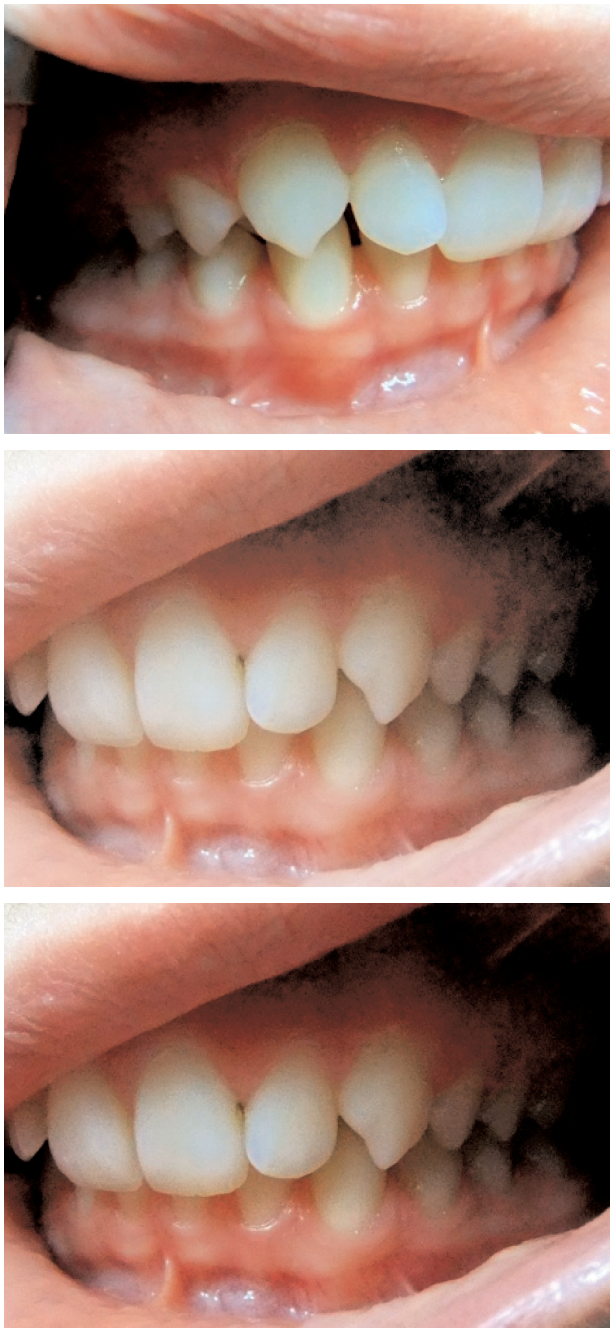


Figure 2. *Intraoral view of distoocclusion Angle Class II division 2.*

We conducted occlusal analysis on 60 patients using T-Scan III system (Tekscan Inc., Boston, MA, USA) (Figure 3) in the position of maximum intercuspidation, protrusion and left and right laterotrusion to determine the parameter of center of occlusal force. Center of occlusal force (COF) describes the occlusal balance and is the „equilibrium point“ of the occlusal forces. It is depicted as a red and white icon that represents the location of the

total force of the occlusal contacts. The total force is calculated by adding the medial and anteroposterior moments of force from the observed occlusal contacts. The trajectory of the center of force gives the path and history of occlusal contacts during mandibular closure or movement. The center of occlusal force is in relation to the double elliptical field, which represents the ideal location of the center of force and serves as a guide to normal occlusion[11-14]. (Figure 4).

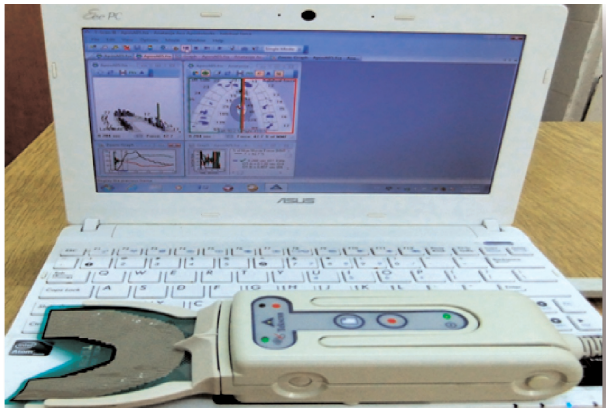
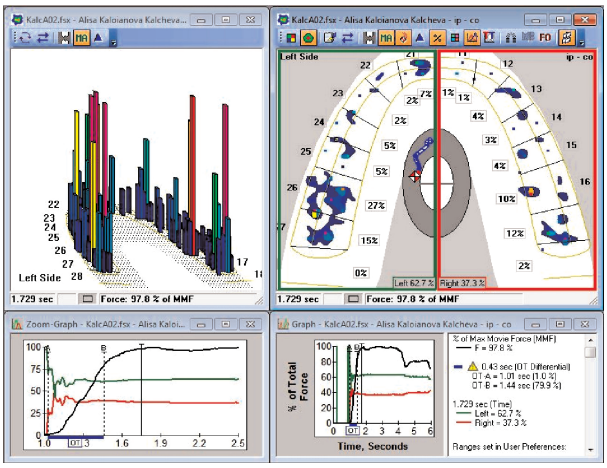


Figure 3. *Overview of the T-Scan III system (Tekscan Inc., Boston, MA, USA).*



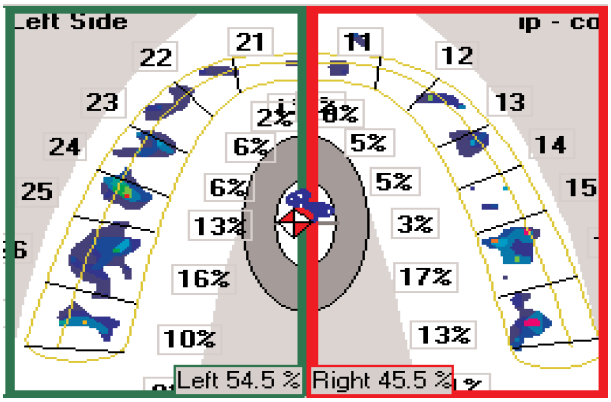


Figure 4. *Overview of the T-Scan III occlusogram and center of occlusal force.*

Results

Table 1. displays data on the center of occlusion in patients with distoocclusion Angle Class II division 1.

Out of a total of 30 patients, 1 (3.33%) had the center of occlusion in the white field of the double ellipse, 10 (33.33%) had the center of occlusion in the gray field of the double ellipse, and 19 (63.33%) had a dislocation of the center of occlusion dislocated outside the double ellipse.

Table 1. Center of occlusion in patients with distoocclusion Angle Class II division 1.

Center of occlusal force	N	Cumulative N	%	Cumulative %
White elipse	1	1	3,33	3,33
Grey elipse	10	11	33,33	36,67
Dislocation	19	30	63,33	100,00
Missing	0	30	0,00	100,00

Table 2. displays data on the center of occlusion in patients with distoocclusion Angle Class II division 2.

Out of a total of 30 patients, 2 (6.67%) had the center of occlusion in the white field of the double ellipse, 12 (40.00%) had the center of occlusion in the gray field of the double ellipse, and 16 (53.33%) patients had a dislocation of the center of occlusion outside the double ellipse.

Table 2. Center of occlusion in patients with distoocclusion Angle Class II division 2.

Center of occlusal force	N	Cumulative N	%	Cumulative %
White elipse	2	2	6,67	6,67
Grey elipse	12	14	40,00	46,67
Dislocation	16	30	53,33	100,00
Missing	0	30	0,00	100,00

Table 1. Center of occlusion in patients with distoocclusion Angle Class II division 1 and in distoocclusion Angle Class II division 2.

	Group	Center of occlusal force			Total
		White elipse	Grey elipse	Dislocation	
N	Distoocclusion Angle Class II division 1	1	10	19	30
%		3,33%	33,33%	63,33%	
N	Distoocclusion Angle Class II division 2	2	12	16	30
%		6,67%	40,00%	53,33%	
N	Total	3	22	35	60

For Pearson Chi-square = 28.40 and p <0.001 (p = 0.000) between the two groups of patients there is a significant difference in the shown frequency distribution referring to the center of occlusion (Table 3).

Discussion

We can see two elliptical fields in the center of the dental arch based on the relative position of the center of occlusal force of the occlusograms from the T-Scan III system. On the inside, a smaller white ellipse and on the outside, a larger gray ellipse. During the recording of the maximal intercuspidation in each patient, the position of the center of the occlusal forces is shown in the form of a red-white icon, which speaks about the balance of the occlusal forces during the occlusion. The inner ellipse represents the area where the center of occlusal force is located in 68% of the population with "normal" occlusion, while the outer ellipse represents the area where the center of occlusal force is located in 95% of the population with "normal" occlusion. Our findings are consistent with Kerstein's[15], that in 3 subjects in both subgroups the center of force is located in the white field of the double ellipse, in 22 subjects it is located in the gray field, while in 35 subjects a dislocation of the center of force outside the field of the double ellipse was registered. According to the analyzed results, there are protrusive and balanced occlusal interferences with increased dislocation time and right and left laterotrusion of the mandible in subjects with distoocclusion Angle Class II division 1. The center of occlusion in 1 (3.33%) patients is in the white field of the double ellipse, in 10 (33.33%) patients the center of occlusion is in the gray field of the double ellipse and 19 (63, 33%) patients have a dislocation of the occlusion center outside the double ellipse. The center of occlusal force of the occlusograms from the T-Scan III system in the subjects of the second subgroup follows an asymmetric distribution, with dislocation of the center of force at 53.33%.

Conclusion

Patients with distoocclusion Angle Class II division 1 and 2 have a bilateral asymmetric distribution of occlusal contacts on the right and left sides of the dental arch at the position of maximum intercuspidation. Occlusal force parameters are not symmetrical about the midsagittal axis of occlusal plane. There is a presence of protrusive and balanced occlusal interferences during mandibular excursions. The center of force for the antero-posterior occlusal contacts, as measured from the incisal axis of occlusal plane, was found to be more mesially from the double elliptic field and its dislocation was observed. Based on the results, we can conclude that there is positive correlation between morphological and functional occlusal parameters between subjects with malocclusion-distoocclusion Angle Class II division 1 and division 2[16-18]. This study's hypothesis about the difference between static occlusion and functional occlusion can be confirmed.

Reference

1. Angle EH. Classification of malocclusion. Dental Cosmos 1899, 41:248–264.
2. Зужелова М. „Ортодонција 1“. Скопје: Марив-С, 2014.

3. Ѓоргова Л., Кануркова Л., Џипунова Б., Тошевска-Спасова Н. „Ортодонтска морфолошка анализа и дијагностика“. Скопје, 2012.
4. Ramfjord SP, Ash MM. Occlusion, ed 3. Philadelphia: Saunders, 1983: 175-265.
5. Aubrey RB. Occlusal objectives in orthodontic treatment. Am J. Orthod. 1978 Aug; 74(2):162-75.
6. Ash M., Ramfjord S. Occlusion, W. B. Saunders Co; 4th edition, 1995.
7. Andrews LF: The six keys to normal occlusion. Am J. Orthod. 1972, 62:296-309.
8. Andrews LF, Andrews WA. The six elements of orofacial harmony. Andrews J. 2000; 1:13–22.
9. Thomson H. Occlusion. Wright, London, 1990, 33-43pp.
10. Clark JR, Evans RD., Functional Occlusion: I.A Review, J Orthod. 2001Mar; 28(1):76-81.
11. Şoaita, C., Popşor S. Computer analyses of functional parameters and dental occlusion. Scientific Bulletin of the Petru Maior University of Targu Mures; 2011, Vol. 8 Issue 2, p192 Dec 2011.
12. Baldini A. et al. Importanza clinica della valutazione computerizzata dell'occlusione. DENTAL CADMOS 2009 Aprile; 77(4).
13. Carcavilla, Marta Munoz; Zabalza, Rebeca Daemi; Cuenca, Anna: Importancia de la Valoracion Digitalizada de los Contactos Oclusales. Gaceta Dental Vol. 227 July 2011, pp. 172-187.
14. Pyakurel U 1, Long H2, Jian F2, Sun J3, Zhu Y1, Jha H4, Lai W5 Mechanism, accuracy and application of T-Scan System in dentistry-A review. Journal of Nepal Dental Association, Jan-Jun 2013.
15. Kerstein RB., Obtaining measurable bilateral simultaneous occlusal contacts with computer-analyzed and guided occlusal adjustments. Quintessence Int 2001:32:7-18.
16. Hassan R., Rahimak AK. Occlusion, malocclusion and method of measurements - an overview. Archives of Orofacial Sciences (2007) 2, 3-9.
17. Kazem S. Al-Nimria; Anwar B. Batainehb; Sawsan Abo-Farhac. Functional occlusal patterns and their relationship to static occlusion. Angle Orthodontist, Vol 80, No 1, 2010.
18. Al-Hiyasat AS, Abu-Alhaija ESJ. The relationship between static and dynamic occlusion in 14–17-year-old school children. J Oral Rehabil. 2004; 31:628–633.