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ORIGINAL ARTICLE

MORPHOLOGICAL VARIABILITY OF ROOT CANALS IN PERMANENT MAXILLARY TEETH

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Abstract: *Background*: The root morphology of maxillary teeth constitutes a fundamental component of dental anatomy, providing essential information for the planning and implementation of complex dental treatments. The aim of the study was to identify the anatomical features and morphological variations in the root canals of the permanent maxillary teeth. *Methods*: The study was conducted on a total of 80 patients who presented to the dental clinic for maxillary tooth treatments. After performing the clinical and radiological examination, any particular anatomical variations were recorded for each tooth examined. *Results*: The complex anatomy of molars, with multiple roots and root canals, makes them more susceptible to untreated or incompletely treated endodontic conditions. Severely curved, fused, or apically divided roots complicate endodontic treatments, increasing the risk of perforation, instrument fractures, or therapeutic failure. The rate of incomplete identification of accessory or supplementary canals is directly correlated with treatment failure and the occurrence of complications. *Conclusions*: The root morphology of maxillary teeth, through its complexity and variability, directly influences the planning and success of dental treatments.

Keywords: conventional impression, digital dentistry, intraoral digital impression, implant supported restorations

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1. Introduction

Dental units represent the hardest structures of the body, playing an essential role in mastication, phonation and aesthetics [1]. Each type of tooth contributes uniquely to these processes, ensuring optimal functionality of the oral cavity [1]. In addition, maxillary teeth contribute significantly to pronunciation and maintaining aesthetic function [2].

The root structure of maxillary teeth is determined by factors such as: masticatory function, distribution of occlusal forces and biomechanical requirements of each tooth type. This involves particularities related to the shape, number and orientation of the roots, as well as the internal architecture of the root canals [1]. The architectural complexity of roots and root canals involves a constant challenge for dentists, requiring a detailed understanding as well as the use of modern technologies [3]. Studying it not only improves clinical outcomes, but also contributes to maintaining overall oral health in the long term [1]. A detailed understanding of the shape, number and trajectory of root canals contributes to performing more precise procedures and reducing the risk of failure [4]. A good knowledge of root anatomy helps the dentist to prevent complications such as persistent infections, which can occur when certain canals are not treated properly [1].

The roots and root canals of teeth are fundamental structures that influence the stability, functionality and success of endodontic treatments [5]. Each tooth presents significant morphological variability, which requires a good knowledge of the root anatomy for precision dental interventions [6,7]. In such cases, the use of cone beam computed tomography (CBCT) is essential for a clear visualization of the canal structure [8]. A correct approach, based on a thorough understanding of the root morphology, contributes to obtaining long-lasting results and prevents possible post-treatment complications, such as root perforations, tooth fractures or blockage of instruments in the canal [9]. Exploration of root canals requires the use of precise imaging methods to allow for a correct diagnosis and adequate treatment planning [10].

The anatomical differences in root canals play a crucial role in establishing therapeutic strategies in dentistry. These variations can significantly affect endodontic, prosthetic, and surgical procedures, influencing the success and durability of treatments [11].

The present study was conducted taking into account the fact that the root morphology of maxillary teeth constitutes a fundamental component of dental anatomy, providing essential information for the planning and implementation of complex dental treatments. In addition to optimizing existing treatments, the detailed study of root canals plays an important role in the development of modern technologies in the field of endodontics. Discoveries related to the anatomical variations of root canals allow the improvement of the instruments and techniques used in treatments, thus increasing the efficiency of dental procedures [12]. Therefore, a good knowledge of these aspects is essential for the success of endodontic treatment and for maintaining the oral health of patients [1,2]. The objectives of this study were to characterize the root morphology of maxillary teeth by identifying anatomical

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peculiarities and canal variations, integrating the data obtained with modern imaging methods and emphasizing the clinical relevance of this information in the planning and personalization of dental treatments.

2. Materials and method

Study design

This retrospective study included a total of 80 patients aged between 18 and 65 years, of both genders, who presented between November 2024 and April 2025 for consultations or treatments involving radiological analysis of maxillary teeth. Inclusion criteria in the study were the presence of permanent maxillary teeth (incisors, canines, premolars and molars) in the dental arches, structural integrity of the roots and the availability of relevant imaging investigations (retroalveolar radiographs or CBCT examinations).

For each tooth examined, the following data were recorded: number of roots, shape and trajectory of the roots, presence and type of root curvatures, number of visible root canals, and any special anatomical variations. The data were collected using conventional radiological images (intraoral retroalveolar radiographs), and in cases where detailed three-dimensional analysis was required, cone beam computed tomography (CBCT) examinations were used (Figure1).

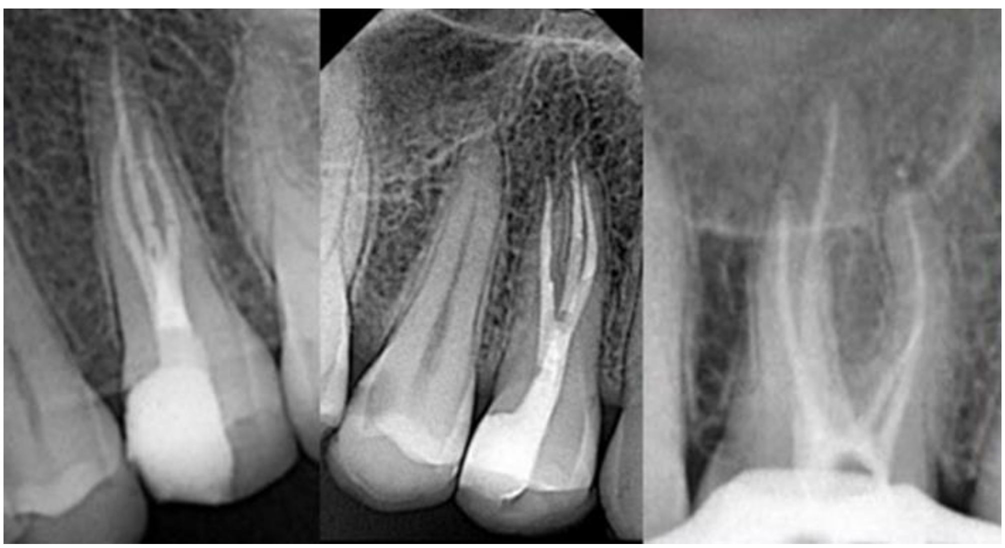

Figure 1. Morphological variability of root canals.

The data obtained were centralized and statistically analyzed using Microsoft Excel, tracking the frequency of different types of root morphology depending on the type of tooth, as well as the presence of individual variations or correlations between age, gender and the type of morphology identified.

All patients included in the study gave informed consent for all medical procedures performed. All participants signed the agreement for the management of personal data (GDPR) and completed the standard form for inclusion in the medical research study according to law no. 46/2003. The study was approved by the Ethics Committee of the University of Medicine and Pharmacy of Craiova, with no 63/29.01.2024.

3. Results

A total of 80 patients met the inclusion criteria to participate in the study. The patients were aged between 18 and 65 years. Of these, 42 (52.5%) were female and 38 (47.5%) were male (Figure 2a, Table 1), coming from both urban (55 patients, 68.8%) and rural (25 patients, 31.2%) areas (Figure 2b, Table 1).

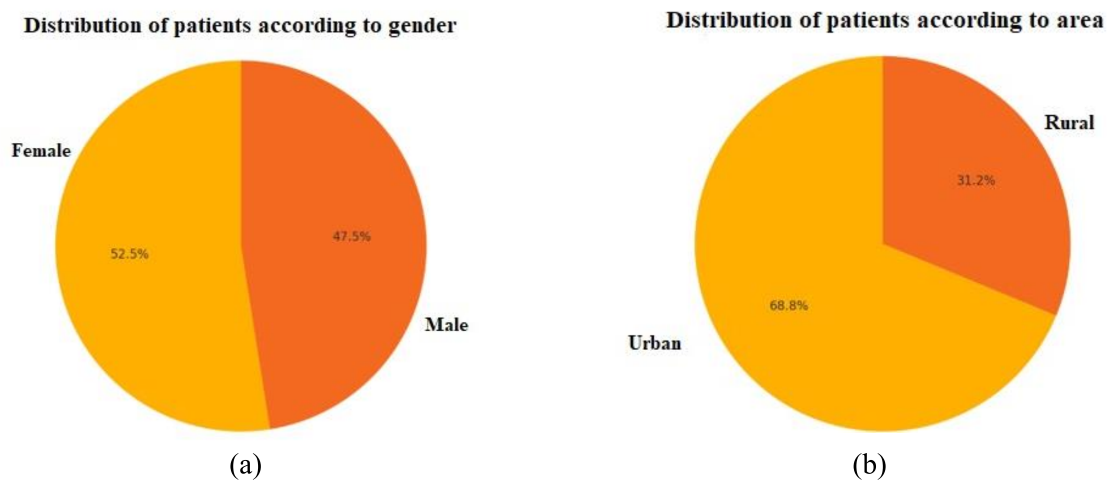

Figure 2. (a) Distribution of patients according to gender; (b) Distribution of patients according to area.

Table 1. Demographic data.

Parameter	Category	Patients	Total
Gender	F	42 (52.5%)	80 (100%)
	M	38 (47.5%)	
Area	Urban	55 (68.8%)	80 (100%)
	Rural	25 (31.2%)	
Age group	18-29 years	15 (18.75%)	80 (100%)
	30-39 years	22 (27.5%)	
	40-49 years	20 (25%)	
	50-59 years	13 (16.25%)	
	60+ years	10 (12.5%)	

The distribution of patients by age, organized by decade groups, shows that the largest category is between 30- 39 years old (22 patients), followed by the 40- 49 years old group (20 patients), indicating an increased prevalence of interest in dental treatments among professionally active adults. The 18–29 and 50- 59 years old groups are moderately represented, while the 60+ years old category has the lowest number of patients (10 people) (Figure 3, Table 1).

Regarding the distribution of patients according to the number of roots of the affected maxillary teeth, it was found that the majority of the examined teeth had either one root (30 cases) or three roots (25 cases), these values being specific for the maxillary incisors, canines and molars respectively.

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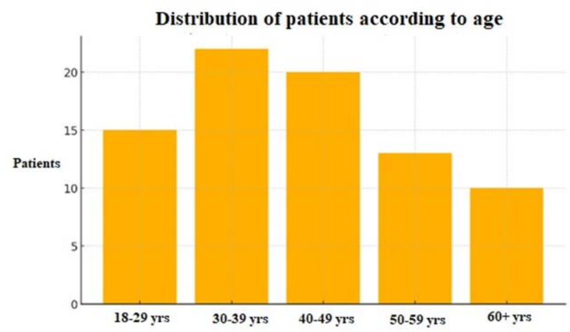

Figure 3. Distribution of patients according to age.

Teeth with two roots (20 cases) correspond mainly to the upper premolars, and a small number of cases (5 cases) involved teeth with more than three roots, which suggests the presence of rare anatomical variations or root anomalies (Figure 4, Table 2).

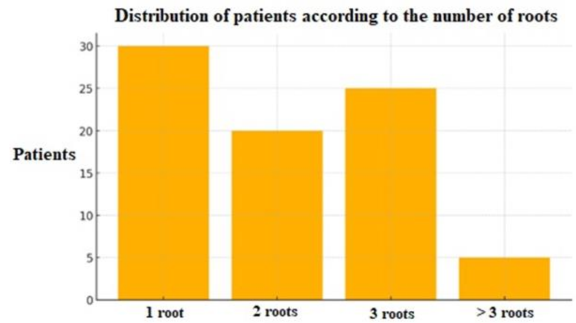

Figure 4. Distribution of patients according to the number of roots.

Table 2. Distribution of patients according to the number of roots.

Parameter	Patients	Percentage (%)
1 root	30	37,5%
2 roots	20	25%
3 roots	25	31,25%
>3 roots (root abnormalities)	5	6,25%
Total	**80**	**100%**

It was also observed that maxillary molars were the most frequently involved (30 cases), which reflects their anatomical complexity, increased masticatory wear and higher susceptibility to endodontic diseases. Premolars follow with 20 cases, these having a significant root variability, especially the first upper premolar which can have two roots and canals.

Incisors (18 cases) and canines (12 cases) are involved in a smaller proportion, being anterior teeth, easier to clean and with simple root morphology (a single root, usually straight). This distribution supports the observation that posterior teeth, due to their position and complexity, present an increased risk of damage and require increased attention in diagnosis and treatment (Figure 5, Table 3).

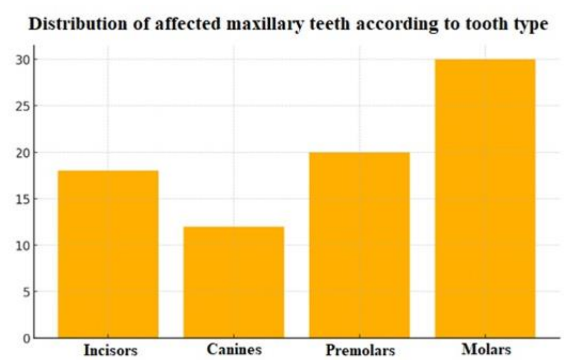

Figure 5. Distribution of affected teeth according to tooth type.

The distribution of the roots of the maxillary teeth analyzed according to their shape and trajectory showed that the most common are straight roots (28 cases), followed by slightly curved ones (25 cases), these being frequently found in incisors, canines and premolars.

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Table 3. Distribution of affected teeth according to tooth type.

Tooth type	No. of affected teeth	Percentage (%)
Incisors	18	22,5%
Canines	12	15%
Premolars	20	25%
Molars	30	37,5%
Total	**80**	**100%**

The distribution of the roots of the maxillary teeth analyzed according to their shape and trajectory showed that the most common are straight roots (28 cases), followed by slightly curved ones (25 cases), these being frequently found in incisors, canines and premolars. Roots with a pronounced curved trajectory (15 cases) pose difficulties in endodontic and surgical treatments, being specific especially to molars. Also, 7 cases of fused roots were recorded, a particularity found especially in molars, and in 5 cases apically divided roots were identified, i.e. branched only in the apical third, an aspect that can significantly complicate root canal treatment (Figure 6, Table 4).

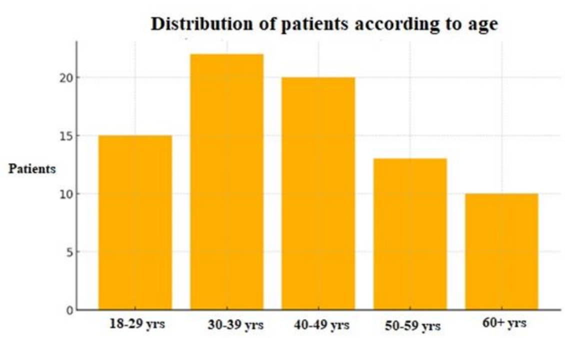

Figure 6. Distribution of roots according to their shape and trajectory.

Of the total analyzed teeth, most teeth presented a single root canal (26 cases), a situation frequently encountered in incisors and canines. Two root canals were identified in 24 cases, predominantly in maxillary premolars, especially the first premolar. Three root canals were observed in 20 teeth, a typical appearance of maxillary molars, which usually present one root canal in each root. Of note, 10 cases presented more than three root canals, indicating important anatomical variations, such as the presence of the MB2 root canal in upper molars (Figure 7) or additional root canals in fused roots (Table 5).

Figure 7. Upper 1st molar with 4 root canals.

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Table 4. Distribution of roots according to their shape and trajectory.

Root shape and trajectory	No. of cases	Percentage (%)
Straight roots	28	35%
Slightly curved roots	25	31,25%
Sharply curved roots	15	18,75%
Fused Roots	7	8,75%
Apically divided roots	5	6,25%
Total	**80**	**100%**

Table 5. Distribution of maxillary teeth according to the number of visible root canals.

No. of root canals	No. of teeth	Percentage (%)
1 root canal	26	32,5%
2 root canals	24	30%
3 root canals	20	25%
>3 root canals	10	12,5%
Total	**80**	**100%**

4. Discussion

The analyzed data show a relatively balanced distribution of patients by gender, with a slight predominance of women comparative to men. This result can be interpreted from the perspective of accessibility and different behavior towards dental medical services, women being, in general, more concerned about oral health and more motivated to seek preventive and curative care. Studies in the field support the idea that female patients access dental services more frequently, including for aesthetic purposes [13]. Regarding the distribution by gender, epidemiological studies indicate a constant trend of higher frequency of dental services by women, an aspect correlated with a greater concern for the aesthetic aspect and prevention [14].

In terms of origin, a significantly higher representation of patients from urban areas is observed compared to those from rural areas. This disequilibrium can be explained by a combination of socio-economic, cultural and geographical factors. Easier access to dental clinics, higher levels of health education and higher incomes in urban areas contribute to this difference [15]. In contrast, the rural population often faces barriers such as lack of medical infrastructure, costs of services and lower awareness of the importance of oral health [16].

The analysis of the distribution by age group shows that the largest share of patients is in the active age categories: 30-39 years and 40-49 years. This suggests that the prevalence of dental diseases, especially endodontic or periodontal, is significant in these age ranges [17]. Intense professional activity, stress and eating habits can contribute to the deterioration of dental condition. The age group 18-29 years is represented in a proportion of 18.75%, reflecting the possible presence of hereditary problems or resulting from poor oral hygiene in adolescence. The decrease in the number of patients in the

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categories 50-59 years and 60+ years may be associated either with partial or total edentulism, or with the decrease in interest or possibilities to access complex dental treatments among the elderly [18].

The distribution according to the number of roots of the affected maxillary teeth shows that teeth with a single root are the most frequently involved, followed by those with three roots and two roots. This distribution may reflect the increased prevalence of lesions in the frontal and premolar region, where teeth with one or two roots predominate, but also the difficulty of complex endodontic treatments in the case of molars with three roots [19]. Only 6.25% of the cases presented root anomalies with more than three roots, which confirms the rarity of these anatomical variants. The results obtained in this analysis are largely in line with those presented in the current literature [20]. The studies of Vertucci et al. have highlighted a wide variety of root anatomical types, and configurations with one or two roots are most common in the anterior area, while molars often present three or more roots, sometimes fused or divided apically [21].

Regarding the type of the affected teeth, molars are most frequently involved, followed by premolars, incisors and canines. This hierarchy corresponds to the increased functional demands on molars and the difficulty in maintaining effective hygiene in the posterior areas [22,23]. Furthermore, the complex anatomy of molars, with multiple roots and root canals, makes them more susceptible to untreated or incompletely treated endodontic diseases [24]. Also, premolars, although easier to treat, are frequently involved due to their intermediate position and mechanical overload during mastication [25]. A study by Cleghorn et al. showed that 76% of maxillary first molars have three roots and the MB2 root canal is present in over 50% of cases, which frequently complicates endodontic treatments [26]. Thus, the data presented above confirm the importance of accurate radiological diagnosis [27].

Analysis of root shape and trajectory reveals that straight and slightly curved roots are the most common. These generally allow for a predictable therapeutic approach. Conversely, sharply curved, fused or apically split roots complicate endodontic treatments, increasing the risk of perforation, instrument fractures or therapeutic failure [28]. These findings highlight the importance of detailed preoperative assessment, including CBCT, to identify potentially risky anatomical variants. Regarding root trajectory, root curvature occurs in approximately 30-40% of teeth, which corresponds to a combined percentage of 25% (slightly and sharply curved) in the analyzed sample [29]. Thus, the incidence of anatomical variants is considerable and cannot be neglected in current practice [30].

The distribution according to the number of root canals confirms the predominance of teeth with one and two root canals, followed by those with 3 and more than 3 root canals. These data are relevant for endodontic treatment planning, as the complexity increases proportionally with the number of root canals [31]. The rate of incomplete identification of accessory or additional root canals is directly correlated with treatment failure and the occurrence of complications [32]. Therefore, correct identification of all root canals is essential for a favorable long-term prognosis [33]. Regarding the prevalence of molar and premolars, the results are comparable to those reported by Siqueira et al., who showed that maxillary molars are most frequently involved in persistent endodontic infections, due to their complex anatomy [34].

5. Conclusions

The root morphology of maxillary teeth is not only an anatomical feature, but a decisive element in the planning of dental treatments. The structural variability and complexity of root canals require the use of modern imaging and a careful evaluation of each case. The root morphology of maxillary teeth, through its complexity and variability, directly influences the planning and success of dental treatments, and the integration of anatomical knowledge with modern imaging supports the need for a personalized and rigorous approach in clinical practice. In conclusion, the integration of root morphological information in clinical practice should not be seen as a simple theoretical stage, but as an essential pillar in defining the quality and efficiency of modern dental treatments.

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Author contributions

Authors read and approved the final manuscript. All authors have equally contributed to this work.

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Conflict of interest statement

The authors declare no conflicts of interest concerning this study.

Data availability statement

Will be provided on request.

Ethics statement

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ORIGINAL ARTICLE

DENTAL HYPERSENSITIVITY IN THE CONTEXT OF TOOTH WEAR

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Abstract: *Background*: Dentin hypersensitivity (DHS) is one of the most common complaints of patients in dental offices and its pathogenesis remains a subject of debate. The aim of this study was to present the current state of knowledge of DHS among young practitioners and to assess the prevalence of DHS and cervical tooth wear in young patients and also to present modern treatment options. *Methods*: For this study, an electronic questionnaire was created and distributed online. To assess the clinical and therapeutic aspects of DHS in the context of early cervical tooth wear, we examined and treated 20 patients with this condition. *Results*: The questionnaire was completed by 104 participants. To the questions regarding the definition of the symptoms of DHS, over 75% of the participants provided the correct answers. A smaller number of participants (66.3%) answered correctly to the question regarding the association of DHS with early cervical tooth wear. Approximately 90% of participants stated that their oral health was affected. For the present study, 20 patients with DHS were included and divided into 4 study groups. It is noted that for patients who did not receive treatment for DHS, the painful symptoms remained the same or worsened. For the other patients, the painful symptoms experienced a significant reduction. *Conclusions*: The development of DHS in the context of incipient cervical tooth wear is an aspect insufficiently known by dental practitioners. Laser irradiation of the tooth surface for its desensitization represents a modern and effective dental treatment of DHS.

Keywords: dentinal hypersensitivity, tooth wear, cervical wear

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1. Introduction

Dentinal hypersensitivity (DHS) has been defined as a brief, sharp toothache that usually occurs following the action of a physical/chemical/mechanical stimulus applied to the exposed dentinal tubules in the cervical area, and that cannot be attributed to any other dental pathology [1-4].

DHS has been recognized as an important dental condition for more than 50 years, but its pathogenesis remains a subject of debate. DHS is generally considered to be associated with dentin exposure, particularly exposure of open dentinal tubules [4]. The Brännström hydrodynamic theory is the widely accepted explanation for the occurrence of cervical DHS. It states that physical stimuli, applied to the tooth surface, cause fluid displacement in the dentinal tubules, which causes contraction and distension of the odontoblastic processes and stimulation of nerve fibers present at the dentin-pulp interface [5].

The causative etiological factors of DHS are: stress, friction and biocorrosion. Soares and Grippo [2], two specialists in dental wear and DHS, argue that there is a strong relationship between the two pathologies and that both originate from eccentric loading forces on the teeth. These forces subject the periodontium and the cervical region of the tooth to stress and are perceived by the pulp as pain [2].

The concentration of stress in the cervical area has been reported by numerous clinicians and researchers using finite element analysis. This stress causes the loss of the smear layer, cementum and enamel/dentin in the cemento-enamel junction region [6-9]. When the rate of this loss exceeds the rate of remineralization and reformation, the open dentinal tubules reach the nociceptive threshold, that of DHS. Therefore, the presence of DHS is an early sign and symptom of the clinical formation of stress-induced abfraction/non-carious cervical lesion (NCCL) [2].

Dentin hypersensitivity is one of the most common complaints of patients in dental offices. Studies have shown wide variations in the prevalence of DHS, from 2 to 98% [2, 4] and that DHS is more common in patients aged 30 to 40 years [10,11].

Severe DHS can last more than 6 months and can induce psychological and emotional instability, which can trigger the development of neuralgia, requiring treatment as neuropathic pain. Also, the quality of life of patients is related to their oral health and in the case of patients with DHS, it can be improved after DHS has been successfully treated [4].

Although DHS is one of the most common problems encountered by dental professionals, universally accepted guidelines for differential diagnosis and selection of reliable treatment modalities are lacking. The problems associated with the diagnosis and treatment of DHS are further exacerbated by the fact that several dental conditions have symptoms that can mimic DHS at different stages of their progression [4, 12].

Treatment of DHS is a specific treatment that can be performed on an outpatient basis, by local application of desensitizing products, or/and in the dental office using desensitizing agents, laser therapy, and/or surgical treatment [2]. Some specialists have stated that if the painful symptoms do not improve and the depth of the lesion approaches 1 mm, restorative treatment is recommended [13].

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The aim of this study was to present the clinical and therapeutic aspects of HSD, knowing that this condition is associated with early cervical tooth wear. The present study aimed to present the current state of knowledge of DHS among young practitioners. It was also aimed to assess the prevalence of DHS and cervical tooth wear in young patients and to present modern treatment options.

2. Materials and method

The study was approved by the Ethics Committe of the University of Medicine and Pharmacy of Craiova (no. 55/16.02.2023). For this study, an electronic questionnaire was created in Google Forms, consisting of 16 questions (Q1-Q16). This questionnaire was distributed between 05.05.2025-26.05.2025 to dentists and students in the 4th, 5th and 6th years of study from Faculty of Dentistry, University of Medicine and Pharmacy of Craiova.

The questionnaire was sent online, using social networks. By completing the questionnaire, participants expressed their consent to participate in the study and to process their personal data. The results were collected by Google Forms in the form of graphs and a database. The database was processed using Microsoft Excel.

The questions in the created questionnaire are systematized in Table 1 and aimed at classifying the participant according to their level of training and age, their level of knowledge of DHS, self-reporting of this condition and tooth wear. The questions also aimed at participants' appreciation of the role of DHS in affecting the way they consume certain foods and, implicitly, in affecting quality of life.

Also, to assess the clinical and therapeutic aspects of DHS in the context of early cervical tooth wear, we examined and treated 20 patients with this condition. The patients were aged between 20 and 50 years and presented themselves in private dental practice for the treatment of DHS between 03.03.2025 and 30.04.2025. All patients included in this study expressed their written consent to participate.

The patients were divided into 4 study groups:

- group M, the control group, represented by 5 patients with DHS with no treatment for this condition;
- group P, represented by 5 patients with DHS to whom the use of desensitizing tooth pastes was recommended;
- group L, represented by 5 patients with DHS to whom laser desensitization of the affected dental surfaces was done;
- group A, represented by 5 patients with DHS to whom an adhesive system for the treatment of DHS was applied.

At the time of presentation in the dental office, all patients were asked to rate the intensity of pain on a scale from 0 to 10 when a thermal stimulus (cold air jet) was applied. Patients in the control group were asked to return to the office in 2 weeks and to mention a score for the pain they felt. Patients in groups P, L and A were asked, after the treatment, to mention the pain score they felt when a cold air stimulus was applied.

The desensitizing tooth pastes recommended to the patients in group P were the ones based on sodium monofluoro-phosphate (Elmex Sensitive Professional). The laser used in the treatment of patients from group L was a diode laser with a wavelength of 980 nm (Biolase). The laser

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desensitizing protocol involved placing the tip of the laser at a 5 mm distance from the dental surface, activating the laser at a power of 0.5 W, for 90 sec, during which time the laser tip had circular movements and no contact with the dental surface. The adhesive system used in the treatment of patients from group A was a one component light-cured universal adhesive (G-Premio Bond, GC). After etching the dental surface, the adhesive was applied, then the operator waited for 10 seconds, air-dryed the dental surface for 5 seconds and then light cured for 10 seconds.

Table 1. The questions in the questionnaire.

Number	The questions in the questionnaire.	Response possibilities
Q1	Please state your professional degree.	Student/Dentist
Q2	Your gender	Male/Female
Q3	If you are a student, please specify your year of study.	4th year/5th year/6th year
Q4	Your age	20-25/26-30/31-40/41-50/over 50
Q5	DHS is a condition characterized by discomfort/pain that occurs	When applying thermal, chemical or mechanical stimuli to the teeth/Spontaneous/At night
Q6	Discomfort/pain from DHS	It is short-lived (for as long as the stimulus is applied) /It is prolonged, for a few minutes
Q7	DHS is the specific sign of the early stages of cervical tooth wear.	True/False/I don't know
Q8	I believe I have DHS	Yes/No/I don't know
Q9	If the answer to the previous question was yes, I am undergoing treatment for DHS	Yes, I use specific toothpastes/Yes, I went to a dentist for treatment in the dental office/No
Q10	I think I have tooth wear.	No/ Yes, early stage on the occlusal surfaces/Yes, early stage in the cervical area/Yes, advanced stage (more than 1/3 of the coronal height is affected)/I don't know
Q11	If you have/would have DHS, do you think that toothache limits your consumption of certain favorite foods/drinks?	True/False/Don't know
Q12	If you have/would have DHS, do you think that toothache prolongs the time required to consume certain foods/drinks?	True/False/Don't know
Q13	If you have/would have DHS, do you think that toothache prevents you from consuming cold foods?	True/False/Don't know
Q14	If you have/would have DHS, do you think that toothache has caused a change in the way you chew certain foods/drink certain liquids?	True/False/Don't know
Q15	If you have/would have DHS, do you think that in order to avoid toothache, you should be careful how you breathe on a cold day	True/False/Don't know
Q16	If you have/would have DHS, do you think that	Your oral health is affected/Your quality of life is affected/Your oral health is good/Your quality of life is not affected

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3. Results

3.1 Results of the questionnaire

The questionnaire was completed by 104 participants. Of the 104 participants, 86.5% were final year students at the Faculty of Dentistry, UMF Craiova, and most of them were 6th year students, aged between 20 and 25 years.

To the questions regarding the definition of the symptoms of DHS (Q5 and Q6), over 75% of the participants provided the correct answers.

A smaller number of participants (66.3%) answered correctly to the question regarding the association of DHS with early cervical tooth wear (Q7). Almost 10% of the participants did not know the correct answer to this question.

One question in the questionnaire (Q8) referred to self-reporting of DHS. Most of the participants (68.3%) stated that they did not have this condition.

Among participants with DHS and undergoing treatment for this condition, most mentioned that treatment consisted of using specific toothpastes (26%). Only 10.4% of participants with DHS sought specialized treatment in the dental office.

Another question in the questionnaire (Q10) referred to self-reported tooth wear. Most participants (53.9%) stated that they did not have tooth wear.

Approximately 30% of participants stated that they had incipient tooth wear on the occlusal surfaces. Only 5.9% of participants stated that they had incipient tooth wear in the cervical area.

The following questions focused on the influence of DHS on quality of life. A first question in this section referred to limiting the consumption of certain foods and beverages in the presence of DHS (Q11). Most participants (67.7%) stated that they considered that this condition influences eating behavior (Figure 1).

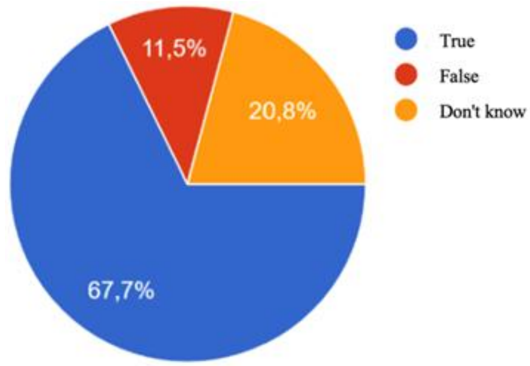

Figure 1. Answers given to Q11.

Participants were then asked whether they considered that the dental pain characteristic of DHS prolongs the time required to consume certain products (Q12). Most participants (66.7%) answered affirmatively and considered the painful symptomatology as a factor increasing the chewing time (Figure 2).

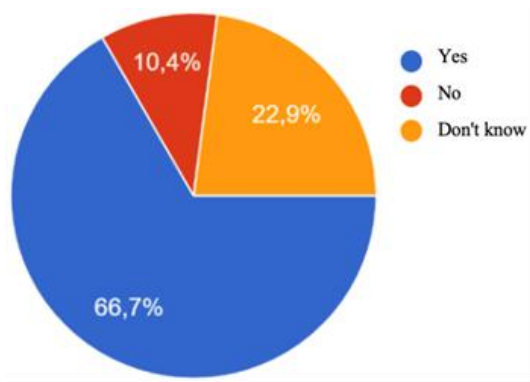

Figure 2. Answers given to Q12.

The next question (Q13) referred strictly to the consumption of cold foods in patients with DHS. Most participants (76%) stated that they were aware that this condition does not allow optimal consumption of foods with a low temperature.

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Another question in this section (Q14) followed the participants' assessment of the masticatory pattern in relation to DHS. Most participants (73.2%) stated that mastication is influenced by the characteristic painful symptomatology (Figure 3).

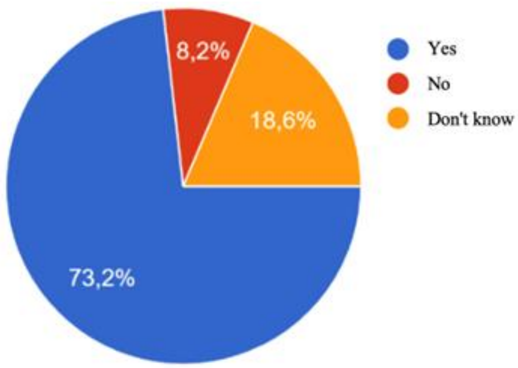

Figure 3. Answers given to Q14.

The next question referred to the correlation of DHS pain with another important patient behavior, unrelated to mastication, namely breathing (Q15). Participants were asked whether they considered that patients with dentin hypersensitivity avoid mouth breathing during a cool day. Approximately half of them (49.5%) answered affirmatively.

The last question in the questionnaire aimed at the direct correlation of DHS with the patient's quality of life (Figure 4). Approximately 90% of participants stated that their oral health was affected. One third of participants stated that this condition decreases their quality of life.

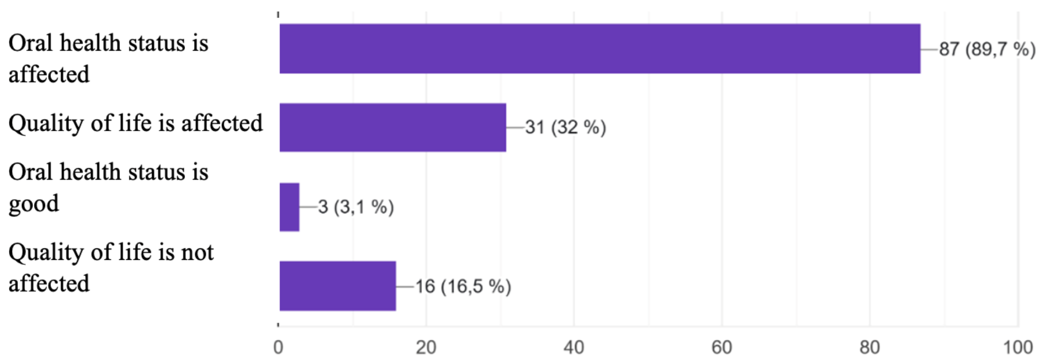

Figure 4. Answers given to Q16.

3.2 Clinical cases

For the present study, 20 patients with DHS were included and divided into 4 study groups. Each patient was assigned a code to protect personal data. The code was composed of: the initial P, the initial of the group, the number within the group (e.g.: P-M-1 represents patient no. 1 in the marker/control group).

For patients in groups P, L and A, DHS treatment was performed using one of the 3 techniques: outpatient use of toothpastes dedicated to this condition (group P), laser treatment of the affected tooth surfaces (group L) and application of an adhesive system on the tooth surface (group A).

Patients were asked to rate the painful symptoms on a scale from 0 to 10 at the time of presentation to the dental office and, respectively, after the treatment of DHS or after 2 weeks. The answers provided by them are shown in Table 2.

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It is noted that for patients who did not receive treatment for DHS, the painful symptoms remained the same or worsened. For the other patients, the painful symptoms experienced a significant reduction.

For the present study, we considered 2 clinical cases to be relevant for the presentation of the clinical picture and treatment options.

Table 2. Pain assessment by patients included in the study.

No.	Patient identification code	Pain score at presentation	Pain score after treatment/2 weeks
1.	P-M-1	7	7
2.	P-M-2	7	8
3.	P-M-3	8	8
4.	P-M-4	6	6
5.	P-M-5	6	7
6.	P-P-1	7	6
7.	P-P-2	6	3
8.	P-P-3	8	6
9.	P-P-4	5	3
10.	P-P-5	7	3
11.	P-L-1	7	1
12.	P-L-2	7	0
13.	P-L-3	6	0
14.	P-L-4	5	1
15.	P-L-5	6	0
16.	P-A-1	6	0
17.	P-A-2	7	0
18.	P-A-3	8	1
19.	P-A-4	8	1
20.	P-A-5	6	0

3.2 Clinical case no. 1

Patient B.F (patient code P-A-2), 31 years old, presented herself to the dental office complaining of localized pain in tooth 4.4. The patient stated that the pain occured when consuming cold foods and drinks and was of high intensity, which decreased within 10-15 seconds.

From the anamnesis, the dentist identified one of the etiological factors of cervical tooth wear and DHS, namely, the consumption of acidic foods and drinks. The patient mentioned that every morning, after brushing her teeth, she consumes a glass of lemonade.

The clinical dental examination revealed the existence of a enamel fissure on the buccal surface of tooth 4.4 and a localized demineralization in the buccal cervical area (Figure 5). Demineralization in the buccal cervical area was also identified on other teeth, including neighboring teeth. When applying the cold air jet and palpating the buccal cervical area of tooth 4.4 with the probe, the patient complained of painful symptoms, which she rated on a scale from 0 to 10 with a value of 7.

The diagnosis of DHS was established at the level of 4.4. The treatment indication was

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to apply an adhesive system to the identified fissure and demineralization to improve the symptoms characteristic of DHS.

During the treatment session, professional brushing of the dental arches and personalized oral hygiene habbits were delivered.

As a result of the existence of demineralization in the buccal cervical area, the dentist insisted on controlling the etiological factors by limiting the consumption of acidic foods and drinks, but also by brushing the dental cervical third with a soft-bristled toothbrush and fluoride toothpaste.

After professional brushing, the buccal surface of tooth 4.4 was re-examined using the operating microscope and it was noted that after palpation with the probe of this intensely demineralized area, a superficial loss of dental enamel occurred, in the form of NCCL. The specific treatment steps of applying an adhesive system and flowable composite followed. At the end of the treatment session, the painful symptomatology accused by the patient at the level of tooth 4.4 was re-evaluated. When applying the cold air stimulus, the patient mentioned the complete disappearance of pain, giving the value 0.


(a)

(b)


(c)


(d)

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(e) (f)

Figure 5. Clinical case no. 1 - Sequences of the treatment stage: a) pre-operative appearance; b) orthophosphoric acid used; c) demineralization of the interested surface; d) application of the adhesive; e) application of the flowable composite; f) final appearance.

3.2 Clinical case no. 2

Patient A.M (patient code P-L-2), aged 29, presented to the dental office complaining of cold pain, located at the level of tooth 1.4. The patient mentioned that the pain is intense and occurs when brushing teeth, which is why the brushing in that area is avoided. From the anamnesis, the dentist deduced that the patient had used desensitizing toothpastes in the last 3 months, but the painful symptoms had not improved. Following the clinical dental examination, bacterial plaque deposition, gingival retraction on the buccal side of tooth 1.4 and superficial enamel loss in the buccal cervical area, with a depth of less than 1 mm, were identified. The diagnosis of incipient, saucer-shaped NCCL, associated with gingival retraction and DHS at the level of tooth 1.4, was established.

The treatment indication was to perform professional brushing and desensitization of the dental surface by laser irradiation. For this treatment, the Biolase diode laser was used, with a wavelength of 940 nm and a dedicated uninitiated tip (Figure 6). The procedure did not require dental anesthesia.

The patient gave a value of 7 for the pain felt pre-operatively. The patient gave a value of 5 for the pain felt after the first cycle of laser irradiation. The procedure was repeated. Upon re-examination of the painful symptoms, the patient mentioned the complete disappearance of the pain, giving a value of 0 on the VAS scale (Figure 6).

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(a) (b)

Figure 6. Clinical case no. 2 - Sequences of the treatment stage: a) the diode laser used; b) laser irradiation.

4. Discussion

Pain is considered a subjective and complex experience. Dental pain is characterized as discomfort originating from the teeth and supporting tissues and is most often associated with primary and secondary caries, poor restorations, and exposed root surfaces. Pain is the main feature of DHS. Dental pain interferes with daily activities such as brushing teeth, drinking cold liquids, eating ice cream, talking, or inhaling cold air [14].

The starting point in diagnosing DHS is the pain experienced by the patient. The most common clinical signs associated with DHS include the initial non-carious loss of dental hard tissues in the cervical area in the form of erosion/abfraction/abrasion lesions. These non-carious cervical lesions are included in the clinical forms of tooth wear [15].

The objective of our study was to create a questionnaire with a reduced number of questions and to assess, based on the responses provided, the prevalence and impact of self-reported dentin hypersensitivity among final year students at the Faculty of Dentistry, UMF Craiova and among young dentists. We also aimed to investigate the association of DHS with early tooth wear.

The questionnaire constructed for this study included questions regarding self-reporting of DHS and tooth wear, as a result of constructing the study group from specialists in the field of dentistry, final years students and dentists. Their level of training was sufficient to express their appreciation of the existence of these conditions in their own oral cavity.

To the questions aimed at assessing the level of knowledge of the clinical signs of DHS, the participants provided the correct answers in a significantly high percentage. Thus, a high level of knowledge of this dental condition was noted.

To the question regarding the definition of DHS as a pathognomonic sign of incipient tooth wear in the cervical area, the participants provided the correct answers in a lower percentage. This aspect draws attention to the need to deepen the study of the etiopathogenic mechanisms and symptomatology of tooth wear and, implicitly, of NCCL. Similar results have been obtained in other studies in the literature [6].

Since most participants were young, and tooth wear is a common condition among

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elderly patients, it is not surprising that tooth wear was not self-reported by the participants. The low percentage of participants (approximately 6%) with early tooth wear in the cervical area is correlated with the low percentage of participants with dentin hypersensitivity.

We noted that only half of the participants observed the connection between tooth pain from DHS and mouth breathing during a cold day, although the relationship between atmospheric air quality and tooth pain is known. Atmospheric air during mouth breathing, especially in winter, when low temperatures are recorded, triggers tooth pain [16].

Also, only one third of the participants stated that DHS decreases the quality of life of the patients, although several participants noted changes in eating behavior. This fact denotes the need for additional training of dental professionals in the direction of assessing the patient as a whole. Dentists must appreciate that certain oral conditions change the patient's lifestyle. Oral conditions with painful symptoms influence the way in which the patient masticates, but also the type of food consumed. The reduction in masticatory efficiency and the avoidance of foods with a high consistency and rich in vitamins determine over time a series of gastrointestinal conditions. When the patient develops these conditions, he becomes dependent on certain drug treatments that modify his social life and reduce his financial possibilities [17].

Considering the impact of DHS on the patient's quality of life, multiple treatments have been described in the literature, each with its advantages and disadvantages. Among these, the use of specific pharmaceutical products, the application of adhesive systems and laser irradiation of the affected surface stood out for their ease of application and efficiency, for which we included relevant clinical cases in this dissertation.

In recent years, the attention of specialists has focused on laser treatment of the affected dental surface for its desensitization. Both high/medium power and low power lasers can relieve pain when used with appropriate power settings. These treatments demonstrate an instant pain relief effect upon application and offer long-term benefits [18]. The effectiveness of laser treatment was also noted in patients who benefited from this treatment in our study.

However, there is very limited evidence available to support the advantages of laser therapy over conventional therapy for the treatment of DHS. In addition, there are no widely accepted working protocols regarding which types of lasers or laser parameters (e.g. wavelength, mode, power density) are more effective. Future studies are needed to further investigate the clinical efficacy of lasers, as well as their cost-effectiveness [19].

The widely accepted and widely used treatment option for DHS remains the use of desensitizing pharmaceuticals. Clinical and laboratory studies have demonstrated the beneficial clinical effects of pharmaceuticals containing calcium phosphate on DHS. Regardless of the test used (air jet, tactile, or cold water), calcium phosphate induced a reduction in pain levels by an average of 2.5 on the VAS scale after 4 weeks. These results can be explained by the ability of calcium phosphates to spontaneously form

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hydroxyapatite at physiological pH and to adhere to exposed dentin, forming a layer of calcium phosphate components, which may allow them to seal exposed dentinal tubules and, consequently, be a good candidate for the treatment of DHS [20].

The present study draws attention to the impact of DHS on the quality of life of patients and the need for an individualized and complete treatment that also addresses cervical tooth wear.

One of the limitations of this study is that the results cannot be extrapolated to the general population, since all subjects were of similar ages and backgrounds. Also, the study groups were composed of a small number of participants, and a significant statistical analysis could not be performed.

5. Conclusions

1. Final year dental students and young dentists demonstrated a high level of knowledge of the etiology, symptomatology and treatment of DHS.

2. The development of DHS in the context of incipient cervical tooth wear is an aspect insufficiently known by dental practitioners.

3. The results of the distributed questionnaire demonstrated that DHS has a profound effect on the quality of life of individuals.

4. This study demonstrates the need for further studies on the mechanism of cervical wear for a better understanding among dentists and dental students.

5. Laser irradiation of the tooth surface for its desensitization represents a modern and effective dental treatment of DHS.

6. The use of desensitizing pharmaceutical products implies compliance with the application protocol to improve painful symptoms.

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Author contributions

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ORIGINAL ARTICLE

MANAGEMENT OF THE HYPERTENSIVE PATIENT IN THE DENTAL OFFICE

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Abstract: This study investigates the dental treatment possibilities for patients with arterial hypertension, focusing on the interplay between systemic health and oral care. Conducted at the Oral Rehabilitation Clinic of the Faculty of Dental Medicine in Craiova, Romania, the research involved 820 patients aged 25–75, including both hypertensive individuals and a control group. Findings revealed a higher prevalence of dental issues among hypertensive patients, characterized by elevated DMFT scores, increased plaque accumulation, and deeper periodontal probing depths. Risk factors such as high salt intake, alcohol consumption, smoking, stress, and genetic predisposition were prevalent in the hypertensive cohort. Additionally, some patients experienced gingival hyperplasia as a side effect of antihypertensive medications, notably calcium channel blockers. The study underscores the necessity for personalized dental treatment plans that consider blood pressure control, medication effects, and overall health status. Furthermore, it highlights the importance of interdisciplinary collaboration between dental and medical professionals to optimize care for hypertensive patients. These insights contribute to the development of comprehensive care strategies that integrate dental and medical expertise.

Keywords: hypertension, oral health, dentistry, dental treatment, interdisciplinary collaboration

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1. Introduction

Hypertension (HTN) remains one of the most prevalent and modifiable risk factors for cardiovascular morbidity and mortality worldwide. According to recent data, hypertension affects approximately 30–40% of the global adult population, posing a major public health burden [1]. The definition of hypertension has been refined in recent years: while older thresholds (e.g., ≥140/90 mmHg) were standard, many guidelines now recognize lower thresholds (e.g., ≥130/80 mmHg) for diagnosis and treatment initiation in high-risk populations [2].

Despite the availability of effective antihypertensive therapies, blood pressure control remains suboptimal. In the United States, recent analyses showed that the proportion of adults with controlled hypertension has stagnated or declined in the past decade [3]. Globally, uncontrolled hypertension (uHTN) and treatment-resistant hypertension (rHTN) remain significant challenges, especially in patients with comorbidities or complex cardiovascular profiles [4]. For instance, a single-center study found that approximately 3.4% of hypertensive patients met criteria for resistant hypertension, most of whom had high or very high cardiovascular risk [5].

In the context of dental practice, hypertensive patients pose specific challenges. First, many patients presenting for dental care may have undiagnosed or poorly controlled blood pressure, since hypertension is often asymptomatic [6]. Second, dentists must consider how both hypertension and its pharmacologic treatment may interact with dental procedures, including the use of local anesthetics with vasoconstrictors, management of bleeding risk, and potential drug interactions [6]. Finally, the dental office represents an opportunity for opportunistic screening and early referral for medical evaluation, particularly in patients without regular access to primary care [7].

The 2024 ESC Clinical Practice Guidelines, introduced a significantly simplified classification system for office blood pressure (BP) measurement, aimed at enhancing clinical applicability and decision-making [8]. The classification now includes only three main categories: non-elevated BP, elevated BP, and hypertension, eliminating the older multi-tiered system that included “optimal,” “normal,” and “high-normal” ranges [9].

Patients with non-elevated blood pressure (i.e., <120/70 mmHg) are not candidates for pharmacological treatment and should undergo routine monitoring only. Those with elevated BP (systolic 120–139 mmHg and/or diastolic 70–89 mmHg) require a more nuanced evaluation. According to Williams et al. [10], treatment decisions in this category depend on the individual's total cardiovascular risk, presence of organ damage, or comorbid conditions such as diabetes or chronic kidney disease. For individuals with hypertension, defined as a systolic BP ≥140 mmHg and/or diastolic BP ≥90 mmHg, diagnosis must be confirmed through repeated office or out-of-office measurements. Once confirmed, initiation of antihypertensive therapy is generally indicated. Whelton and Carey emphasize that out-of-office blood pressure measurements (via home or ambulatory monitoring) are increasingly critical to accurate diagnosis and management, as they

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correlate better with target-organ damage and long-term outcomes [11].

The 2024 guidelines also propose lower treatment targets than previous versions. Specifically, McEvoy et al. recommend that most patients under treatment should aim for a systolic BP between 120–129 mmHg, provided this target is well tolerated [8]. Kreutz et al. highlight this as a major shift from the 2018 and 2023 guidelines, reinforcing the need for more aggressive, individualized BP management strategies [9].

Hypertension (HTN) significantly impacts dental care, necessitating tailored management strategies to ensure patient safety and optimal outcomes. Elevated blood pressure levels can increase the risk of cardiovascular complications during dental procedures, especially those involving anxiety, pain, or use of vasoconstrictors [12]. Patients with uncontrolled hypertension are at higher risk for intraoperative hypertensive crises, which can lead to adverse events such as stroke or myocardial infarction [13].

The use of local anesthetics containing vasoconstrictors, such as epinephrine, is common in dental procedures to prolong anesthetic effect and reduce bleeding. However, vasoconstrictors may transiently raise blood pressure and heart rate, posing a potential risk for hypertensive patients. Studies have shown that careful dose control and avoidance of excessive vasoconstrictor amounts can mitigate these risks, and local anesthesia remains generally safe when used appropriately [14]. Furthermore, drug interactions between antihypertensive medications (e.g., beta-blockers, calcium channel blockers) and dental drugs must be considered to avoid adverse effects such as excessive hypotension or arrhythmias [15].

Dental procedures themselves can trigger sympathetic nervous system activation due to anxiety or pain, which can exacerbate hypertension. Effective pain management and anxiety control, including behavioral techniques and pharmacological support, are therefore crucial in hypertensive patients undergoing dental treatment [16]. Moreover, certain antihypertensive agents may cause oral side effects, including xerostomia, gingival overgrowth (notably with calcium channel blockers like nifedipine), and altered taste, which require specific dental management [17].

Importantly, the dental office represents a valuable setting for opportunistic blood pressure screening and early detection of hypertension. Studies suggest that many dental patients are unaware of their hypertensive status, and routine BP measurement during dental visits can facilitate timely medical referral and improve cardiovascular outcomes [18].

The aim of the study was to determine the possibilities for dental treatment in patients with arterial hypertension (HT), and to highlight the factors that influence the dental treatment plan in patients with HT and the way of implementing it in everyday dental practice with the goal of achieving the best outcomes, offering a standard of life quality and maintaining the oral health of these patients.

2. Materials and method

The study was conducted on a group of dental patients who attended the Oral Rehabilitation clinical rotations at the Faculty of Dental Medicine, Craiova on a period of

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eight years, from 2013 to 2020, including patients from general population but also from Craiova Nursing Home.

The patients consented to clinical examination and completed a health questionnaire. All patients included in the study gave informed consent for all medical procedures performed. All participants signed the data management agreement (GDPR) and completed the standard form for inclusion in medical research according to Law no. 46/2003. The study was approved by the Ethics Committee of the University of Medicine and Pharmacy of Craiova, with no 22/31.01.2013.

For each patient, a detailed medical history was taken, during which data regarding general health and medication were recorded, along with extraoral and intraoral clinical examinations. For each patient a file was completed; inspection, palpation, and evaluation of the dental-periodontal status were conducted; photographs were taken; a diagnosis was established, a treatment plan was laid out, and the progression of the case was monitored.

3. Results

820 patients were included in this study, aged between 25 and 75 years. Of these, 438 patients were female and 382 patients were male. Among the patients included in the study group (with HTN), 377 were aged between 30–50 years, 315 between 50–65 years, and 128 were over 65 years. Most patients in the control group fell in the 30–50 age range, followed by the 50–65 age group, and then those over 65 years (Table no.1).

Table 1. Demographic data.

Parameter	Category	Control Group (without HTN)	Study Group (with HTN)	Total
Gender	Women	405	33	438
	Men	352	30	382
Age (years)	30-50	355	22	377
	50-65	288	27	315
	Over 65	114	14	128
Total	-	755	63	820

Among the risk factors that lead to arterial hypertension, the most frequently encountered in the study group were salt intake, alcohol consumption, smoking, stress from various situations, and genetic factor (Table no.2).

Table 2. Risk factors for arterial hypertension in the study group.

Risk Factor	Women	Men	Total
High salt intake	11	20	31
High alcohol consumption	7	15	22
Smoking	4	9	15
Sedentary lifestyle	22	14	36
Stress	33	20	53
Age	3	4	7
Family history	6	13	19
Sleep apnea	0	0	0
Kidney diseases	2	3	5

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Thyroid diseases	12	3	15
Adrenal gland disorders	0	0	0
Depression	5	1	6

In the control group, women and men exhibited average blood pressures of 122/78 mmHg and 124/76 mmHg respectively, while in the hypertensive study group their values rose to 153/95 mmHg and 169/103 mmHg. Overall, the aggregate average blood pressure increased from 123/77 mmHg in non-hypertensive individuals to 161/99 mmHg in hypertensive subjects, with a combined mean of 142/88 mmHg (Table no.3).

Table 3. Average blood pressure values of patients in the study group.

Sex	Control Group (without HTN)	Study Group (with HTN)	Average BP Value
Women	122/78 mmHg	153/95 mmHg	138/87 mmHg
Men	124/76 mmHg	169/103 mmHg	147/90 mmHg
Average BP Value	123/77 mmHg	161/99 mmHg	142/88 mmHg

Following the intraoral clinical examination, it was found that the oral health of patients in the study group is poor. The patients have a large number of missing and decayed teeth and a small number of treated teeth, the mean DMFT being quite high (Figure 1).

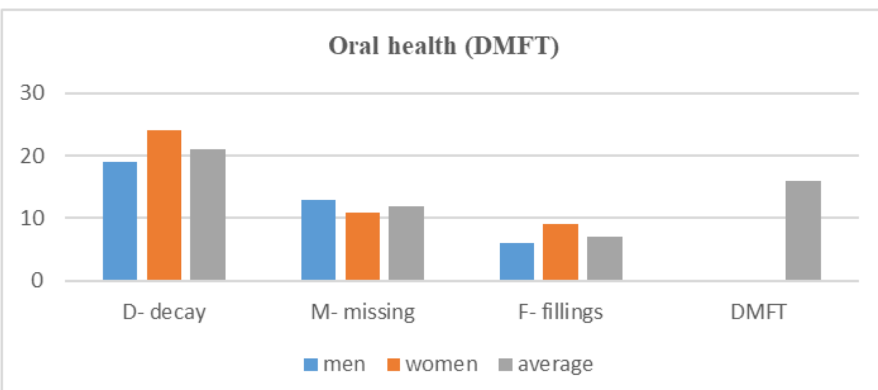

Figure 1. DMFT index of the patients from the study group.

In the examined cohort, edentulous patterns followed the Kennedy classification, with seventeen patients showing Class I edentulism (ten women, seven men), eight female patient and six men displaying Class II. Six men and four women patient were diagnosed with Class III edentulism; notably, no cases of Class IV edentulism occurred. This distribution suggests that free-end (posterior) edentulous spaces (Classes I and II) are more prevalent in this hypertensive sample than anterior bounded spaces, which may influence prosthetic planning, support requirements, and biomechanical considerations in partial denture design. (Table no.4).

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Table 4. Types of edentulism in the patients from the study group.

Kennedy Class	Women	Men	Total
Kennedy Class I edentulism	10	7	17
Kennedy Class II edentulism	8	6	14
Kennedy Class III edentulism	4	6	10
Kennedy Class IV edentulism	0	0	0

The hypertensive patients from this study exhibited a range of dental issues, from dentin hypersensitivity and carious lesions to partial or total edentulism and periodontal complications. Most patients were on antihypertensive medication, with notable differences in blood pressure control and treatment adherence. Poor oral hygiene was a common factor, linked to the progression of dental and periodontal lesions, highlighting the interconnection between hypertension and oral health. Additionally, the impact of antihypertensive drugs, such as calcium channel blockers, was observed in the development of gingival hyperplasia in some patients. Despite variations in age, living environment, and medical history, dental treatments were individually tailored considering blood pressure control and overall patient condition (Figure 2).

(a) (b) (c)

Figure 2. Clinical photos of the some of the patients from the study group, showing: (a) cervical carious lesions; (b) following the removal of the prosthetic restoration, the coronal abutments exhibited structural fractures and active carious lesions, indicating underlying dental tissue compromise; (c) patient with Kennedy class III/1 mandibular edentulism, poor oral hygiene and a non-restorable root remnant.

4. Discussion

The management of hypertension primarily focuses on reducing cardiovascular risk through effective blood pressure control, which involves lifestyle modifications combined with pharmacological therapy when necessary. The main classes of antihypertensive medications recommended by recent guidelines include angiotensin-converting enzyme inhibitors (ACE inhibitors), angiotensin II receptor blockers (ARBs), calcium channel blockers (CCBs), thiazide and thiazide-like diuretics, and beta-blockers [19]. ACE inhibitors and ARBs work by modulating the renin-angiotensin-aldosterone system (RAAS), thereby reducing vasoconstriction and sodium retention. Calcium channel blockers act by inhibiting calcium influx in vascular smooth muscle,

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causing vasodilation, whereas diuretics reduce blood volume by promoting renal sodium and water excretion [20].

Beta-blockers, although less favored as first-line therapy in some recent guidelines, are still used particularly in patients with specific indications such as ischemic heart disease or arrhythmias [21]. Combination therapy is often required to achieve target blood pressure levels, especially in patients with stage 2 hypertension or additional cardiovascular risk factors [22]. Newer therapeutic options and personalized medicine approaches continue to evolve, aiming to improve efficacy and reduce side effects [23].

Dentists play a significant role in oral health and prevention, so, they should have a positive attitude and self-efficacy in doctor-patient communication with practical applications. Communication skills should be included as an important educational goal for dentists and given enough weight in objective, systematic clinical assessments [24, 25]. These cases emphasize the importance of integrated dental management and close collaboration with cardiologists to optimize care for hypertensive patients.

In hypertensive patients, particular attention is drawn to the importance of oral hygiene, as poor oral hygiene has been observed to exacerbate cardiovascular disease. A recent study [26], which included a cohort of over 800 romanian patients, found that the most frequent systemic diseases in the studied group were hypertension, allergies, anemia, sinusitis, sleep disorders, and type II diabetes. The findings highlight the significant impact of hypertension on oral health and underscore the importance of integrated dental and medical management [27].

In hypertensive patients, special attention is drawn to the importance of oral hygiene, as poor oral hygiene has been observed to contribute to the worsening of cardiovascular disease. A recent national study [28] conducted in Italy, demonstrated that home oral hygiene habits, such as brushing teeth at least three times a day and using an electric toothbrush, are inversely associated with blood pressure profiles, independent of sex, age, body mass index, smoking, diet, physical activity, and history of diabetes or hyperlipidemia. This association suggests that adequate oral hygiene may help prevent hypertension and related cardiovascular complications. Additionally, studies [29] from southwestern Romania evaluated periodontal status and oral hygiene in hypertensive patients, emphasizing the importance of maintaining proper oral hygiene in this population.

Several of the risk factors observed in our study have likewise been reported by other researchers as significant contributors to hypertension: high alcohol consumption is significantly associated with increased risk of hypertension, particularly in men. A 2025 meta-analysis emphasizes a near-linear relationship between alcohol intake and blood pressure elevation in men, whereas in women, effects become significant only at higher consumption levels [30].

Regarding salt intake, current research highlights that high dietary sodium is associated with a marked increase in cardiovascular mortality. The adverse effects are amplified by an imbalanced sodium-to-

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potassium ratio, especially among women [31].

Physical inactivity remains an important risk factor in low- and middle-income populations. A recent multi-country study found a strong association between sedentary behavior and hypertension, particularly when coupled with obesity and poor diet [32].

Psychological stress and family history of hypertension are less frequently quantified in clinical trials, but recent evidence shows that their interaction with alcohol use and genetic predisposition may significantly amplify hypertension risk, especially among women [33].

Age is a non-modifiable yet highly relevant predictor of hypertension. Recent findings suggest that, beyond a certain age, women tend to have a higher prevalence of uncontrolled hypertension compared to men [34].

Moreover, sex-specific analysis of risk exposure is essential. For instance, a recent study on alcohol use and hypertension showed that while men have a higher absolute prevalence, the relative hazard ratio (HR) for alcohol exposure is often greater in women when compared to their non-drinking counterparts [35].

Collaboration between dentists and cardiologists is essential for managing hypertensive patients, as oral health can influence cardiovascular outcomes [36]. Studies show that dentists play a crucial role in identifying undiagnosed hypertension and managing associated risks [37]. For instance, a two-step hypertension screening conducted in dental offices identified 170 newly diagnosed hypertensive patients, highlighting the potential of dental settings for early detection [36]. However, research from Saudi Arabia revealed that only 13.3% of dentists regularly measure blood pressure before treatment, indicating a need for better training and clear protocols [38]. Additionally, studies have demonstrated that periodontitis and tooth loss are linked to increased cardiovascular risk, suggesting that dental care significantly impacts cardiovascular health [39] and have highlighted [40] the importance of adequate management of hypertensive patients in dental settings, emphasizing the need for careful assessment of cardiovascular status prior to dental procedures. Therefore, promoting interdisciplinary collaboration between dental and cardiology professionals is crucial for comprehensive patient care.

In recent years, digital technologies have shown their potential to improve efficiency and communication in healthcare settings. A study [41] on the use of digital tools in transferring data between a dental office and a dental laboratory, found out that while orthopantomograms (OPG) were universally used, more advanced modalities like intraoral scanning and digital impressions were still underutilized. Drawing a parallel to hypertension care, similar digital systems could enable real-time sharing of blood pressure data, medical imaging, patient history across care teams, or medication adherence reports, can support timely interventions and personalized treatment plans, especially in multidisciplinary care settings.

A higher prevalence of dental issues among hypertensive patients was observed in our study, as evidenced by elevated DMFT scores compared to the control group. This finding aligns with recent research indicating

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a significant association between hypertension and poor oral health. For instance, a study conducted in Romania reported that hypertensive individuals exhibited higher plaque and bleeding indices, along with increased probing depths, suggesting a greater risk of periodontal disease [26]. This study identified several risk factors contributing to hypertension among dental patients, including high salt intake, alcohol consumption, smoking, stress, and genetic predisposition. These factors are consistent with those reported in the literature. A recent study found that poor oral hygiene and periodontal disease were associated with increased blood pressure, potentially through systemic inflammation pathways [42]

Many hypertensive patients were on antihypertensive medications, with some experiencing side effects such as gingival hyperplasia. This is corroborated by existing literature, which indicates that certain antihypertensive drugs, like calcium channel blockers, can lead to gingival overgrowth, necessitating careful dental monitoring. [42].

Recent evidence suggests a strong link between oral health and cardiovascular conditions. Hospitalized adults with a lower number of remaining teeth were found to have a higher prevalence of specific cardiovascular diseases, indicating that tooth loss may serve as a predictive marker for cardiovascular risk [43,45]. The interplay between cardiovascular medications and dental management has also been highlighted, as the use of propranolol can affect serum concentrations of local anesthetics during dental procedures, emphasizing the need for careful clinical planning in hypertensive patients [44]. Additionally, subjects with cardiovascular diseases exhibited more pronounced dental wear compared to individuals without systemic conditions, suggesting that systemic disease may accelerate oral tissue degeneration [45]. Collectively, these findings underscore the importance of integrating oral health assessments into cardiovascular risk evaluation, reinforcing the bidirectional relationship between dental status and systemic disease [43, 46].

Our study emphasizes the need for interdisciplinary collaboration between dental and medical professionals to manage hypertensive patients effectively, supported by recent research, which suggests that dental professionals play a crucial role in identifying undiagnosed hypertension and managing its oral manifestations [47].

5. Conclusions

- *Prevalence of Oral Health Issues*: Hypertensive patients exhibited a higher prevalence of dental problems, including increased DMFT scores, compared to the control group.
- *Risk Factors for Hypertension*: Key risk factors contributing to hypertension among dental patients included high salt intake, alcohol consumption, smoking, stress, and genetic predisposition.
- *Impact of Antihypertensive Medications*: Some hypertensive patients experienced side effects such as gingival hyperplasia due to antihypertensive medications, necessitating careful dental monitoring.
- *Need for Interdisciplinary Collaboration*: Effective management of hypertensive patients requires interdisciplinary collaboration between dental and medical professionals to address both oral and systemic health.

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- *Importance of Individualized Dental* Treatment Plans: Dental treatment plans for hypertensive patients should be tailored to individual needs, considering factors like blood pressure control, medication use, and overall health status.

These conclusions underscore the complex relationship between hypertension and oral health, highlighting the necessity for comprehensive care strategies that integrate dental and medical expertise.

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Author contributions

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Conflict of interest statement

The authors declare no conflicts of interest concerning this study.

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Will be provided on request.

Ethics statement

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ORIGINAL ARTICLE

DIRECT VS. INDIRECT TECHNIQUES IN CORONAL RESTORATIONS: AN OBSERVATIONAL STUDY

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Abstract: *Background*: In recent years, direct composite resin restorations have become the preferred choice for treating posterior cavities due to their favorable mechanical strength and aesthetic properties. Indirect restorations are generally recommended for managing larger dental defects. This study aims to analyze the therapeutic options employed in coronal restoration using direct and indirect techniques in a real clinical setting, highlighting their distribution according to the types of restorative materials used. *Methods*: An observational study was conducted on a sample of 31 clinical cases involving upper and lower teeth, consecutively selected from private dental practice and a dental laboratory between January and April 2025. *Results*: A correlation analysis was performed between the chosen treatment method and lesion diagnosis. Of the 21 patients diagnosed with carious lesions, the majority received direct restorations, demonstrating that carious lesions (particularly those of moderate size) can be effectively treated with direct restorations performed in the dental office without requiring complex procedures or additional interventions. *Conclusions*: Direct techniques were preferred when a conservative intervention was desired, maximizing preservation of dental hard tissues. Indirect techniques were chosen in cases requiring superior control over the restoration's aesthetics.

Keywords: direct restoration, indirect restoration, dental composites, ceramic materials

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1. Introduction

Since their introduction into clinical practice, both resin composite materials and adhesive techniques have undergone significant improvements [1,2]. When adhesive protocols are carefully followed and direct restorations are correctly placed, they can demonstrate long-term clinical success lasting several decades [3].

Despite these advancements, resin composite restorations remain prone to failures, most commonly due to secondary carious lesions and fractures [4]. The likelihood of failure tends to increase in older patients, in those wearing removable prostheses [5], and in restorations involving molars, endodontically treated teeth, or multiple surfaces [6].

In addition, direct restorations placed by less experienced clinicians or those working in large dental group practices are more susceptible to failure [5]. Gender does not appear to play a significant role in the success of direct restorations [3,5]. The specific type of resin composite material also does not seem to influence the long-term success of direct restorations [6]. However, "sandwich" restorations (combining resin composites with glass ionomer cements) have been associated with marginal defects due to the dissolution of the glass ionomer component [7].

The development of secondary carious lesions is generally attributed to polymerization shrinkage and stress at the tooth-material interface. Fractures are often related to the mechanical limitations of the materials and tooth or patient-specific factors, particularly in larger restorations involving cusp reconstruction [8].

Another important consideration is the effectiveness of polymerization in direct resin composite restorations, which can be compromised by inadequate maintenance of light-curing units and technique-sensitive variables during placement [9].

Indirect resin composite restorations help address several limitations associated with the direct technique and are theoretically expected to offer increased longevity. These restorations can be fabricated using prefabricated resin composite blocks through computer-aided design and manufacturing (CAD/CAM) technology or with laboratory-processed restorative composites fabricated by a dental technician. These materials benefit from prolonged polymerization under controlled conditions and from multiple directions, resulting in a higher degree of monomer conversion and, consequently, improved mechanical properties [10].

Additionally, some resin composites used for indirect restorations can undergo heat treatment, which further increases their degree of conversion and helps improve mechanical properties such as microhardness [11]. The superior monomer conversion achieved in indirect restorations contributes to better biocompatibility, as the release of monomers is significantly lower compared to direct resin composites. This is largely due to the fact that potential monomer elution is limited to the thin layer of resin cement used to bond the restoration to the tooth [12,13]. Another advantage of indirect restorations is the ability to achieve more precise and stable occlusion. This is facilitated by the dental technician’s capacity to accurately reproduce the missing tooth anatomy on gypsum models and to

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verify occlusal guidance using an articulator [14,15].

However, the indirect technique comes with some notable disadvantages. These include higher costs, the need for multiple dental visits-although this can be reduced with CAD/CAM workflows [14,15] as well as the removal of a greater amount of tooth structure during preparation compared to direct restorations [16,17].

Regardless of the material used, the main reasons for failure in indirect restorations are similar to those seen in direct ones, primarily involving fractures and secondary carious lesions. Fractures are more frequently associated with ceramic materials, while carious lesions are more commonly linked to cemented metal-based restorations [18].

In terms of performance, indirect gold restorations have demonstrated superior outcomes compared to indirect resin composite restorations over the medium and long term. Meanwhile, lithium disilicate and leucite-based indirect restorations have shown comparable survival rates to indirect resin composites over the short and medium term [19].

Interestingly, the clinical success of gold restorations does not appear to be influenced by tooth- or patient-related factors such as tooth type, restoration design, margin placement, pulp capping, use of liners, the presence of craniomandibular disorders, patient age, gender, or compliance with maintenance care [20]. Similarly, no consistent associations have been reported between the longevity of indirect resin composite restorations and specific tooth- or patient-related variables [19,21,22].

Furthermore, the method of fabrication and cementation whether using CAD/CAM, pressable, or layered techniques, or applying selective enamel etching before using self-adhesive resin cements does not seem to have a significant impact on the longevity of indirect restorations, including resin composites used in these treatments [23-25].

The novelty of this study lies in its comparative, clinically applied approach to real-world therapeutic choices made in coronal restorations, without experimental interventions or controlled laboratory conditions. The study provides relevant data on the frequency of use of direct and indirect techniques in a current clinical setting, including details related to the restorative materials preferred based on clinical indications.

Additionally, it may contribute to understanding current trends in coronal rehabilitation and to shaping a perspective grounded in direct clinical observation.

The aim of this study is to analyze the therapeutic options adopted in coronal restoration using direct and indirect techniques in a real clinical environment, and to highlight their distribution according to the types of restorative materials used.

2. Materials and method

This observational study was conducted on a sample of 31 clinical cases involving restorations of both upper and lower teeth, consecutively selected from a private dental practice and a dental laboratory between January and April 2025. The study aimed to analyze the use of direct and indirect techniques in partial coronal restorations and to assess the complexity of the clinical cases.

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All patients provided informed consent to participate in the study.

Inclusion criteria:

- Vital teeth diagnosed with simple carious lesions, dental fractures, or discoloration;
- Upper and lower, anterior and posterior teeth;
- Teeth restored using either direct or indirect techniques;
- Good patient cooperation and signed informed consent.

Exclusion criteria:

- Non-vital teeth;
- History of failed prior endodontic treatment;
- Patients with severe systemic conditions;
- Teeth that could not be effectively isolated with a rubber dam system.

For each case, the following parameters were evaluated:

- Patient gender and age;
- Reason for presentation and lesion diagnosis;
- Type of restorative technique used (direct or indirect);
- Restorative material applied.

All clinical procedures were performed by the same clinician, and all inlays/onlays or veneers were fabricated by the same dental technician, in order to minimize technical variability.

Statistical Analysis

For the 31 patients included in the study, a descriptive statistical analysis was conducted using Microsoft Excel, a spreadsheet software developed and distributed by Microsoft Corporation, headquartered in Redmond, Washington, United States. The analysis included pie charts, bar graphs, and line graphs to clearly visualize the distribution of patients based on various clinical criteria, such as the diagnosis of the dental lesion and the chosen treatment method (direct or indirect technique).

3. Results

A total of 31 patients were included in the present study, selected based on clinical criteria relevant to the evaluation of the type of dental lesion and the treatment method applied. Of the total participants, 18 were female, representing 58% of the analyzed sample. The remaining 13 patients, accounting for 42%, were male (Figure 1).

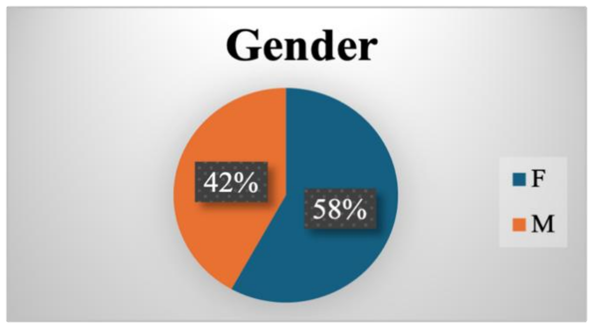

Figure 1. Patient distribution by gender.

The age of the patients included in the study ranged from 24 to 54 years, representing a socially and professionally active population in the adult stage of life. This age group is clinically relevant, as the incidence of dental conditions such as carious lesions, coronal fractures, and tooth discoloration is higher during this period (Figure 2).

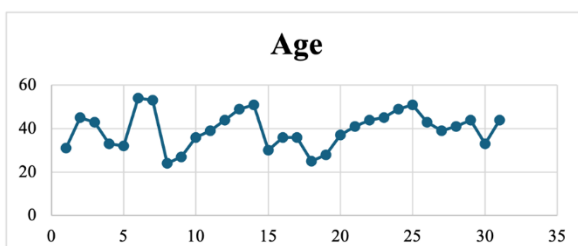

Figure 2. Distribution of patients by age.

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The age distribution between 24 and 54 years allowed for the application of a wide range of treatment methods, both direct and indirect, depending on the extent of dental damage and the individual aesthetic or functional needs of each patient. Moreover, since the study included young and middle-aged adults, the selection of restorative techniques also took into account patients' expectations regarding aesthetics, durability, and treatment time.

In addition to aesthetic concerns, some patients reported sensitivity to sweet foods, a common symptom associated with simple carious lesions, indicating enamel compromise and dentin exposure. Cases of sensitivity during toothbrushing and difficulties in mastication were also reported, generally caused by significant loss of tooth structure (Figure 3).

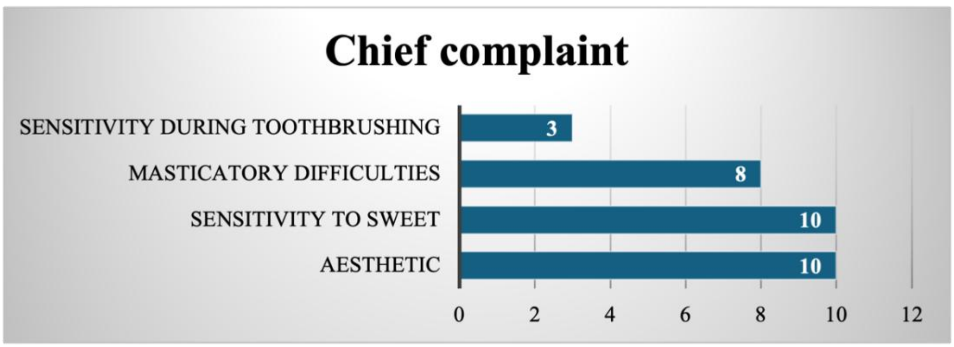

Figure 3. Medical reason for the clinic visit.

Regarding diagnosis, of the total 31 patients included in the study, the majority-21 patients (approximately 68%) were diagnosed with carious lesions, representing the primary dental issue investigated. A smaller number, 5 patients (approximately 16%), presented with dental fractures, which, although less frequent in this sample, often require complex interventions due to structural damage. Additionally, 5 patients (approximately 16%) were diagnosed with dental discolorations, aesthetic conditions that can significantly affect the smile's appearance and necessitated specific treatments (Figure 4).

Regarding the treatment method chosen for the 31 patients included in the study, an indirect technique was selected for 18 patients (approximately 58%), while a direct technique was applied in 13 patients (approximately 42%) (Figure 5).

In the case of the direct restoration technique, the majority of patients were treated with composite fillings. This method was selected for 10 patients, representing approximately 77% of the 13 patients who received direct restorations. Composite fillings are preferred due to their superior aesthetic properties, good adhesion to tooth structure, and long-term durability, making them especially suitable for both aesthetic and functional restorations of anterior and posterior teeth (Figure 6).

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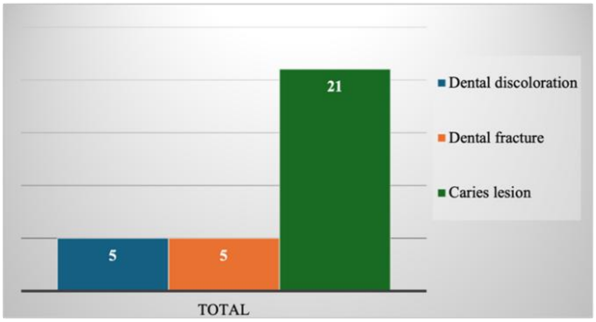

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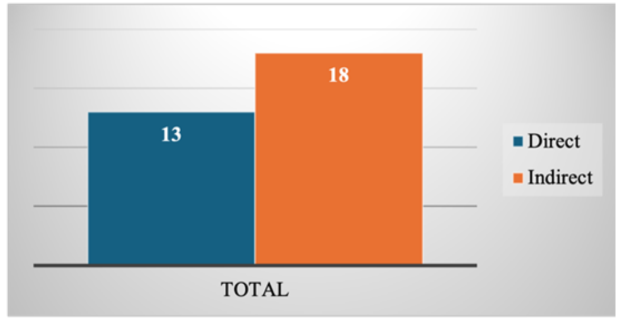

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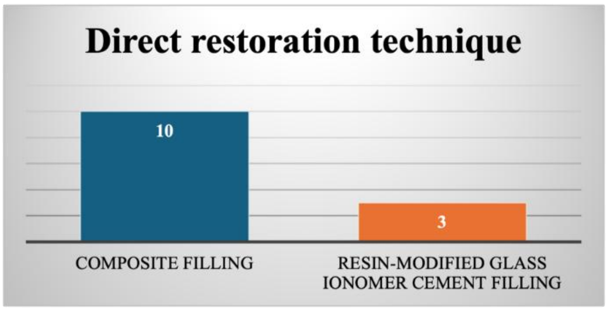

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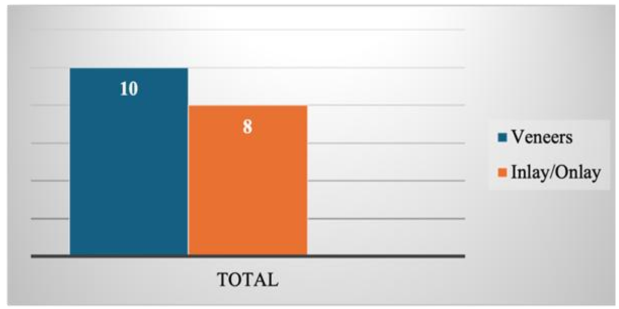

(Figure 7)

Figure 4. Distribution of patients by diagnosis. **Figure 5.** Distribution by chosen technique. **Figure 6.** Distribution for the direct restoration technique. **Figure 7.** Distribution for the indirect restoration technique.

In the case of indirect restoration techniques, applied to 18 patients, the majority received more complex aesthetic and functional restorations. Thus, 10 patients (approximately 56%) were treated with dental veneers, a method that provides significant aesthetic improvements (Figure 7).

Of the 10 patients who received dental veneers as part of the indirect technique, the majority were treated with ceramic veneers, which were used in 8 patients (80%). In contrast, only 2 patients (20%) received composite veneers, which, although a faster and less expensive option, have lower durability and mechanical strength compared to ceramic veneers (Figure 8). Composite veneers are preferred in cases where a minimally invasive treatment approach is desired.

Regarding inlays/onlays, out of a total of 8 patients who received this type of restoration within the indirect technique group, the majority-5 patients (62.5%) were treated with ceramic inlays/onlays. On the other hand, 3 patients (37.5%) received composite material inlays/onlays, a solution that offers advantages in terms of reduced fabrication time and lower costs, being indicated in cases with moderate lesions where a functional and aesthetically acceptable restoration is desired for the medium term (Figure 9).

An analysis of the correlation between the chosen treatment method and the lesion diagnosis was also performed for the 31 patients included in the study. Among the 21 patients diagnosed with carious lesions, the majority (13 patients) underwent direct restoration techniques, reflecting the fact that carious lesions, especially those of moderate

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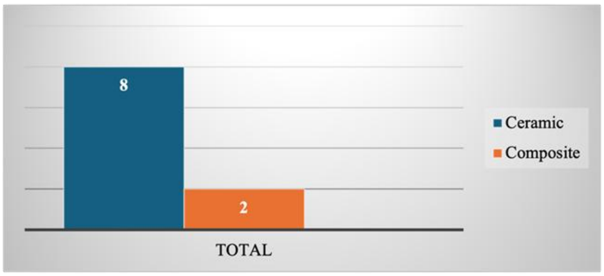
size, can be effectively treated with direct fillings performed in the dental office without requiring complex procedures or additional interventions (Figure 10). On the other hand, 8 patients in this group were treated using indirect techniques, indicating the need for more durable or aesthetic restorations in cases of extensive lesions or clinical situations where direct restorations did not provide an optimal long-term solution (Figure 10).



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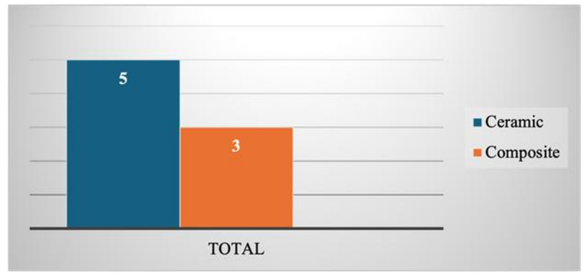

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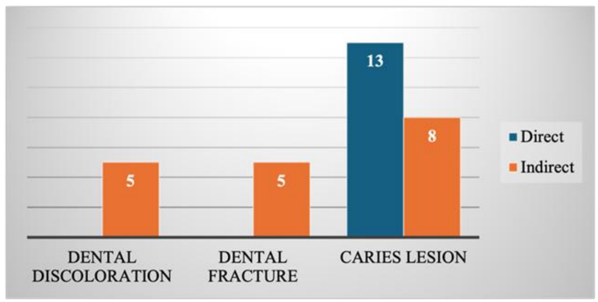

(Figure 10)

Figure 8. Distribution of veneers according to the material used. **Figure 9.** Distribution of inlays/onlays according to the material used. **Figure 10.** Correlation between the chosen treatment method and diagnosis.

The therapeutic approach for patients requiring dental veneers was developed with the main objective of restoring dental aesthetics and functionality through careful planning and minimally invasive clinical execution, tailored to the specific characteristics of each case. An example of this approach, in clinically healthy patients without significant medical history, known allergies, or previous major dental treatments in the anterior region, involves identifying a clear aesthetic motivation and establishing a durable, minimally invasive therapeutic solution aimed at improving the appearance of the smile by achieving a balanced, bright, and harmonious result. An example of clinical examination revealed that teeth 1.3-2.3 were vital and free of carious lesions; however, there was an unbalanced width-to-height ratio of the dental crowns, uneven enamel coloration, and an unaesthetic shape of the maxillary central and lateral incisors, with uneven dimensions (Figure 11).

Paraclinical examination included intraoral and extraoral photography for aesthetic analysis, digital scanning of the upper and lower arches, and the creation of a digital treatment plan using Digital Smile Design software. The diagnosis was dental discoloration accompanied by an incorrect proportion between the size and shape of the crowns.

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(Figure 11)

(Figure 12)

(Figure 13)

(Figure 14)

Figure 11. The initial appearance of the teeth. **Figure 12.** Representation of the 3D model. **Figure 13.** Representation of the ceramic veneers after glazing. **Figure 14.** Ceramic veneers applied on the printed model.

The therapeutic objective was to correct the esthetics of the shape, size, and color of the anterior teeth, achieve a natural, proportionate, and facially harmonious smile, conserve dental tissue through minimally invasive preparation, and use biocompatible, durable, and translucent materials. Ceramic veneers (E.max Press) were indicated due to maximal preservation of enamel, excellent mechanical resistance in the anterior region, superior aesthetics with translucency similar to natural enamel, and precise adaptation enabled by CAD/CAM technology and digitally controlled milling. Unlike traditional crowns, veneers cover only the facial surface of the tooth, preserving vitality and natural dental proportions.

The restorative treatment began with consultation and digital planning, including professional intraoral and extraoral photography, evaluation of facial parameters such as the smile line, symmetry, and proportions, and the creation of a digital mock-up and smile simulation (DSD). This was followed by a discussion with the patient to establish aesthetic expectations and approve the treatment plan. The digital mock-up was physically transferred into the oral cavity using a temporary composite material, verified both functionally and aesthetically, serving as a guide for subsequent conservative tooth preparation.

Tooth preparation involved limited enamel reduction (0.3-0.7 mm) without dentin exposure. Rounded contours were created to facilitate ceramic adaptation, monitored using reduction guides. Impressions were taken with precision using a double-mix, double-phase addition silicone technique, with careful isolation and recording of occlusion and

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antagonist arch. Shade selection was done according to the Vita guide. If necessary, provisional restorations were fabricated from flowable composites to maintain aesthetics until delivery of the final restoration.

In the dental laboratory, the restoration was modeled by 3D printing models based on scans or impressions (Figure 12), digitally designing veneers via CAD, followed by wax milling and pressing of E.max ceramic in the exact anatomical form according to the "press" technology. Finishing and glazing included sintering and glazing cycles (Figure 13), along with individualized staining to replicate the natural enamel effect.

The veneers were fitted on the printed model to verify proximal and occlusal contacts and marginal adaptation (Figure 14), then prepared for delivery to the clinic.

Definitive cementation began with a trial fit of each veneer in the oral cavity, verifying adaptation, shade, and aesthetics, obtaining the patient's approval before cementation. Restorations were prepared by sandblasting the internal surface with fine aluminum oxide, applying silane and allowing it to react according to the manufacturer's protocol. Tooth surfaces were prepared by selective etching of enamel with 37% phosphoric acid for 15 seconds, followed by application of a light-cured adhesive bonding agent. Cementation was performed using dual-cure resin cement applied on both veneer and tooth, with gradual light curing, removal of excess cement, and margin finishing.

Final adjustments included checking occlusal contacts in maximum intercuspation, lateral and protrusive movements, with occlusal refinements as needed. Margins were polished using fine abrasive systems and polishing brushes. Oral hygiene and maintenance instructions were provided to the patient. Postoperative follow-up involved an initial evaluation at 7 days and a subsequent check-up at 6 months to assess adaptation and maintain aesthetic integration.

The restorative treatment with ceramic veneers provided the patients with a natural and stable aesthetic result through a minimally invasive procedure. The choice of pressed ceramic allowed achieving high standards of translucency, gingival integration, and mechanical resistance, contributing significantly to clinical success and patient satisfaction.

The therapeutic approach for patients requiring onlay restorations was developed with the aim of preserving as much healthy dental structure as possible while restoring function, morphology, and aesthetics. Treatment planning was individualized based on the extent of hard tissue loss, occlusal requirements, and material selection to ensure long-term durability. Modern adhesive techniques were employed to achieve precise marginal adaptation and optimal integration within the existing dentition.

An example of clinical assessment and treatment planning in such cases involved patients presenting with occasional discomfort during mastication in the posterior mandibular region, typically caused by extensive coronal destruction or defective restorations. These patients reported no significant systemic conditions and had not undergone prior endodontic or prosthetic treatments in the affected area. Clinical examination revealed visible cavities or loss of dental structure in posterior teeth, often

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accompanied by mild pressure sensitivity during chewing, but without spontaneous or nocturnal pain. The main therapeutic objective was to restore masticatory function and aesthetics through a durable and conservative treatment option using onlay restorations. Clinical and radiographic examination revealed an extensive mesio-occluso-distal carious lesion involving a large portion of the occlusal surface of tooth 3.6, without communication with the pulp chamber. Vitality tests showed a positive response, and the periapical radiograph demonstrated no signs of periapical pathology. The final diagnosis was a mesio-occluso-distal carious lesion with partial loss of support of the buccal cusps, in a vital tooth.

The therapeutic objective was to achieve a durable, functional, and minimally invasive restoration that would protect the weakened cusps, preserve sound dental tissue, and restore anatomical integrity, aesthetics, and a stable occlusal relationship.

An indirect onlay restoration was selected as the treatment option. This prosthetic technique involves the fabrication of a restoration covering one or more cusps of the tooth without completely encasing the crown. The onlay represents an intermediate solution between an inlay (which does not cover the cusps) and a full crown (which covers the entire coronal surface), thus allowing a conservative yet effective approach.

The main advantages of an onlay include conservation of remaining tooth structure, restoration of masticatory function, precise marginal adaptation, superior aesthetics especially when using ceramic materials and protection of fragile cusps against fracture.

In this case, pressed ceramic (E.max Press) was chosen for its high mechanical strength and excellent esthetic properties.

Under local anesthesia and rubber dam isolation, all decayed dentin and fractured enamel margins were removed. The cavity was prepared according to the principles of indirect restorations, ensuring optimal adaptation of the future restoration. The parapulpal wall was preserved to maintain as much sound tooth structure as possible. After verifying the mechanical retention and stability of the margins, an impression was taken using an addition silicone material in two viscosities, accurately recording the cavity and adjacent teeth. An opposing arch impression and bite registration were also obtained.

A temporary restoration made of light-cured provisional composite material was placed to protect the cavity during the laboratory phase.

In the dental laboratory, a high-precision working model was poured using type IV dental gypsum and articulated with the opposing model. The dental technician analyzed the preparation and designed an onlay covering the affected cusps (Figure 15).

An anatomic wax-up was created to reproduce the original occlusal morphology while maintaining correct proximal and occlusal contacts. The restoration was then fabricated by the pressed ceramic technique (E.max Press), achieving an excellent fit on the working model (Figure 16). The onlay was subsequently glazed, its occlusal and marginal adaptation verified, and prepared for cementation.

During the clinical tryin, marginal adaptation, stability, color, and proximal

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contacts were checked. The internal surface of the restoration was sandblasted with fine aluminum oxide, silanized, and conditioned for bonding (Figure 17). The cavity was treated using selective enamel etching and a light-cured adhesive system.

(Figure 15)

(Figure 16)

(Figure 17)

Figure 15. Onlay restoration. **Figure 16.** Onlay adapted on the working model. **Figure 17.** Onlay adapted on the working model after sandblasting and silanization.

Cementation was performed using a dual-cure resin cement, applied both to the internal surface of the onlay and to the prepared cavity. The restoration was seated and maintained in position until complete polymerization was achieved.

After removing the excess cement, occlusal contacts were verified in maximum intercuspation, lateral and protrusive movements. Minor adjustments were performed, followed by final polishing of the restoration margins.

At the 7-day follow-up, the restoration showed excellent functional and esthetic integration. A routine control was scheduled at 6 months to evaluate the long-term stability of the restoration and the periodontal condition of the surrounding tissues.

The indirect ceramic onlay restoration on tooth 3.6 successfully restored the original morphology and function while preserving healthy dental tissue. The technique provided protection for the weakened cusps, precise marginal adaptation, and enhanced mechanical resistance in a highly loaded occlusal area, ensuring long-term clinical success.

Another therapeutic approach for onlay restorations focused on the management of posterior teeth affected by extensive structural loss but maintaining pulpal vitality. In these cases, the clinical objective was not only the replacement of lost tissue but also the reinforcement of the remaining tooth structure through a conservative and biomechanically sound design.

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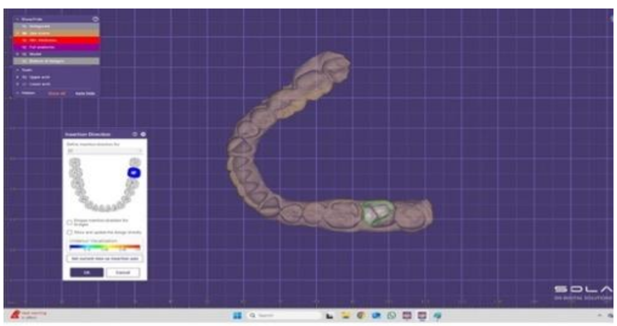
Patients typically presented with occasional masticatory discomfort in the posterior mandibular area, where clinical and radiographic examinations revealed occluso-mesial carious lesions involving cusp damage without pulpal communication or periapical pathology. Vitality tests confirmed positive responses, indicating a favorable prognosis for indirect adhesive rehabilitation.

The treatment strategy emphasized cusp coverage and structural reinforcement to restore occlusal integrity and prevent fracture risk. Pressed ceramic onlays (E.max Press) were selected for their optimal balance between mechanical strength, marginal precision, and aesthetic integration, offering a predictable long-term outcome and high patient satisfaction. The treatment followed the standard protocol for indirect restorations. After complete removal of carious tissue and verification of the cavity configuration, an impression was taken. A digital mock-up was designed, transferred, and tested intraorally to evaluate the esthetics and functionality of the proposed restoration (Figure 18).

This stage allowed a realistic three-dimensional visualization of the final outcome, providing both the clinician and the patient the opportunity to assess the restoration's adaptation in the clinical context (Figure 19). The position, shape, and volume of the planned onlay, as well as its integration into the existing occlusion, were carefully evaluated (Figure 20).



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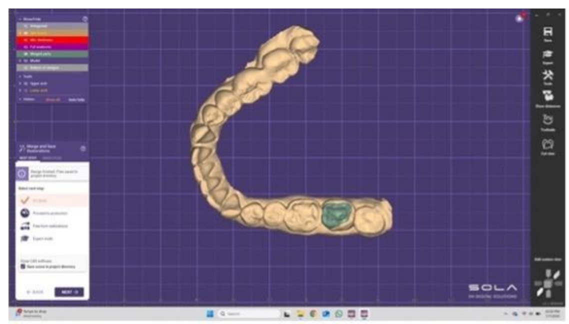

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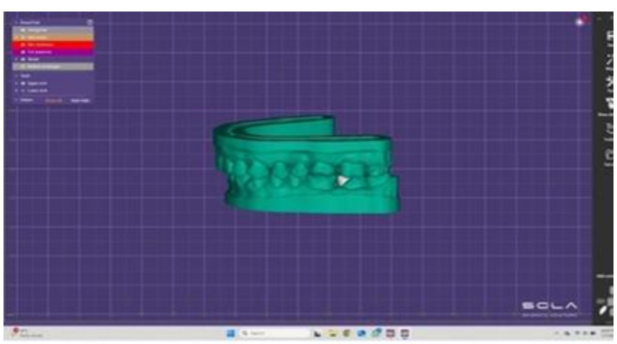

(Figure 20)

(Figure 21)

Figure 18. Digital mock-up representation. **Figure 19.** Three-dimensional view of the onlay. **Figure 20.** Viewing the integrated onlay in occlusion **Figure 21.** Ceramic veneers applied on the printed model.

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To protect the prepared cavity during the laboratory phase, a provisional restoration made of light-cured temporary composite was applied. It was shaped to ensure proper functional adaptation and an acceptable esthetic appearance, maintaining patient comfort and protecting the dental structure until final cementation.

After fabrication by the dental technician, the onlay was clinically tested to verify marginal adaptation, stability, shade match, and interproximal contacts. The internal surface of the onlay was treated by fine aluminum oxide sandblasting, followed by silanization to enhance adhesion with the resin cement. The tooth cavity was conditioned using selective etching and a light-cured adhesive. Cementation was performed with a dual-cure resin cement, applied both to the cavity and to the restoration. The onlay was precisely positioned and maintained in place until complete polymerization was achieved.

After removal of the excess cement, occlusal contacts were checked in maximum intercuspation, as well as in lateral and protrusive movements. Minor adjustments were made, followed by final polishing of the restoration margins to ensure a smooth transition between the restorative material and the natural tooth, optimizing both comfort and periodontal health.

At the 7-day postoperative control, functional and esthetic integration of the onlay was confirmed (Figure 21).

The patients were scheduled for periodic 6-month follow-up evaluations to assess the longevity of the restorations and monitor the periodontal health of the treated areas.

At follow-up examinations, the indirect ceramic onlay restorations demonstrated excellent functional integration and aesthetic harmony with the surrounding dentition. The restorations maintained stable occlusal relationships, ensured proper load distribution in the posterior region, and exhibited favorable periodontal responses. This therapeutic approach confirmed the reliability of adhesive ceramic onlays as a long-term solution for functional rehabilitation and aesthetic enhancement of posterior teeth.

4. Discussion

Contemporary dental medicine continues to advance in accordance with patients' growing expectations for high-quality aesthetic outcomes. Although materials such as amalgam and gold have a long history of clinical reliability, they are often rejected by patients due to their metallic appearance. Today, even restorations placed on posterior teeth are expected to closely mimic the natural appearance of enamel [26].

Minimally invasive restorative dentistry offers a wide range of techniques and materials for the conservative treatment of posterior teeth. Among these, resin composites-used either directly or indirectly-are widely accepted as effective aesthetic alternatives to metallic restorations [27].

Composite resins are composed of an organic polymer matrix combined with various types of inorganic filler particles. The clinical performance of composite resins is influenced by filler content, particle size, and the strength of the filler-matrix bond. In general, a higher filler load increases the mechanical strength of the restoration [27].

Dental composites have evolved significantly, progressing from traditional macrofilled and microfilled types to hybrid, microhybrid, and nanofilled composites. The

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latest generations feature smaller filler particles and higher total filler content, resulting in improved mechanical properties [28,29].

These fine particles reduce polymerization shrinkage and contribute to better color stability, flexural strength, and tensile strength. Various polymerization techniques are used to convert monomers into polymers, and a controlled degree of polymerization can further enhance properties such as strength, fracture resistance, and color stability [28,29].

Direct restorations involve placing light-cured resin composite directly into the prepared cavity. Their main advantage lies in the preservation of tooth structure, in accordance with the principles of minimally invasive dentistry. Typically, they can be completed in a single visit and are relatively inexpensive. However, they are prone to polymerization shrinkage and tend to have lower long-term durability [30].

In recent years, the use of glass ionomer cements has declined due to their limited durability in the oral cavity. They have been mainly recommended for restoring deciduous teeth or as intermediate restorative materials [31]. Nevertheless, glass ionomer-based materials have evolved significantly thanks to ongoing research and technological improvements. Resin-modified glass ionomer cements have been developed, combining the advantages of traditional ionomers with the properties of composites, providing greater mechanical strength, better stability in the oral environment, and superior esthetics [32].

In the current research, the analysis of direct restoration techniques showed that the majority of patients treated with this approach received composite fillings, with 10 out of 13 patients (approximately 77%) benefiting from this method. This preference reflects the advantages of composite materials, including superior aesthetics, strong adhesion to tooth structure, and long-term durability, making them suitable for both anterior and posterior restorations.

These materials have gained renewed interest and are increasingly used for Class I, II, and V restorations (according to Black's classification) in adult patients. Resin-modified glass ionomers offer chemical adhesion to tooth structure and long-term fluoride release, contributing to secondary caries prevention and favorable clinical performance in areas subject to moderate stress [33].

Additionally, because of their versatility and tolerance to moisture, these materials represent an attractive option for provisional or even definitive restorations, especially in cases where moisture control is difficult to achieve [33]. Amalgam has traditionally been used for posterior restorations due to its good marginal adaptation. However, its main advantage has always been the simplicity of application, which makes it a practical choice in many clinical situations [34].

In contrast, indirect restorations are fabricated outside the oral cavity using an impression of the prepared tooth. This technique minimizes shrinkage and allows for improved physical and mechanical performance through additional polymerization processes. Indirect restorations provide better occlusal anatomy, enhanced proximal contacts, and greater compatibility with antagonists. Despite these advantages, indirect techniques require more time, higher costs, and multiple appointments,

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which may not be suitable for all patients depending on their preferences or financial limitations [35].

Indirect restorations are generally recommended for larger dental defects. Before placement, the dentist must take an impression of the prepared tooth, which is then used to fabricate the restoration in a dental laboratory, requiring at least one additional visit for cementation. Alternatively, a digital 3D scan-either of a model or directly from the patient's mouth can be used to design the restoration virtually. The digital file is then sent to a milling device or a 3D printer to produce the final restoration [36].

Common materials used for indirect restorations include cast alloys, resin-based composites, and ceramics. Indirect restorations offer advantages such as increased wear resistance and mechanical strength. While softer metals like gold can adapt to oral conditions due to their malleability, ceramics are rigid and do not offer such flexibility [37,38].

Although several studies have shown that both direct and indirect restorations can achieve similar clinical outcomes, it remains important to determine which method should be considered the preferred first-line option for restoring lost tooth structure [37,38].

Direct restorations have demonstrated higher success rates in teeth with minimal to moderate structural loss compared to those with more extensive lesions. They are a viable option for vital posterior teeth with at least two remaining intact coronal walls. However, when the remaining tooth structure is significantly compromised, indirect restorations are generally preferred [30,34].

Indirect restorations have been shown to be more effective in patients diagnosed with amelogenesis imperfecta, as the altered enamel quality in these cases does not support strong adhesion to resin composites. Excluding cases with significant tissue loss or enamel defects, both direct and indirect restorations have demonstrated similar medium-term survival rates in posterior teeth. Moreover, for teeth with minimal to moderate structural loss, there is no significant difference in clinical performance between the two approaches [31].

In the present study, the treatment method applied to the 31 patients showed a predominance of indirect techniques, chosen in 58% of cases compared to 42% for direct techniques, thus reflecting a clinical tendency to prefer solutions with greater durability and superior aesthetics.

Veneers are custom-made restorative solutions fabricated from ceramic, porcelain, or resin composite, designed to cover the front surface of the teeth to improve their appearance. They are tailored to match the natural color and shape of the teeth and are used to mask imperfections such as discoloration, surface defects, or diastemas [39].

In the current study, regarding indirect restoration techniques applied to 18 patients, most cases involved more complex solutions aimed at achieving both aesthetic and functional improvements. Dental veneers were the most frequently chosen option, applied in 10 cases (approximately 56%), highlighting the importance of aesthetics in treatment planning for indirect restorations.

Different preparation methods exist depending on the type of veneer and the

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condition of the tooth. Traditional preparation involves removing a small amount of enamel from the front surface of the tooth, taking an impression, and sending it to a dental laboratory where the veneer is fabricated to match adjacent teeth. The veneer is then bonded to the tooth using resin cement [40].

For minor aesthetic concerns, such as small gaps, minimal or no-prep veneer techniques may be used. These approaches require little or no enamel removal, with the tooth surface being slightly roughened by acid etching to enhance adhesion [41].

Technological advances now allow digital scanning of the tooth and computer-aided design (CAD) of the veneer, ensuring a more precise fit. The veneer is then fabricated using a milling unit or 3D printer. Once produced, the veneer is bonded to the tooth using cementation techniques. Traditional cementation employs resin cements, while newer self-adhesive resin cements enable bonding without the need for separate enamel etching [42].

Composite veneers are frequently chosen because they offer a conservative and minimally invasive approach for treating discolorations, restoring fractures, and improving unattractive tooth shapes. However, they are prone to issues such as marginal fractures and staining, which can reduce their aesthetic appeal over time [43].

Recent advances in adhesive systems and the physical characteristics of resin composites have significantly improved the success and longevity of these restorations. Ceramic veneers are also widely used due to their durability and highly aesthetic outcomes. Nevertheless, they share some limitations with composites, including brittleness, potential postoperative sensitivity, marginal defects, and fracture risk [44,45].

Although ceramics are often preferred for their superior fracture resistance and long-term color stability, research has shown that composite veneers can also achieve excellent aesthetic and functional results [46]. Ceramic materials have long been the predominant choice for veneers, reflected by the broader body of research available on ceramic veneers compared to composite resin veneers. Numerous studies suggest that ceramic veneers provide better clinical outcomes than indirect composite laminate veneers [47,48].

Despite this, composite veneers have gained significant recognition for their ability to meet increasing aesthetic demands while offering the advantage of minimally invasive or even no-preparation treatment options for patients [43]. Bonding to enamel has been associated with reduced marginal discoloration and lower fracture rates [8]. Moreover, the more natural tooth structure is preserved, the less the tooth flexes, which may explain the low failure rates [44].

However, despite advances in materials and techniques, studies suggest that early veneer failures may be linked to other clinical factors. These early failures can result from inadequate treatment planning, technical errors during the procedure, or patient-related factors. These findings highlight that the success of a clinical treatment depends not only on materials and techniques but also on proper case selection, thorough planning, precise clinical and laboratory procedures, and patient habits [44].

In the present investigation, of the 10 patients who received dental veneers as part of the indirect technique, the majority were treated with ceramic veneers, applied in 8 cases (80%). This choice reflects the superior durability, mechanical strength, and aesthetic qualities of ceramic materials. In contrast, only 2 patients (20%) received composite veneers, which, although offering a faster and less expensive option, present lower longevity and mechanical performance. Composite veneers were chosen in cases where a minimally invasive treatment approach was prioritized.

For teeth with extensive carious lesions, inlays and onlays are often recommended as alternatives to full-coverage crowns. They tend to be more cost-effective and generally better accepted than complete crown restorations. Although ceramics are a popular aesthetic material for anterior crowns, their brittleness makes them less suitable for posterior restorations. The effectiveness of ceramic inlays and onlays in posterior teeth remains a subject of debate [49,50].

Several factors, including parafunctional habits, occlusal forces, and the presence of secondary caries, can influence the success of ceramic inlays and onlays [50,51]. Some studies have found that composite materials used for inlays and onlays show lower survival rates, with material type and follow-up duration significantly affecting restoration longevity. This may be due to greater material degradation over time [52].

Nevertheless, while hybrid materials and ceramics are generally preferred for indirect partial restorations in posterior teeth because of their superior clinical performance, composite materials can still be considered a valid option due to their cost-effectiveness, given that their survival rates remain relatively high despite slightly inferior performance compared to other materials [52].

Limitations of the study

The study presents several important limitations that require caution in interpreting the results. The small sample size and the fact that the research was conducted in a single center limit the generalizability of the conclusions, which reflect local clinical trends rather than universal findings. Additionally, the lack of a detailed evaluation of relevant clinical factors (periodontal status) and the absence of medium or long term follow-up do not allow for a comprehensive assessment of the clinical performance and durability of the restorations. Overall, these limitations highlight the need for future multicenter studies with larger samples and longitudinal monitoring.

Recommendations for future studies

To strengthen and expand the conclusions of the study, future research should be conducted on larger and more diverse samples from multiple dental centers, both public and private, to obtain more representative data; standardize therapeutic choice criteria through clear clinical protocols; implement longitudinal follow-up to assess durability, functionality, aesthetics, and patient satisfaction; investigate subjective and economic factors influencing restorative decisions; and integrate new technologies and digital materials, such as CAD/CAM, intraoral scanning, and 3D printing, to analyze their impact on decision-making and clinical outcomes.

5. Conclusions

The current research highlights the varied application of direct and indirect dental restoration techniques in a real clinical context, where therapeutic decisions were adapted to the specifics of each case. The choice of each technique depended on factors such as the extent of tooth substance loss, aesthetic requirements, material availability, clinical time needed, and long-term prognosis. Direct techniques were preferred in situations requiring a conservative approach with maximum preservation of hard dental tissues, while indirect techniques were chosen in cases demanding superior control of shape, contour, and aesthetics, as well as greater long-term strength.

The study emphasizes the importance of an individualized approach in selecting restorative techniques, considering clinical needs and the functional and aesthetic objectives of the treatment. Appropriate integration of direct and indirect restorations, along with careful material selection, contributes to achieving stable, efficient, and clinically and aesthetically satisfactory results.

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Author contributions

Authors read and approved the final manuscript. All authors have equally contributed to this work.

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Conflict of interest statement

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Data availability statement

Will be provided on request.

Ethics statement

Approved by the Scientific Ethics and Deontology Commission of the University of Medicine and Pharmacy of Craiova (approval data no. 08/20.01.2021).

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ORIGINAL ARTICLE

DRAWING THE DIGITAL DESIGN OF DENTAL BRIDGES IN CLINICAL SITUATIONS WITH MODIFIED POTENTIAL PROSTHETIC SPACE

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Abstract: *Background*: The first digital revolution took place many years ago, with the production of dental restorations such as veneers, inlays, crowns and bridges using CAD/CAM systems. The reduction in the cost of processing power will ensure these developments continue, as exemplified by the recent introduction of a new range of digital intraoral scanners. The aim of this study was to evaluate the application of the digital design of dental bridges in clinical situations with potentially modified prosthetic space, with the help of EXOCAD software. *Methods*: For this study, there were analyzed existing data regarding the possible use of digital designs in potential maxillary and mandibular, frontal and lateral potential spaces in a private dental office between March 2024 and March 2025. *Results*: 24 patients were analyzed and the presence of 2 major groups of changes in the potential prosthetic space in the vertical plane was confirmed, divided into increased potential prosthetic space and decreased potential prosthetic space, but also the presence of some patients who did not show changes in the vertical plane. *Conclusions*: Thanks to CAD/CAM technology and EXOCAD software, communication between the dentist and the dental technician is more efficient and faster.

Keywords: digital design, EXOCAD, dental bridge, CAD/CAM technology

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1. Introduction

The first digital revolution took place many years ago, with the production of dental restorations such as veneers, inlays, crowns and bridges using CAD/CAM systems. The reduction in the cost of processing power will ensure these developments continue, as exemplified by the recent introduction of a new range of digital intraoral scanners.

In terms of prosthetic manufacturing, it is currently dominated by subtractive processing technology, but it is inevitable that additive processing routes of layered manufacturing, such as FDM, SLA, SLM and inkjet printing, will begin to have an impact.

There is no reason why the technology cannot be extended to all aspects of denture manufacturing and include custom implants, full denture construction and orthodontic appliances. In fact, anything you might expect a dental lab to produce can be done digitally, and potentially more consistently, faster, and at a lower cost.

The manufacturing of dental devices will experience a second revolution when layered manufacturing techniques will reach the point of being able to produce high-quality dental prostheses. The challenge for the dental materials research community is to combine technology with materials that are suitable for use in dentistry. This may take dental materials research in a totally different direction [1].

The aim of this study was to evaluate the design of the digital design of dental bridges in clinical situations with potentially modified prosthetic space, with the help of EXOCAD software. EXOCAD is a program that allows the creation of prosthetic parts that meet the requirements of the dentist, but also the patient, being excellent from the point of view of reducing the time needed to create a restoration and the communication between the doctor and the dental technician [2].

2. Materials and method

Clinical-statistical study

For this study, we analyzed existing data regarding the possible use of digital designs in potential maxillary and mandibular, frontal and lateral potential spaces within SC Centrul Medical OM during the period March 1, 2024 – March 1, 2025. According to a protocol approved by the Ethics Committee of the University of Medicine and Pharmacy of Craiova (no. 83/ 19.02.2024).

For this purpose, data were taken from the consultation register as well as from the MeditLink software (Medit, Seoul, South Korea), used for intra-oral scanning, and the following parameters were noted: name, gender, age, missing teeth, change in vertical potential prosthetic space, change in horizontal potential prosthetic space, size of potential prosthetic space.

The data obtained were entered into an Excel table and analyzed statistically, and the results obtained were presented in the form of tables and graphs.

Representative cases

In order to document the digital designs, 4 representative cases were selected for which, after obtaining the patient's informed consent and agreement, the clinical stages of intraoral digital impression were performed using the Medit i700 scanner (Medit, Seoul, South Korea) and the obtained data were transferred to the EXOCAD digital design software (Exocad GmbH Darmstadt Germany).

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Within the dental technique laboratory of the University of Medicine and Pharmacy, Craiova, we designed the dental bridges designs in these clinical situations with potentially modified prosthetic space and screenshots were taken to highlight the stages of the digital techniques for creating the digital design, simulating several reconstruction possibilities depending on the particularities of the clinical case.

3. Results

3.1 Clinical and statistical study results

The study included the examination of 24 patients, 13 of whom were females and 11 males (Figure 1).

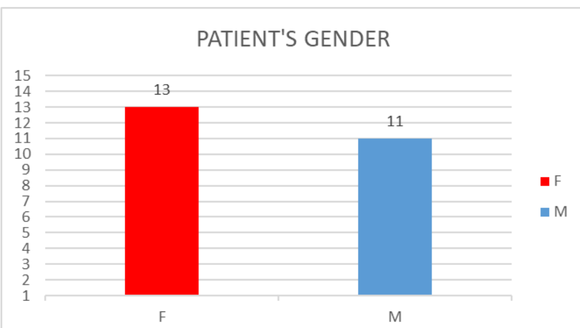

Figure 1. Distribution of cases analyzed by gender.

Among the 24 cases, 6 age groups were found, from 30 years old to over 80. The predominant age group was 50-60 years old, representing 38% of the total patients, and the group with the fewest integrated patients was 80+, representing 4% of the total (Figure 2).

Regarding the potential prosthetic present spaces, we divided the missing teeth into 4 quadrants. The most predominant hemiarches with missing teeth are quadrants 2 and 4, each with 17 missing teeth, and the least affected quadrant is the first, with a value of 5 (Figure 3).

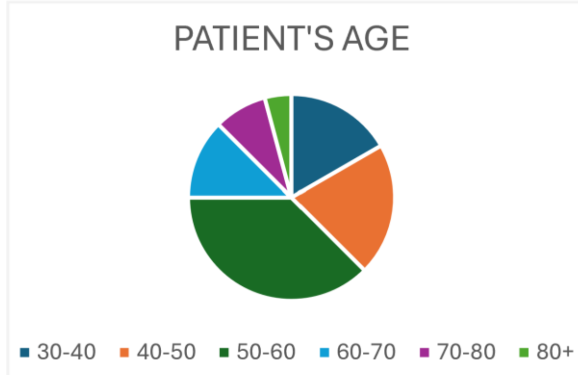

Figure 2. Distribution of cases analyzed by age.

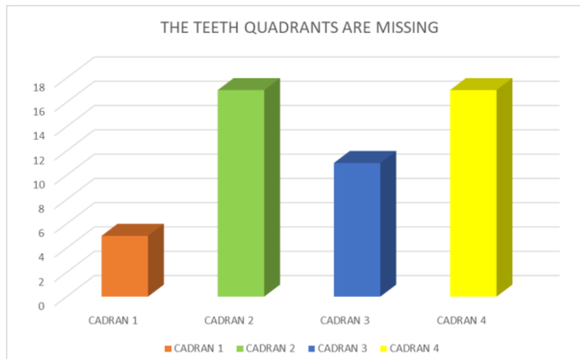

Figure 3. Distribution of cases analyzed by age.

The 24 patients were analyzed and the presence of 2 major groups of changes in the potential prosthetic space in the vertical plane was confirmed, divided into increased potential prosthetic space and decreased potential prosthetic space, but also the presence of some patients who did not show changes in the vertical plane. In the table presented, we observe a number of 9 patients with decreased potential prosthetic space, most of them falling into small decreased potential prosthetic space and only 2 into medium decreased potential prosthetic space. In contrast, the distribution of patients presenting an increased potential prosthetic space is more balanced, 3 of the patients presenting a small increased potential prosthetic space and 4 a medium increased potential prosthetic space (Figure 4).

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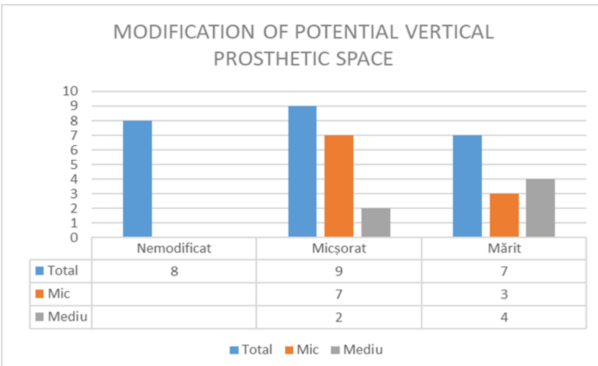
In the diagram below we have the representation of patients according to changes in the potential prosthetic space in the horizontal plane (Figure 5). While 10 patients out of the total number of 24 did not present changes in the horizontal plane, the remaining 14 fell into either the reduced horizontal prosthetic potential space category or the increased horizontal prosthetic potential space category.



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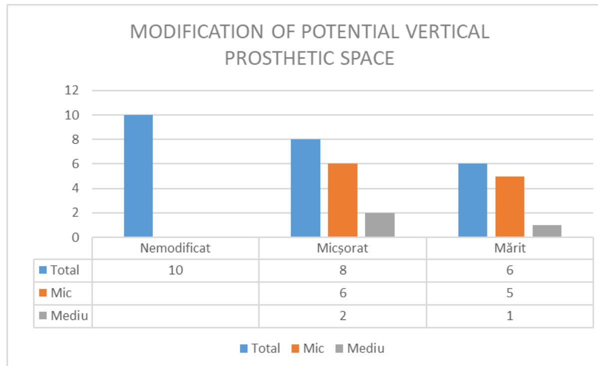

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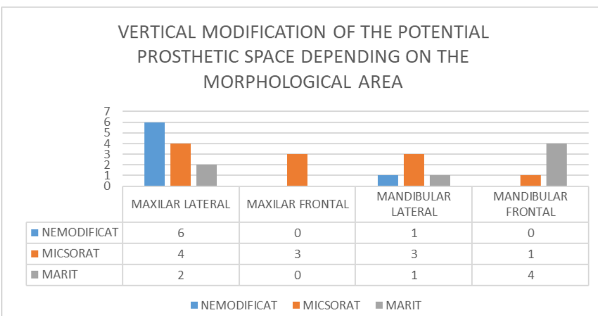

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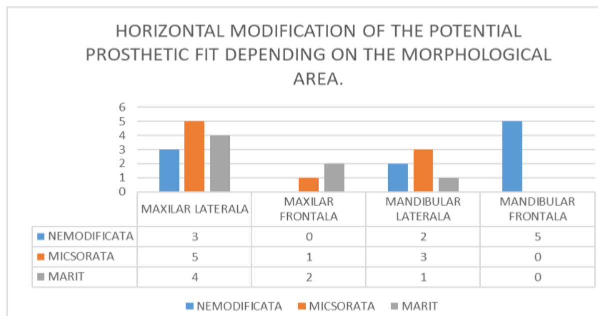

(Figure 7)

Figure 4. Distribution of the size of the potential prosthetic space in the vertical plane. **Figure 5.** Distribution of the size of the potential prosthetic space in the horizontal plane. **Figure 6.** Distribution of changes in the potential prosthetic space in the vertical plane, depending on the morphological area. **Figure 7.** Distribution of changes in the potential prosthetic space in the horizontal plane, depending on the morphological area.

In Figure 6, we divided the changes in the potential prosthetic space in the vertical plane, depending on the morphological area. Predominantly, changes in the potential prosthetic space were noted in the lateral maxillary area and in the frontal mandibular area.

Figure 7 highlights the distribution of changes in the potential prosthetic space in the horizontal plane, correlated with the topography of the edentulous region, classified into the four morphological zones: lateral maxilla, frontal maxilla, lateral mandibular and frontal mandibular.

First case

For the first case, with the help of the EXOCAD program, we made the design of a temporary dental bridge made immediately post-extraction in the maxillary frontal area, which will replace the absent tooth 2.1 and will rest on teeth 1.3, 1.2, 1.1, 2.2 and 2.3 which were used as abutment teeth. The prosthetic particularity of this case was

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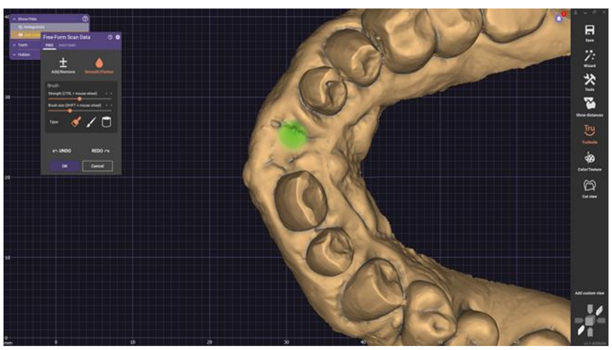
represented by the increase of the potential prosthetic space as a result of the periodontal diseases that determined the excessive vestibularization of the upper left central incisor and finally required its extraction. To solve this situation, it was initially decided to make a central incisor within the body of the bridge, where a modeling of the coronal third of the root was also made, partially simulating the existing situation before its extraction, but keeping a space for post-extraction sanitation. Another design option that was simulated was the creation of an ovoid bridge body to esthetically direct post-extraction healing.

(Figure 1.1)



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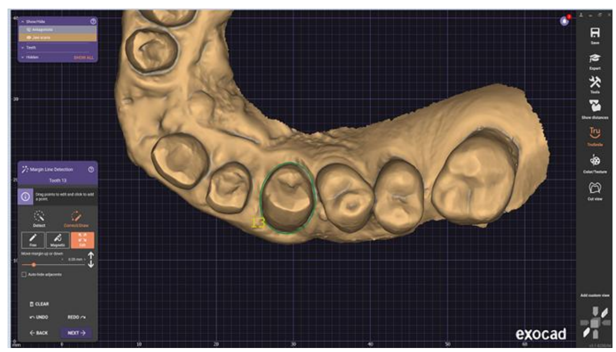

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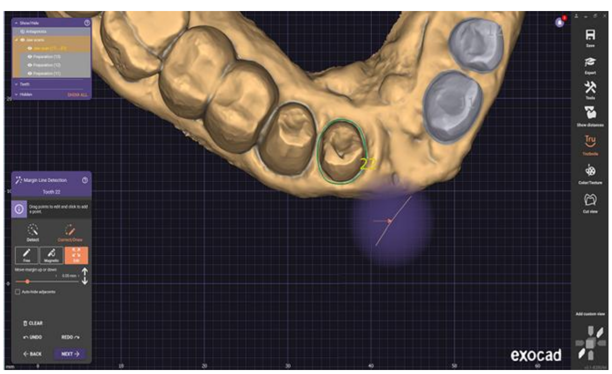

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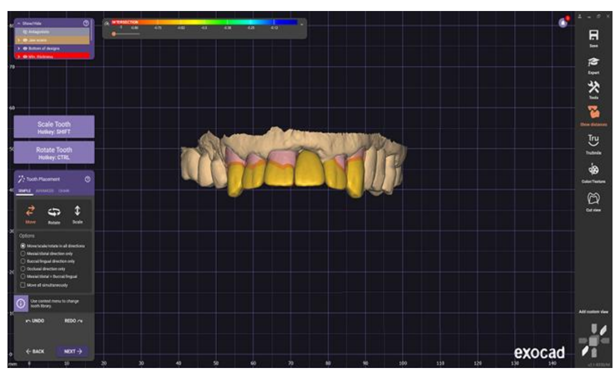

(Figure 1.5)

Figure 1.1. Digital impression made immediately post-extraction. **Figure 1.2.** Partial leveling of the post-extraction alveolus, using the function „smooth/flatten. **Figure 1.3.** Drawing the margin line at the level of the tooth 1.3. **Figure 1.4.** Drawing the margin line at. the level of the tooth 2.2. Figure 1.5. The initial tooth model suggestion from the software library. **Figure1.5.** The initial tooth model suggestion from the software library.

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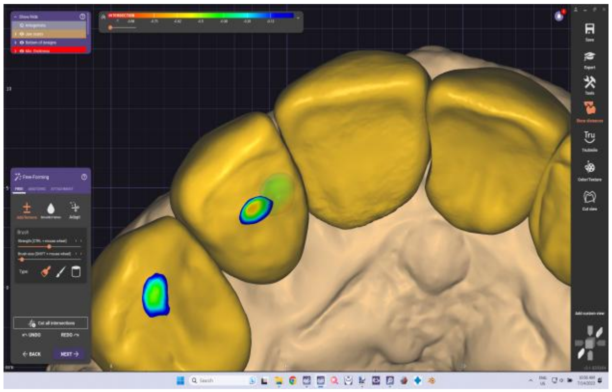

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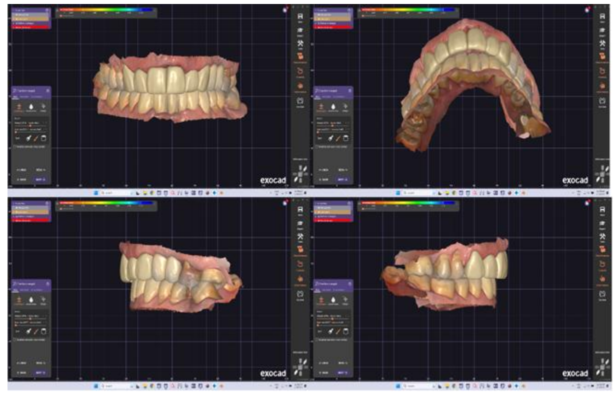
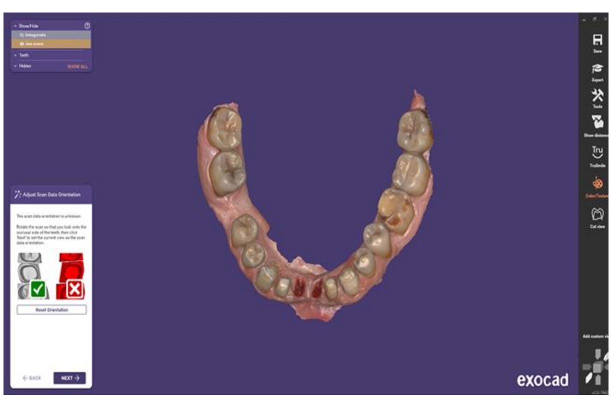


(Figure 1.7)

Figure 1.6. Highlighting the contact areas obtained at the level of teeth 1.3 and 1.2 and the intensity of occlusal contacts. **Figure 1.7**. The final design of the prosthetic restoration.

Second case

In the second case, also with the help of the EXOCAD program, we made the design of a temporary dental bridge made immediately post-extraction in the frontal mandibular area, which will replace the absent teeth 3.1 and 4.1 and will rest on the teeth 3.3, 3.2 and 4.2, 4.3 which were used as abutment teeth. The prosthetic particularity of this case was represented by the vertical growth of the potential prosthetic space through the atrophy of the edentulous ridge as a result of the periodontal diseases that required the extraction of the central incisors. To solve this situation, it was initially decided to make the missing central incisors with a modeling of the coronal third of the root was also made, partially simulating the existing situation before their extraction, but keeping a space for post-extraction hygiene. Another design option that was simulated was the creation of an ovoid bridge body to esthetically direct post-extraction healing.



(Figure 2.1)

(Figure 2.2)

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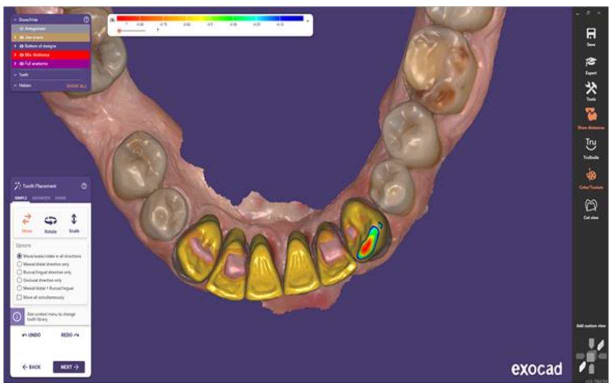

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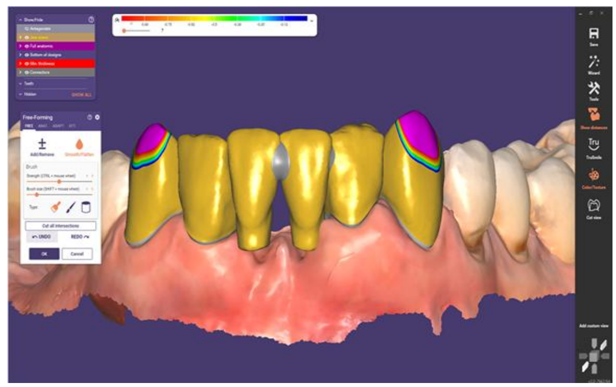

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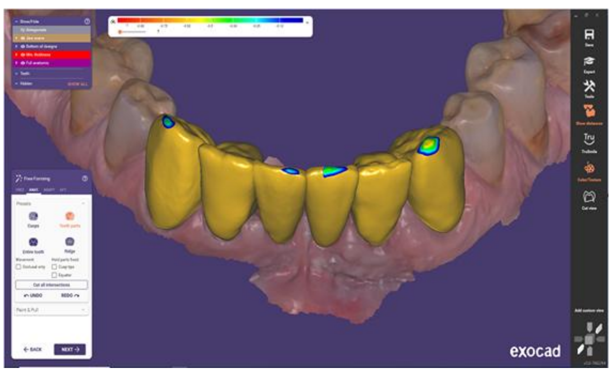

(Figure 2.7)

Figure 2.1. Overview of the initial situation of the mandibular arch after the preparation. **Figure 2.2.** Drawing the margin line at the level of the tooth 4.3. **Figure 2.3.** Drawing the margin line at the level of the tooth 4.2. **Figure 2.4.** Drawing the parcel line at the level of the tooth 3.3. **Figure 2.5.** Initial tooth shape selection made by EXOCAD software from its library. **Figure 2.6.** Highlighting the areas of occlusal contact with the opposing arch and the initial shape of the interdental connectors. **Figure 2.7.** Final appearance of the provisional bridge design.

Third case

In the third situation we made the design of a dental bridge in the left mandibular lateral area, which will replace the missing teeth 3.6 and 3.7 and will rest on the teeth 3.5 and 3.8 which were used as abutment teeth. The prosthetic particularity of this case was represented by the horizontal reduction of the potential prosthetic space by the tipping migration of the teeth neighboring the

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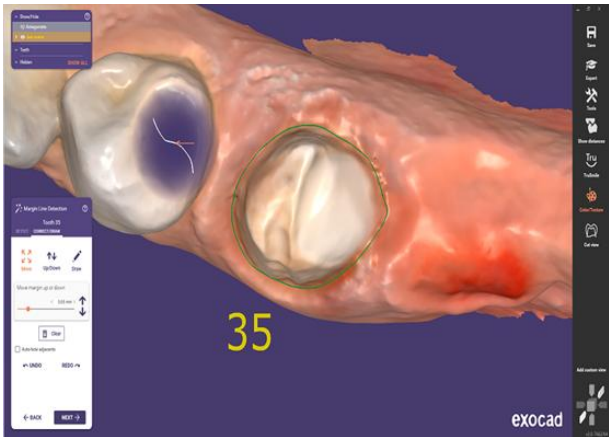
edentulous gap, especially the wisdom molar. To solve this situation, it was decided to create a second molar of small dimensions within the body of the bridge.



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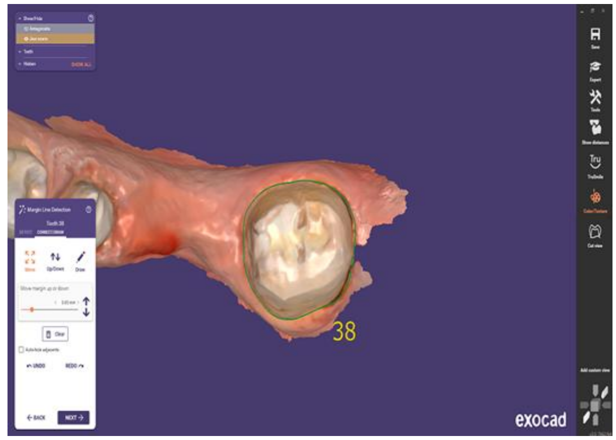

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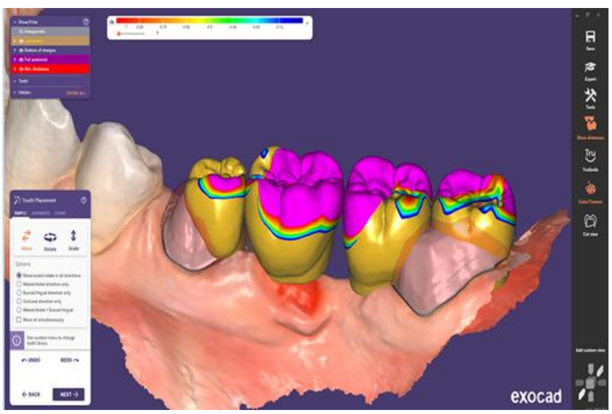

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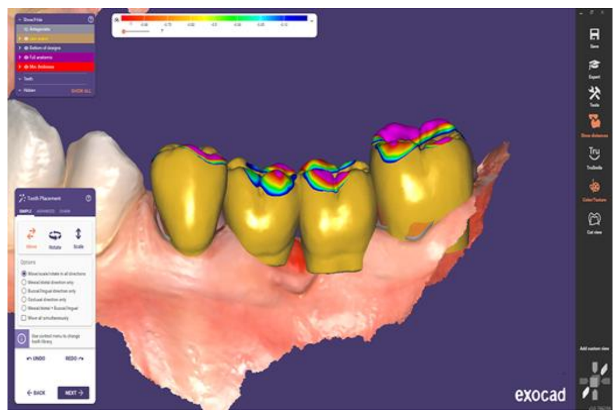

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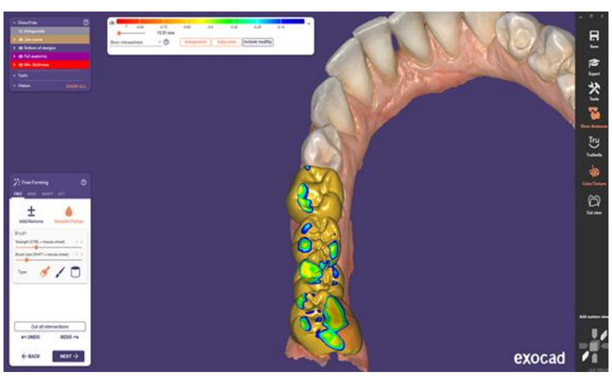

(Figure 3.5)

Figure 3.1. Drawing the margin line at the level of the tooth 3.5. **Figure 3.2.** Drawing the margin line at the level of the tooth 3.8. **Figure 3.3.** The initial choice of the tooth shape of the future restoration, made by EXOCAD from the existing tooth library. **Figure 3.4.** Changes to the initial placement made from the teeth placement menu. **Figure 3.5.** Manual adaptation of occlusal relationships, final result.

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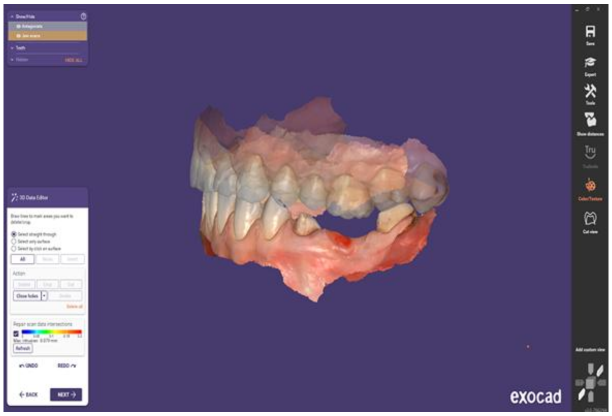
The fourth case

For the last case, with the help of the EXOCAD program we made the design of a dental bridge in the left mandibular lateral area, which will replace the absent tooth 3.6 and rest on teeth 3.5 and 3.7 which were used as abutment teeth. The prosthetic particularity of this case was represented by the vertical reduction of the potential prosthetic space by the extrusion of the opposing molar to the edentulous space.



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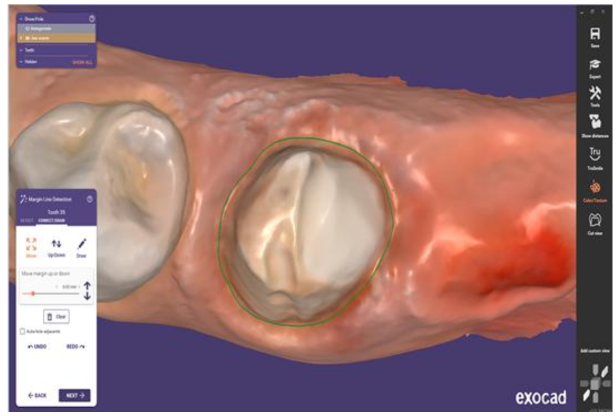

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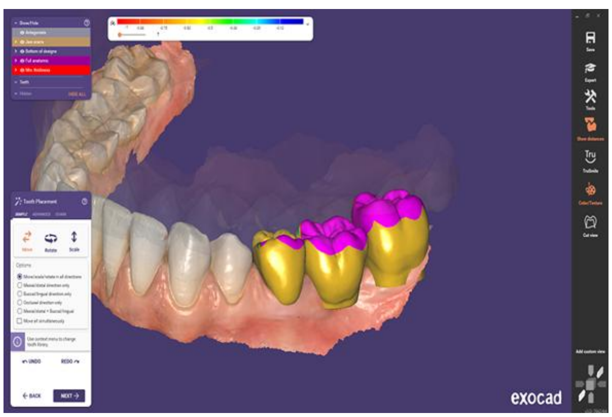

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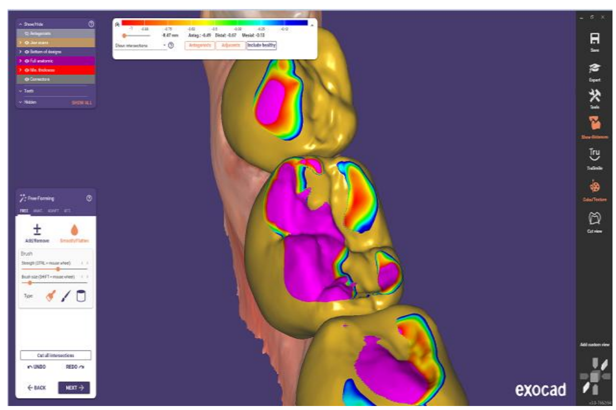

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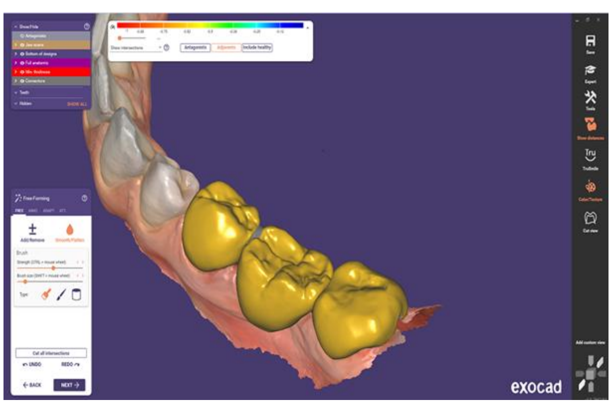

(Figure 4.5)

Figure 4.1. The initial appearance.

Figure 4.2. Drawing the margin line 3.5.

Figure 4.3. Initial choice of tooth shape made by EXOCAD software in its library.

Figure 4.4. Highlighting the occlusal contact areas.

Figure 4.5. The final design of the prosthetic restoration.

4. Discussion

The knowledge about the muscles and the size of the face contributes to the design of a perfect aesthetic smile. Since not all individuals are the same, each person should study their facial anatomy and find their perfect smile. Although in practice a software is used to predict a perfect smile, a multidisciplinary approach that includes several branches of dentistry is needed [3].

Intraoral scanners as well as software programs have developed in recent years, and this has led to good communication between the doctor and the dental technician.

In recent years, several intraoral scanners have appeared on the profile market, but the best criterion for choice must be the accuracy of the data extracted from the scan [4]. Especially in the case of children, the method using an intraoral scanner is clinically accepted as an easier and more comfortable method. In the patient's perception, the comfort provided by intraoral scans compared to the classic method using alginate, as well as the sensation of pain or vomiting, or dry mouth is well known [5].

Digital scanning offers benefits such as obtaining the perfect impression, with maximum precision every time, possibility of virtual simulation of treatments, better contact between patient and dentist [6].

Digital methods for detecting and drawing the margin lines of dental preparations reduce manual operations, but the accuracy of correctly detecting the placement of the cervical edge may differ, depending on the clinical situation, because the automatic detection depends on the software that analyzes the particularities of the images [7].

Dental materials and 3D restorations have grown significantly in recent years. The progress of digital dentistry is enormous and consists in the appearance of CAD/CAM imaging and milling systems [8,9]. 3D printing is the most revolutionary field in digital dentistry.

The CAD process for fixed prostheses requires drawing a cervical line on the prepared tooth. The first step in the design project is the execution of the finish line, which must match the marginal adaptation of the future prosthesis [10].

The success of a crown manufactured using the CAD-CAM technique is determined by several factors such as aesthetic appearance, strength and marginal adaptation.[11] Marginal and internal fit is significant in ensuring the success of crowns and can be negatively influenced by cement layer thickness, marginal fit, pressure force, type of material and CAD-CAM system used.

Through the digital workflow, personalized abutments and personalized crowns are made and thus the maintenance of soft tissues is made easier, and an advantage is the use of a high-performance restorative material [12].

In patients with a single implant, monolithic restorations had high success rates, without severe complications in a relatively short period of time 3-5. Patient acceptance and low clinical and laboratory time were high [13].

The accuracy of a impression depends on the data matching algorithm. Intraoral scanners lack a fixed reference; therefore, the first scanned image is used as a reference, and all subsequent images are stitched onto the previous image using an image matching

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algorithm. A larger area in size requires more merging processes which can lead to results with more considerable errors [14,15].

The virtual articulator improves denture design by adding visual analysis to the design process performed by CAD systems. It provides flexibility in tailoring the treatment plan to the unique needs of the patient. With some classic articulators, some positions cannot be adjusted, but this obstacle can be easily overcome. Thus, the prostheses produced with the help of the virtual articulator are more precise than those where a classic articulator was used. Virtual models that are digitally mounted in the virtual articulator are used for diagnosis and planning of prosthetic treatments, from single or multiple crowns to dental bridges, including complex cases such as full mouth rehabilitation [16]. Arakida et al. reported the importance of ambient light during intraoral scanning; The values of 3900 K and 500 lux of ambient light are a mandatory condition, a normal thing for clinc ambient. Under these conditions, the scan is more faithful and the scan time can be changed compared to other ambient light conditions [17].

It was shown that the surface coating process did not cause large differences and it was concluded that the coating and non-coating procedures did not influence the accuracy of the scanning systems. The accuracy of an intraoral scan can be affected by the operator's experience using intraoral scanners. Experience is a necessary condition in daily clinical practice [18,19].

5. Conclusions

CAD/CAM technology is increasingly used in dental practices. Thanks to advances in CAD/CAM technology, the dentist can make a temporary work for the patient right in the dental office. Using the EXOCAD software, the treatment plan can be customized to meet the individual wishes and needs of each patient. Zirconia is frequently used as a material for making dental bridges because it offers increased resistance, very good aesthetics, but also long-term stability.

Thanks to CAD/CAM technology and EXOCAD software, communication between the dentist and the dental technician is more efficient and faster.

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The authors declare no conflicts of interest concerning this study.

Data availability statement

Will be provided on request.

Ethics statement

Approved by the Scientific Ethics and Deontology Commission of the University of Medicine and Pharmacy of Craiova (approval data no. 83 / 19.02.2024).

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