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Prevalence of white spot lesions in patients with fixed orthodontic technique and their correlation with the level of plaque control and gingival inflammation

SUMMARY

of a thesis for the educational and scientific degree

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Note: In the abstract the numbers of the tables and figures do not correspond to the numbers in the dissertation.

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LIST OF ABBREVIATIONS

ЗЧД	Dental and jaw deformities
ПОХ	Professional oral hygiene
CAT	Caries Assessment Tool
CHX	Chlorhexidine
CPP-ACP	Casein phosphopeptide - amorphous calcium phosphate
CRA	Caries Risk Assessment
DMFT	Decayed, Missing and Filled Teeth
EDI	Enamel decalcification index
GI	Gingival Index
ICDAS	International Caries Detection and Assessment System
OHI	Oral Hygiene Index
OPI	Orthodontic Plaque Index
PI	Plaque index
PLM	Polarized light microscopy
PSR	Periodontal screening and recording
QLF	Quantitative Light-induced Fluorescence
RI	refractive index
SEM	scanning electron microscopy
TMR	transverse microradiography
WSL	White Spot Lesion

Introduction

Fixed orthodontic appliances are used for the treatment of jaw deformities for a certain period of time, but they are a risk factor for development of dental caries, because they are retentive and support plaque accumulation. The elements of fixed orthodontic technique can change the biological balance in the oral cavity. This puts the patients treated with such orthodontic appliances at high risk of developing dental caries, regardless of the presence or absence of other risk factors. It is necessary to observe these risk factors in order to identify patients who need special preventive care.

The long-standing problem with the development of white spot lesions during treatment with fixed orthodontic technique has been investigated for many years through in-vitro, in-situ, ex-vivo and in-vivo studies, using different assessment methods and various protocols for their treatment have been tested.

The results for the period of appearance of white carious lesions around the braces are contradictory. It has been reported that they are diagnosed in 60.9% of patients treated with a fixed orthodontic technique after about 1.9 years, but some studies show that they appear as early as the fourth week of starting orthodontic treatment (60).

Orthodontic treatment can hamper the oral health of patients who are not motivated for adequate oral hygiene and don`t have a properly designed individual prevention program. It is important for both the patient and the dental specialist to prevent the development of initial enamel carious lesions, the problems with inflammation of the gingiva and periodontium, which could compromise the desired result of orthodontic treatment, and thus the self-esteem of patient.

An integral part of orthodontic treatment is the patient's desire to heal and to be ready to assist the dental specialist. The lack of patient cooperativity, poor oral hygiene, and other individual risk factors for the development of dental caries may result in delayed treatment or inability to complete its final and successful completion.

Orthodontic treatment has become an inseparable part of modern life in recent decades. The results of a study conducted in 2003 show that 14% of 12-year-old children underwent orthodontic treatment, while in 1983 they were only 5% (206). It is often commented in the scientific community that the expectations of patients and/or their parents after orthodontic treatment are to improve oral health, aesthetics and increase self-esteem. Like any other type of treatment, orthodontic has its advantages, but it also carries some risks. Orthodontic treatment is often associated with several complications. Apart from the closely related to the orthodontic influence (return of the teeth to their position before the treatment, resorption of the tooth root under the action of unmeasured orthodontic forces, allergy to the orthodontic components with extraoral or intraoral manifestations, etc.), the development of white carious problems is also a problem due to enamel demineralization.

Orthodontic treatment with a fixed technique is an example of creating retentive areas for the accumulation of dental biofilm (185, 242, 254) with the subsequent development of

white carious lesions (156). Some authors diagnose these lesions as early as the fourth week of treatment with braces (60), and they are observed long after the completion of orthodontic treatment, if they are not affected by remineralizing agents (145). Allowing the development of such lesions is a serious aesthetic problem and negatively affects the patient's attitude to the results of treatment.

So far, we have a dissertation by Dr. Ribagin, examining the epidemiology of dental deformities and associated changes in oral status, in particular the impact on periodontal health of patients undergoing orthodontic treatment. They investigate the diagnostic potential of gingival crevicular fluid and markers of tissue remodeling during orthodontic treatment. The problem of carious disease in this scientific paper is considered for lesions with diagnostic threshold D_3, but not the initial enamel carious lesions. Other such research in the field of orthodontics, especially on our topic, has not been done. The teams of Prof. Dr. Peneva, Prof. Dr. Rashkova and Assoc. Prof. Doichinova worked on the initial enamel carious lesions, and the conducted examinations and observations were performed on children who were not treated with orthodontic appliances. These are the only studies that draw the attention of the scientific community to white spot lesions - the object that we observe.

Aim and tasks

1. Aim

The aim of the dissertation is to study the prevalence and severity of white carious lesions in relation to the level of plaque control and gingival inflammation in patients with fixed orthodontic technique.

2. Tasks

To achieve the aim, the following tasks were formulated:

1) To study the prevalence of white carious lesions in patients with fixed orthodontic technique
2) To study the level of plaque accumulation in children with fixed orthodontic technique and to compare with the control group
3) To study the level of gingival inflammation in children with fixed orthodontic technique and to compare with the control group
4) To assess the severity of white carious lesions in patients undergoing treatment with fixed orthodontic technique
5) To assess the specific caries risk profile of patients with fixed orthodontic technique
6) To create an algorithm for prevention of white carious lesions in patients with fixed orthodontic technique depending on the level of oral hygiene

3. Research hypotheses

1) We assume that the prevalence and severity of white carious lesions are influenced by various factors that are relevant to the patient's motivation and cooperation during orthodontic treatment with a fixed technique.

2) We assume that regardless of the patient's cooperation in the treatment process, the prevalence and severity of white carious lesions increase.

3) We assume that the education and motivation of patients to maintain good oral hygiene are major factors in prevention and affect the prevalence of white carious lesions.

Materials and methods

1. Material

For the purposes of this dissertation, it was studied the oral profile of children performing treatment with fixed orthodontic technique and of children without orthodontic treatment according to age, sex, change in hygiene and eating habits and behavior. All children were clinically examined and evaluated on various indicators, depending on the tasks.

The object of the study on all tasks are: 246 patients who have passed through the University Medical and Dental Center of Faculty of Dental medicine - Varna at the Medical University - Varna, the dental practice of Prof. Dr. R. Andreeva and patients treated by dental professionals, for a period of 2 years. Patients are divided into two groups:

- First group - 123 patients who undergo treatment with fixed orthodontic technique (braces).
- Second group - 123 patients who visited the dental offices on another occasion.

The selection of patients is based on well-defined criteria:

a) Criteria for inclusion

- Children aged 12 - 18 years with permanent dentition
- Presence of carious lesions as a result of orthodontic treatment with braces
- Desire to participate in the study (of the parent and the child)
- Without the presence of concomitant systemic diseases

b) Exclusion criteria

- Children of different ages from 12 to 18 years, or those with still mixed dentition
- Refusal to participate in the study (of the parent and the child)
- Presence of dysplastic changes in the hard dental tissues
- Non-carious lesions of the enamel
- With concomitant systemic diseases

In order to obtain reliable results, the patients included in the study were evenly distributed by sex and age between the two groups.

All participants in the study underwent a dental examination and medical history taking, examination of oral hygiene status, examination of the prevalence of white carious lesions with initial diagnostic threshold D_{1a}, which will diagnose the earliest carious lesions. These lesions may regress after non-operative preventive measures, examination and assessment of the patients' oral risk profile.

Each group of examined patients is detailed by gender, age, type of braces and caries risk.

Duration and follow-up of patients

The duration of the study is two years. The study of patients is divided into four stages:

- Stage I: Preliminary examination of patients indicated for orthodontic treatment.

- Stage II: 1 month after applying the braces.
- Stage III: 6 months after applying the braces.
- Stage IV: Retention phase of treatment.

1.1. In performing the **first task - To study the prevalence of white carious lesions in patients with fixed orthodontic technique:**

- **The subject of the study** were 123 patients who underwent orthodontic treatment with a fixed orthodontic technique.
- **Observation unit -** white carious lesions located in close proximity to the elements of the fixed technique
- **Place of study -** University Medical Dental Center of Faculty of Dental medicine - Varna at Medical University - Varna, the dental practice of Prof. Dr. R. Andreeva.
- **Study time -** 2019-2021 incl.

1.2 In connection with the **second task - To study the level of plaque accumulation in children with fixed orthodontic technique and to compare with the control group:**

- **The subject of the study** were 246 patients divided into two groups:

- First group - 123 patients who undergo orthodontic treatment with fixed technique (braces)
- Second group - 123 patients who visited the dental offices on another occasion.

- **Unit of observation –** plaque accumulation in children
- **Place of study -** University Medical Dental Center of Faculty of Dental medicine - Varna at Medical University - Varna, the dental practice of Prof. Dr. R. Andreeva.
- **Study time -** 2019-2021 incl.

1.3. In performance of the **third task - To study the level of gingival inflammation in children with fixed orthodontic technique and to compare with the control group:**

- **The subject of the study** were 246 patients divided into two groups:
  - First group - 123 patients who undergo orthodontic treatment with fixed technique (braces)
  - Second group - 123 patients who visited the dental offices on another occasion.
- **Unit of observation –** the level of gingival inflammation in children from the clinical and control groups
- **Place of study -** University Medical Dental Center of Faculty of Dental medicine - Varna at Medical University - Varna, the dental practice of Prof. Dr. R. Andreeva.
- **Study time -** 2019-2021 incl.

1.4. In performance of the **fourth task - To assess the severity of white carious lesions in patients undergoing treatment with fixed orthodontic technique:**

- **The subject of the study** were 123 patients who underwent orthodontic treatment with a fixed orthodontic technique.

- **Unit of observation -** number of lesions and their severity in children undergoing orthodontic treatment with fixed technique
- **Place of study -** University Medical Dental Center of Faculty of Dental medicine - Varna at Medical University - Varna, the dental practice of Prof. Dr. R. Andreeva.
- **Study time -** 2019-2021 incl.

1.5. In connection with the **fifth task - To assess the specific caries risk profile of patients with fixed orthodontic technique:**

- **The subject of the study** were 123 patients who underwent orthodontic treatment with a fixed orthodontic technique.
- **Unit of observation –** caries risk assessment in children undergoing orthodontic treatment with a fixed technique
- **Place of study -** University Medical Dental Center of Faculty of Dental medicine - Varna at Medical University - Varna, the dental practice of Prof. Dr. R. Andreeva.
- **Study time -** 2019-2021 incl.

1.6. In performance of the **sixth task - To create an algorithm for prevention of white carious lesions in patients with fixed orthodontic technique depending on the level of oral hygiene:**

- **The subject of the study** were 123 patients undergoing orthodontic treatment with a fixed orthodontic technique, who were additionally surveyed for a change in their behavior, regarding hygiene and eating habits after braces placement.
- **Unit of observation**
    - Survey - questions included in the original, direct questionnaire (Appendix 2).
    - The analyzes made so far, based on which we have created an algorithm for the prevention of white carious lesions
- **Place of study -** University Medical Dental Center of Faculty of Dental medicine - Varna at Medical University - Varna, the dental practice of Prof. Dr. R. Andreeva.
- **Study time -** 2019-2021 incl.

2. Methods

2.1. For task 1: To study the prevalence of white carious lesions in patients with fixed orthodontic technique

A detailed ambulatory sheet created for the purposes of the study is completed for each patient (Appendix 1). It includes information about name, sex, age, duration of treatment with a fixed orthodontic technique and registration of the spread of white lesions. This distribution is registered via the EDI index.

Researched indicators:

- mean EDI value by sex and age
- the relation between treatment duration and EDI
- mean EDI values according to the follow-up stages
- mean EDI values according to the type of braces
- mean EDI value according to the patient's cooperation
- average EDI value according to the child's oral hygiene

2.1.1. Observation and registration of the prevalence of white carious lesions

For the purpose of this study, the EDI index of Banks and Richmond (1994) (33) was used to determine the prevalence of white carious lesions around the braces and their number near the surface of the braces (Fig. 1).

Each tooth is divided into nine zones, with the body of the bracket occupying the central part. Each area with visible demineralization of the enamel is marked with codes:

0 – areas without visible demineralization;

1 – areas with visible demineralization;

The EDI index for a single tooth is determined by the sum of these eight peripheral areas, with the exception of the bracket area divided by 8. The patient's total EDI index is the average of the individual EDI values of the examined teeth.

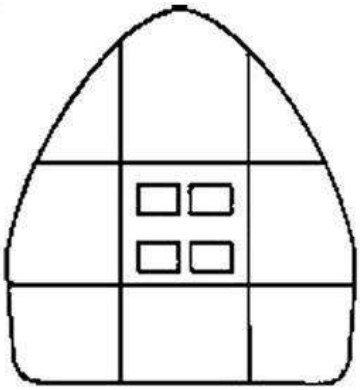


Fig. 1. EDI-index (Banks and Richmond, 1994)

Examinations are performed in a clinical setting and in appropriate light in accordance with WHO recommendations. Sterile individual kits for each child and disposable gloves are used.

2.2. For task 2: To study the level of plaque accumulation in children with fixed orthodontic technique and to compare with the control group

The oral hygiene status of the examined children was diagnosed and registered with the OPI (Orthodontic Plaque Index) for the children from the clinical group and Greene-Vermillion index for the children from the control group. The registered data are entered in the ambulatory card of each of the children.

Researched indicators:

- average value of plaque indices by sex and age

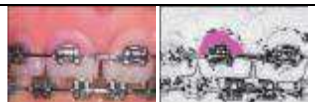
- the relation between the duration of treatment and OPI
- mean values of OPI according to the follow-up stages
- mean value of OPI according to the type of braces
- mean value of the plaque index according to the patient's cooperation

2.2.1. Examination of oral hygiene status in patients with fixed orthodontic technique

To determine the oral hygiene status, the oral hygiene index **OPI (Orthodontic Plaque Index)** by Beberhold and colleagues was used (36). It focuses on the area of the teeth in close proximity with the bracket, which is an additional plaque-retentive factor. To assess the level of plaque accumulation with this index, the dentition is divided into sextants.

The degree of plaque accumulation is evaluated with a numerical code from 0 to 4. The areas medially, distally, incisally and cervically around the bracket are examined (Table 1) (36). At the same time, signs of gingivitis are registered. The highest score for a sextant is entered in a table. Increased risk of caries and gingivitis is considered, if score 3 is available. OPI can be used for vestibular or lingually fixed braces. With the help of visualizing means (eg coloring tablet or gel) the plaque becomes visible in the area around the bracket. Only teeth or surfaces with fixed braces are evaluated. Teeth with orthodontic bands are not included in the examination due to the lack of possibility to examine the tooth surface.

Table. 1. OPI (Orthodontic Plaque Index)

Code 0		No plaque accumulation is detected
Code 1		Plaque buildup is found on one tooth surface around the base of the bracket
Code 2		Plaque buildup is found on two tooth surfaces around the base of the bracket
Code 3		Plaque buildup is found on three tooth surfaces around the base of the bracket
Code 4		Plaque buildup is found on all tooth surfaces around the base of the braces and/or presence of gingival inflammation.

Assessment of marginal gingiva for inflammation is a key component of OPI and helps to predict additional preventive measures. The design of the study involves dividing the dentition into sextants, just as with the periodontal screening and recording index (PSR), the successor to the CPITN index. The score is from 0 to 4. Codes 1 to 3 reflect the degree of plaque

accumulation near the braces. Code 4 reflects plaque all over the tooth surface and the presence of gingival inflammation.

- Code 0 - No plaque accumulation is detected;
- Code 1 - Plaque buildup is found on one tooth surface around the base of the bracket;
- Code 2 - Plaque buildup is found on two tooth surfaces around the base of the bracket;
- Code 3 - Plaque buildup is found on three tooth surfaces around the base of the bracket;
- Code 4 - Plaque buildup is found on all tooth surfaces around the base of the braces and/or presence of gingival inflammation.

The highest score found for a sextant is applied to the figure. It is representative of the entire sextant and reflects the result for the teeth of the group (Fig. 2). The highest score of all sextants determines the level of oral hygiene and identifies the need for preventive measures during orthodontic treatment. Result 3 is associated with an increased risk of caries and gingivitis.

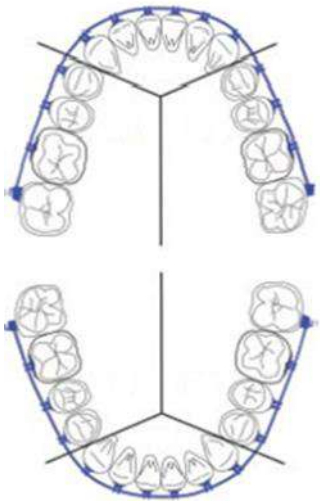


Fig. 2. Figure for application the value for sextant

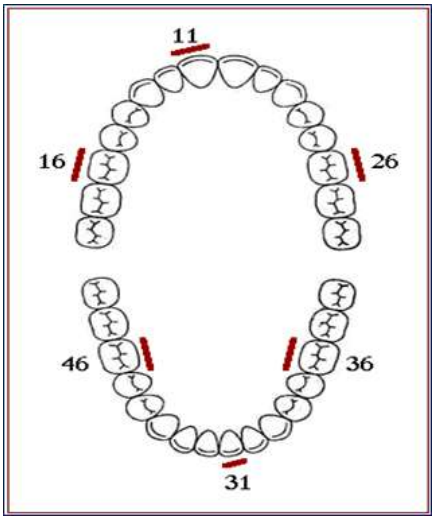


Fig. 3. Greene-Vermillion index

The similarities in the design of the two indices used (via plaque visualization) required for the control group to use the Greene-Vermillion index, in particular the Oral Hygiene Index-s (Simplified) (Greene and Vermillion, 1964).(Fig.3) (113). The indices of the clinical and control groups have been selected to simplify the clinical protocol for data collection, with each tooth being representative for a sextant. This excludes the possibility of making mistakes, e.g. in case of missing, retained teeth, in the presence of bands in the area of the molars, etc. The need for more precise objectification of plaque accumulation in close proximity to the elements of the fixed orthodontic technique in the clinical group, necessitated the use of the OPI index. It differs in design from Greene-Vermillion, but no differences in interpretation are found (36).

2.2.2. Study of oral hygiene status in patients from the control group

The oral-hygiene status of the examined children from the control group was diagnosed and registered with the OHI-s. It differs from the original in that 6 tooth surfaces are examined (instead of 12).

The examined tooth surfaces are stained with a plaque visualizer, then rinsed with water. The stained plaque is evaluated according to the following scheme:
Criteria for assessment of dental plaque
0 - No dental plaque.
1 - Dental plaque covers no more than 1/3 of the tooth surface.
2 - Dental plaque covers 1/3 to 2/3 of the tooth surface.
3 - Dental plaque covers more than 2/3 of the tooth surface.

The obtained values of the examined tooth surfaces are summed. The sum is divided by the number of surfaces examined. The arithmetic mean is the numerical expression of the plaque index and reflects the oral hygiene status.
Interpretation of the index:
0-1 – good oral hygiene
1-2 – satisfactory
2-3 – poor

2.3. For task 3: To study the level of gingival inflammation in children with fixed orthodontic technique and to compare with the control group

The assessment of the gingival inflammation of the children from the two studied groups was realized with the help of the gingival index (GI according to Löe and Silness). The registered data are entered in the ambulatory card of each of the children. The index was created to assess the condition of the gingiva and register qualitative changes. The marginal gingiva and the interdental papilla with codes from 0 to 3 are examined.

The criteria are:

- 0 = Normal gingiva
- 1 = Mild inflammation - a slight change in color and slight swelling, but no bleeding when probing;
- 2 = Moderate inflammation - redness, swelling and smoothing, bleeding when probing;
- 3 = Severe inflammation - marked redness and swelling, ulcers with a tendency to spontaneous bleeding.

Researched indicators:

- mean value of GI according to the studied groups by sex and age
- the relation between treatment duration and GI
- mean GI values according to the follow-up stages in the clinical group
- mean GI value according to the type of braces
- mean GI value according to the patient's cooperation in the treatment process
- the relation between GI and oral hygiene

2.3.1. Evaluation of gingival inflammation in patients from both study groups

Bleeding is assessed by carefully probing the soft tissue wall of the gingival sulcus. The results from the four areas of the tooth can be summed and divided into four to give a GI for the tooth. The individual's GI can be obtained by adding the values of each tooth and dividing

the number of teeth examined. GI can be used to assess the prevalence and severity of gingivitis in populations, groups, and individuals.

- 0.1-1.0 = mild imflammation;
- 1.1-2.0 = moderate imflammation;
- 2.1-3.0 = severe imflammation;

The GI can be calculated for all teeth, or for selected teeth. When examining selected teeth, the following are considered: 16, 12, 24, 36, 31, 46.

Code	Gingival status	Criteria
0	Healthy gingiva	Normal pale pink color of the gingiva, without swelling and signs of inflammation
1	Mild gingival inflammation	Minor color changes, slight swelling. No bleeding on probing
2	Moderate gingival inflammation	Hyperemia, edema and smoothing. Bleeding on probing
3	Severe gingival inflammation	Significant bleeding and swelling, ulcerations, tendency to spontaneous bleeding

2.4. For task 4: To assess the severity of white carious lesions in patients undergoing treatment with fixed orthodontic technique

For the purposes of the study, the Gorelick index and the diagnostic criteria for lesion activity were used.

Researched indicators:

- relative share of children according to the severity of white carious lesions according to Gorelick
- distribution by gender and Gorelick index
- distribution by age and Gorelick index
- the relation between the duration of treatment and the Gorelick index
- Gorelick index according to the follow-up stages
- distribution according to the type of braces and Gorelick index
- distribution of patients according to their cooperation and Gorelick index

2.4.1. Examination of the severity of white carious lesions in patients with fixed orthodontic technique

Visual and visual-tactile examination are the main diagnostic methods and are widely used in clinical practice to identify carious lesions around the body of the braces. They show low sensitivity and moderate to high specificity in clinical examinations. In order to improve the sensitivity and reproduction of the visual-tactile method for detecting and assessing the depth of lesions in the early stages, criteria have been developed demonstrating appropriate levels of reliability. These criteria also include the assessment of the activity of carious lesions. They allow differentiation of non-cavitated from cavited carious lesions, as well as active from inactive lesions.

To assess the severity of white carious lesions in the studied patients with fixed orthodontic technique, the Gorelick index modified by Øgaard in 1989 was used (111, 208).

Fig. 4. Schematic representation of the severity of white carious lesions according to the Gorelick Index, modified by the Øgaard 1989

The severity of white carious lesions is assessed with the following codes:
0 = healthy tooth surface;
1 = white carious lesion in the form of a spot or formation of lines;
2 = extensive white lesions;
3 = white lesions with cavitation.

Modern dental caries management focuses on non-operative or preventive treatment strategies. This approach is based on the modern understanding of the development of a carious lesion and requires diagnostic systems for its early detection. The modern concept for the diagnosis of dental caries assumes three stages of examination: detection of the carious lesion, assessment of the severity and assessment of the activity of the carious lesion. The activity of carious lesions is determined by applying visual clinical criteria for active and stationary carious lesion (4).

The following diagnostic criteria are used: loss of enamel gloss; loss of transparency; enamel whitening; loss of smoothness; boundaries of the enamel lesion; color - yellow, brown or black enamel lesion; enamel cavitation; hidden dentin caries; cavitated dentin caries; a large cavitated dentin lesion affecting the pulp.

The activity of carious lesions is determined by the following criteria: lesion located in areas prone to caries development, located under the plaque; loss of transparency of the enamel (impaired to varying degrees in active lesions); loss of enamel smoothness (active ones are rough); change in the color of the lesion (the active ones are whitish); lack of clear boundaries with healthy enamel (active ones have unclear boundaries); presence of poor oral hygiene - plaque on the lesion (there is plaque on the active ones); loss of gloss (active ones are without gloss); secondary carious lesions to old obturations are also active.

Criteria for a stationary lesion: a lesion located at a distance from the typical caries development surfaces; cavited or non-cavitated; limited in size; presence of clear boundaries with healthy enamel; color ranging from white to brown and black; lack of plaque.

2.5. For task 5: To assess the specific caries risk profile of patients with fixed orthodontic technique

We used the methodology of Heymann and Grauer (122) to assess the specific carious risk profile in patients with fixed orthodontic technique.

2.5.1. Caries risk assessment and registration

Table. 2. Methodology for risk assessment of development of white carious lesions according to Heymann and Grauer

Critera	HIGH RISK	LOW RISK
Presence of white carious lesions before treatment	Yes	No
Oral hygiene	Poor	Good
Cariogenic diet	Frequent use of sugar	Rare use of sugar
Duration of treatment	Long term	Short term
Location of the braces	Vestibular	Lingual
DMFT	High	Low
Developed white carious lesions during treatment	Yes	No

The methodology uses eight evaluation criteria, which are divided into two groups (Table 2). The presence of two or more criteria from this group is considered as high risk. If a patient develops white carious lesions during treatment, he is automatically classified in the high-risk group, regardless of other criteria (122).

Unlike other caries risk assessment systems, where only one indicator in the high-risk column assigns the patient to the high-risk group, much fewer parameters are considered here (7, 18, 19, 119, 273). In the original method of Heymann and Grauer, in the presence of two or more indicators in the column "HIGH RISK", the patient is classified in high risk of developing white carious lesions during orthodontic treatment (122).

- **DMFT index**

The DMFT index is used to assess dental status in children who have not undergone orthodontic treatment. It represents the sum of the number of teeth with caries (D), missing (M) and those that are filled (F). For patients in the clinical group, the DMFT index is used as a marker in the methodology for assessing the specific caries risk profile.

This index is calculated on the basis of a clinical examination and was established in 1930 (150). For example, if a patient has two carious, three obturated, and one missing tooth, his DMFT index will be 6.

It is one of the most commonly used methods in oral epidemiology to assess the prevalence of dental caries and the population's need for dental treatment. It is based on a clinical examination, including a dental mirror, a probe and isolating agents.

Although widely used in practice, the DMFT index also has some limitations, such as the lack of data on the number of teeth at risk or other data that can be used in the assessment

of treatment needs. The index gives equal weight to missing teeth, untreated caries and fillings. Moreover, it does not take into account the cause of tooth loss (24, 52).

Researched indicators:

- distribution according to caries risk and the studied groups
- assessment of caries risk according to gender and age of the studied group
- the relation between the degree of caries risk and the average duration of orthodontic treatment
- caries risk assessment according to the follow-up stages
- assessment of caries risk according to the type of braces
- assessment of caries risk according to the degree of the patient`s cooperation

2.6. For task 6: To create an algorithm for prevention of white carious lesions in patients with fixed orthodontic technique depending on the level of oral hygiene

To perform the sixth task, a survey was conducted through a direct questionnaire, completed anonymously, aimed at gathering information about the nutritional preferences of participants, their awareness of the appearance of white lesions around the braces and the possibilities for their prevention and treatment (Appendix 2). The questionnaire consists of 12 questions. Two of the questions are demographic, three questions are related to oral hygiene and the other seven questions are focused on the study of food preferences and changes in behavior after the placement of fixed orthodontic appliances.

Based on the data obtained from the survey and the summarized results of the studies, as well as the assessment of caries risk, an algorithm for prevention and follow-up of white carious lesions in patients with fixed orthodontic technique was prepared. Patient prevention protocols have been developed according to risk. Informative and motivational materials have been prepared for patients and their parents regarding nutrition, oral hygiene and dental care during orthodontic treatment with a fixed orthodontic technique.

Researched indicators:

- frequency of brushing teeth according to gender
- frequency of brushing teeth according to age
- duration of brushing according to gender
- duration of brushing teeth according to age
- distribution of children according to the change of eating habits
- distribution of children according to the change of eating habits and age
- distribution of children according to the change in eating habits and the duration of treatment

3. Statistical methods - for all tasks

The results were processed with SPSS v. 20.0, using the following analyzes:

- Dispersion analysis (ANOVA);
- Variation analysis - arithmetic mean ± standard deviation (mean±SD);

- Correlation analysis - Pearson's ratio and Spearman's ratio
- Regression analysis - univariate linear regression
- Risk analysis - Odds Ratio (OR)
- Comparative analysis (hypothesis evaluation)– χ^2, F and t-test.
  Graphic and tabular method of displaying the obtained results
  In all analyzes performed, an acceptable level of significance $p < 0.05$ is assumed.

The clinical trial was conducted after obtaining permission from the Commission for Ethics of Scientific Research at Medical University -Varna - Decision №87, meeting on 24.10.2019. All participants in the study have signed an informed consent (Appendix 8 and 9).

Results and discussion

1. Study of the prevalence of white carious lesions in patients with fixed orthodontic technique

The mean age of the children in both groups was 14.7 years ± 2.1 years, with girls predominating (65.9%).

The mean EDI value is 0.18 ± 0.17 (0-0.44) or it can be said that in the group of children with fixed orthodontic technique the lesions have a transparency of less than 1 mm in length or diameter. There is no difference in terms of gender, although for boys the index has a slightly higher value (0.18 for girls to 0.19 for boys, respectively).

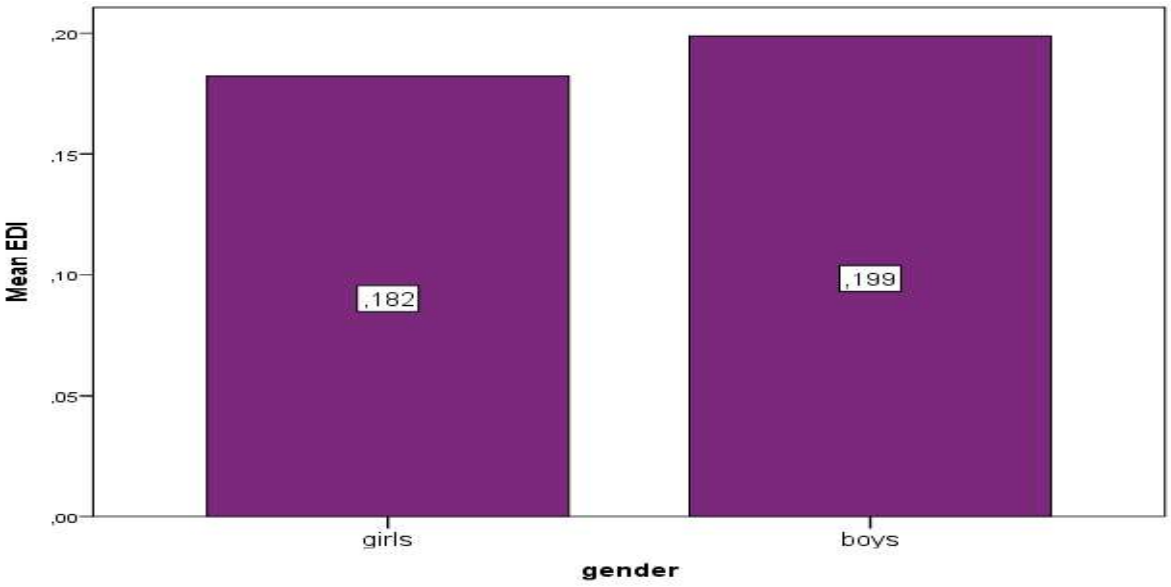


Fig. 5. Mean EDI value according to the gender

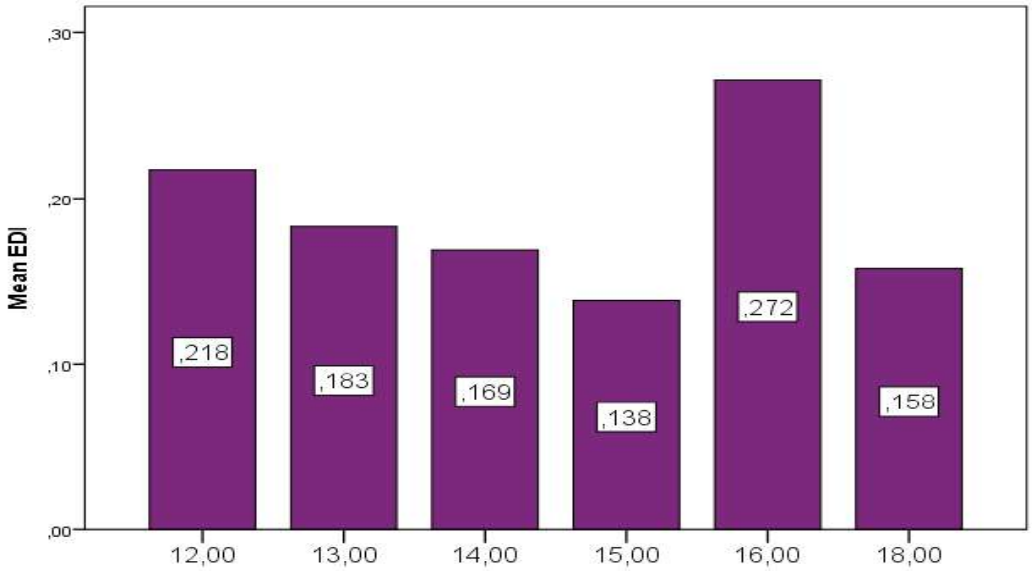


Fig. 6. Mean EDI value by age

No relation has been established between the age of the children and EDI. Despite the lack of difference, elevated mean EDI values were observed in children aged 16 years (0.272) and 12 years (0.218), the lowest mean value was observed in adults aged 15 years (0.138) (Fig. 6).

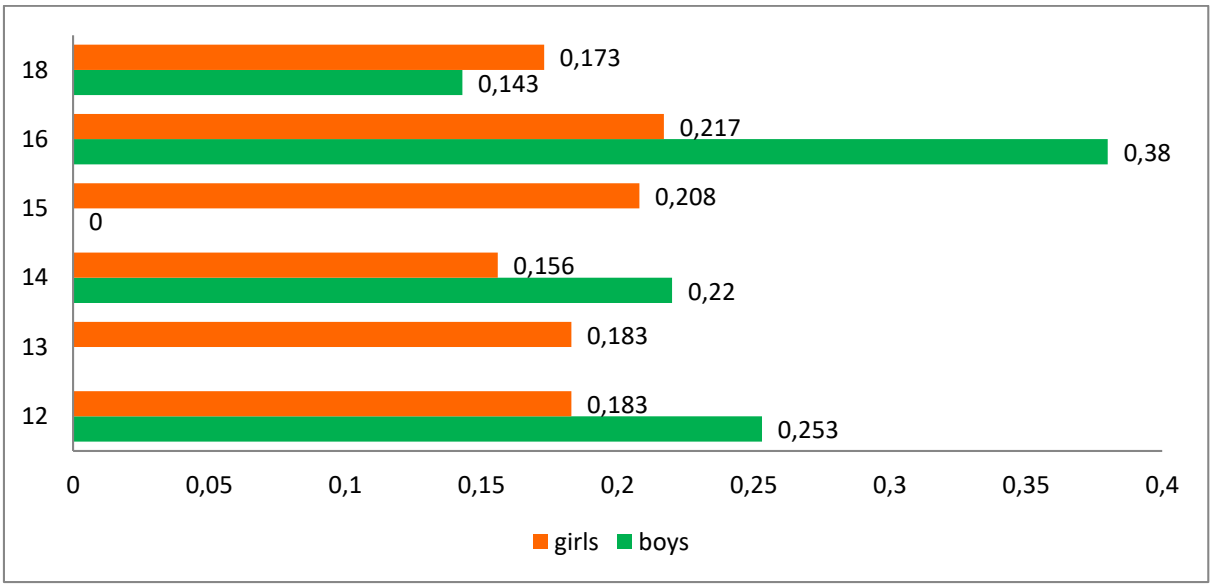


Fig. 7. Mean EDI values by gender and age

There was a statistically significant difference in EDI in the simultaneous study of gender and age of the studied children ($p < 0.05$), and in girls there were increased values of EDI at the age of 16 years (0.218) and 15 years (0.208). In boys, elevated EDI values were observed at age 16 years (0.380), followed by 12 years (0.252) and 14 years (0.220) (Fig. 7).

On the other hand, a positive moderate correlation was found between EDI and the duration of treatment with a fixed orthodontic technique ($r = 0.423$; $p < 0.001$), which shows that with increasing duration of treatment the risk of white carious lesions increases (Table 3 and Table 4).

Table 3. Linear regression analysis of the relationship between treatment duration and EDI

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11,158	1,140		9,789	,000
	EDI	23,056	4,496	,423	5,129	,000

a. Dependent Variable: Duration of treatment (months)

Table 4. Correlation analysis between treatment duration and EDI

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,423[a]	,179	,172	8,49366

a. Predictors: (Constant), EDI

The analysis of the change in EDI according to the follow-up stages showed that as the duration of treatment increased, the mean value of the index also increased (p = 0.002) (Fig. 8). At the beginning of treatment on the 1st month of follow-up, EDI had the lowest values (0.135 ± 0.166), with a steady upward trend at 6 months after braces and in the retention phase of treatment (0.188 ± 0.179 for the 6th month and 0.269 ± 0.137 for the retention phase).

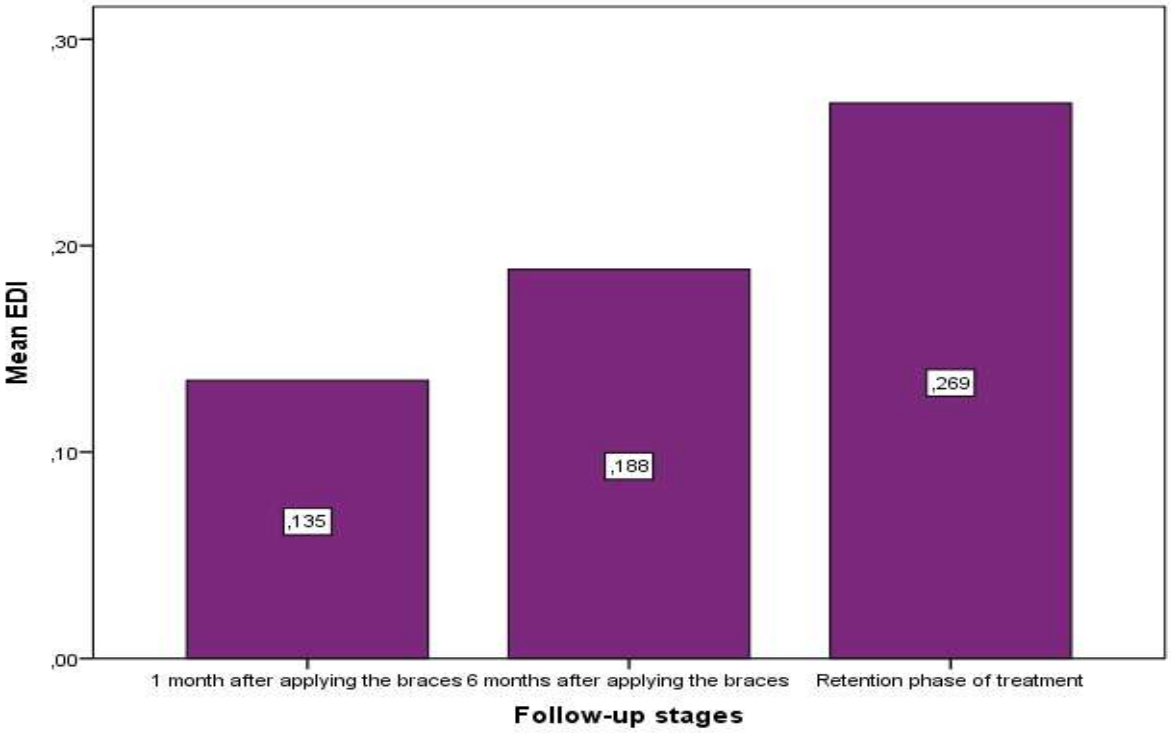


Fig. 8. Mean EDI values by follow-up stages

There was a significant difference in the mean values of EDI and the type of braces (p<0.001) (Fig. 9). Children with metal braces have significantly higher EDI values.

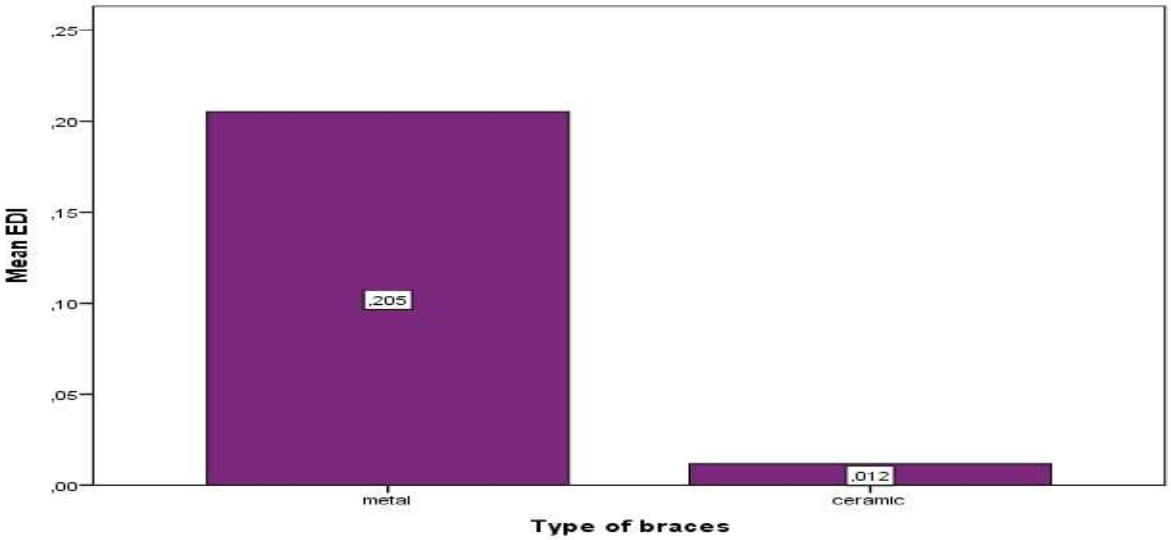


Fig. 9. Mean values of EDI according to the type of braces

Over 1/3 (36.6%) of the children who receive treatment with a fixed orthodontic technique do not cooperate in the treatment process. Patients who did not cooperate in the treatment process had a higher EDI index (p = 0.001) (Fig. 10).

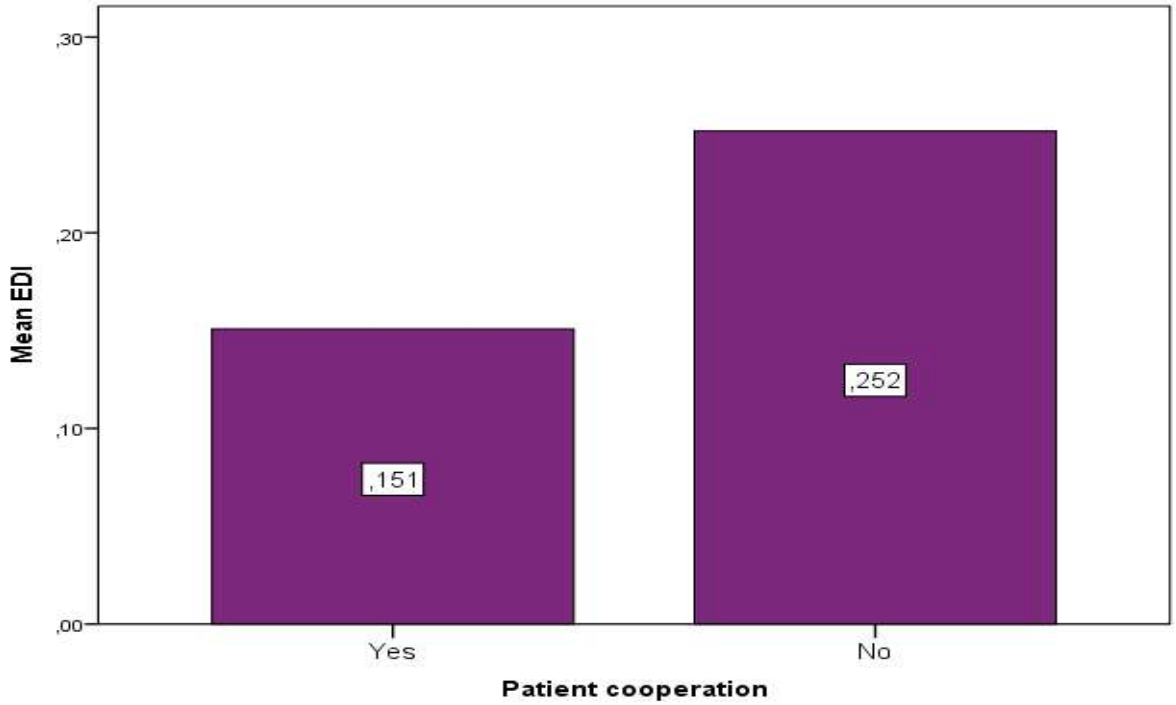


Fig. 10. Mean EDI value according to patient cooperation

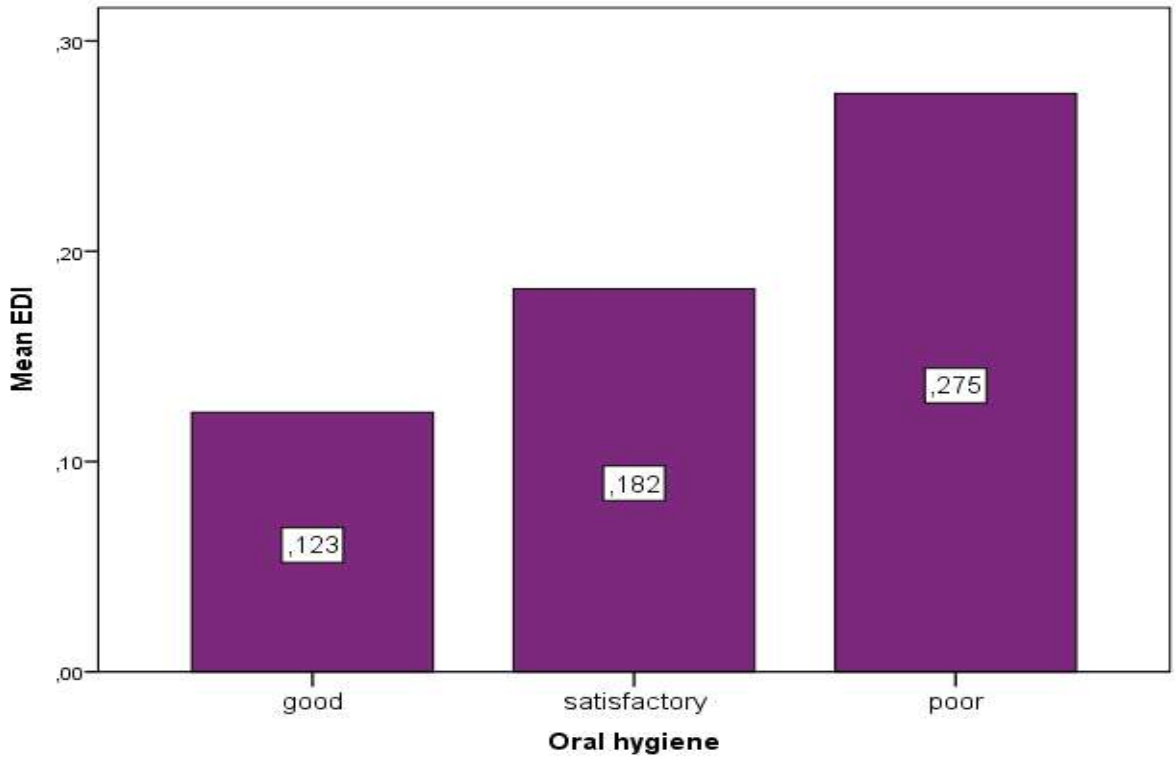


Fig. 11. Mean EDI value according to the child's oral hygiene

Fig. 11 shows the change of EDI according to the level of oral hygiene of children with fixed orthodontic technique. The results show that the poorer the hygiene of the child during orthodontic treatment, the higher the incidence of white carious lesions ($p < 0.001$).

1.1 Discussion on task 1

White carious lesions are one of the most common complications due to orthodontic treatment with a fixed technique. Fixed appliances are areas for plaque retention and in the absence of good oral hygiene, plaque accumulates and acidogenic bacteria through their metabolism cause progressive demineralization. In the present study, 58.5% of children undergoing orthodontic treatment with a fixed technique have white carious lesions, and in some of them the lesions appeared as early as the second month after starting treatment. The incidence of white carious lesions in the present study was higher than that reported by Tufekci et al. (272) - 38%, as in the study by Farishta et al. (94) - 39.7% and that of Lucchese and Gherlone (172) - 40%.

A review of the literature shows a large discrepancy in the results obtained by different researchers. The incidence of enamel demineralization in orthodontic patients is estimated at 2–96%. A study conducted by Hamdan et al. (118) showed that in the opinion of general dentists, on average 20% of patients had white carious lesions after orthodontic treatment, while according to orthodontists about 10% of patients had white carious lesions after orthodontic treatment. Enaia M. et al. (91) examined white carious lesions that developed during orthodontic treatment with a fixed technique. Their study revealed that the incidence of white carious lesions during orthodontic therapy was 60.9% of patients. Demineralization in a group of patients aged 12–18 years with poor oral hygiene was observed by Fornell et al. (100). Sagarika N. et al. (240) found a high incidence of white carious lesions in 75.6% of patients undergoing orthodontic treatment. Khalaf K. (144) showed a frequency of at least one white carious lesion in 42% of patients. The study by Julien et al. (138) revealed that 23.4% of patients developed at least one white carious lesion during the course of treatment. Assessing the presence of lesions on the vestibular surface of 8 anterior teeth, Chapman et al. (60) show the presence of at least one demineralization zone in 36% of cases. Richter et al. (234) reported that 72.9% of patients had at least one lesion during orthodontic treatment. Hadler-Olsen et al. (115) show the presence of at least one lesion in 60% of orthodontic patients, and Al Maaitah EF et al. (14) found lesions in 71.7% of patients. Such a high percentage can probably be explained by the fact that the study was conducted after the end of treatment.

Regarding the prevalence of white carious lesions by gender in the present study, it was found that there was no difference between boys and girls, as in girls their frequency was 59.3% and in boys it was 57.1%. The present results contradict those of Boersma et al. (49), who reported a prevalence of 40% in men and 22% in female patients, they indicated that men were at higher risk of developing white carious lesions. In the study by Farishta et al. (94) white carious lesions were 17.6% in men and 22.1% in women.

The high variability of the results obtained by different authors can be attributed to the wide variety of methods used to assess white carious lesions. Not all studies have performed a

qualitative critical analysis between white carious lesions and other non-carious diseases, dysplasia or fluorosis. They can be mistaken for an initial carious process.

2. Study the level of plaque accumulation in children with fixed orthodontic technique and compare with the control group

OPI is used to assess the level of plaque in children with fixed orthodontic technique, and in children in the control group - OHI. The mean value of OPI was 1.91 ± 1.33 (0-4.0), and in the children of the control group was 1.22 ± 0.75 (0-3.0), and there was a significant difference in the plaque index in the two studied groups (p <0.05) (Fig. 12).

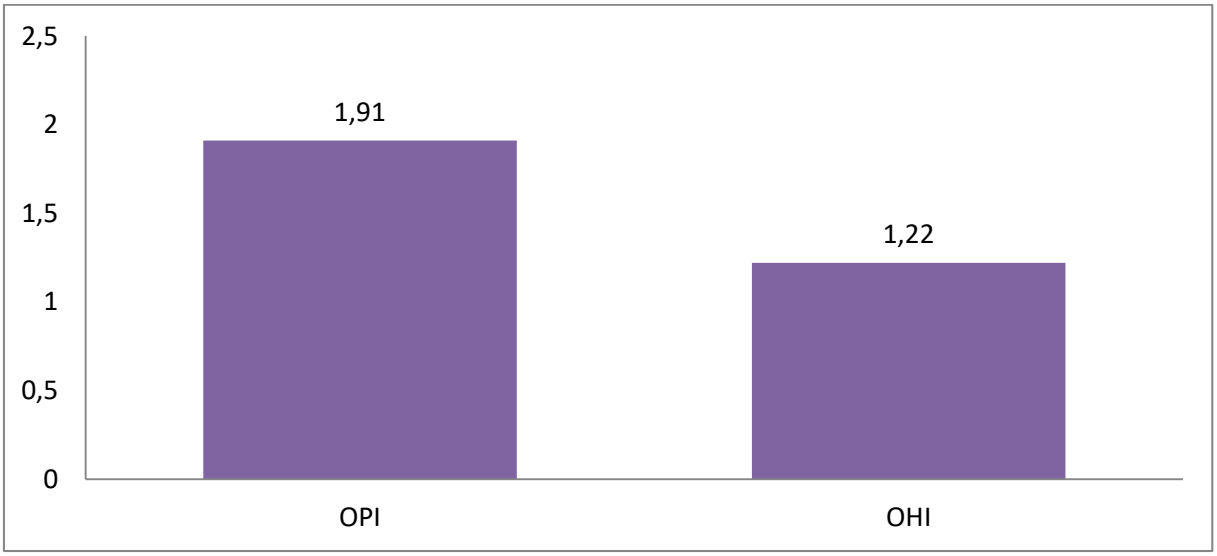


Fig. 12. Mean value of plaque indices

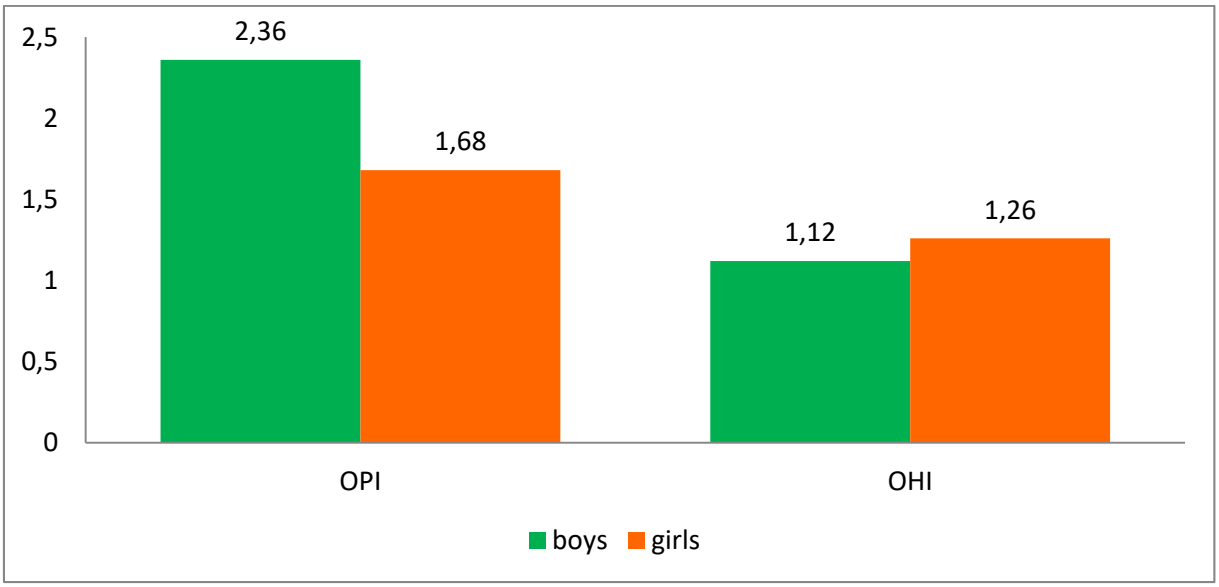


Fig. 13. Mean value of plaque indices by gender

In children with fixed orthodontic technique there is a significant difference in the plaque index in boys and girls (p = 0.007), and in boys there is more accumulated plaque (respectively 1.68 to 2.36). In the control group, no difference in the plaque index was found according to gender, although in girls the value was slightly higher (Fig. 13).

There was a significant difference in the plaque index and the age of the children both in the control group (p = 0.006) and in the group of children treated with a fixed orthodontic technique (p = 0.004) (Fig. 14). On the other hand, a significant difference in the plaque index was found in the different age groups, and it is most pronounced at the age of 12 (OPI 2.5 to OHI 1.1), 13 (OPI 2.66 to OHI 1.5), 18 (OPI). 2.04 to OHI 1.59) and 14 years (OPI 1.87 to OHI 0.87).

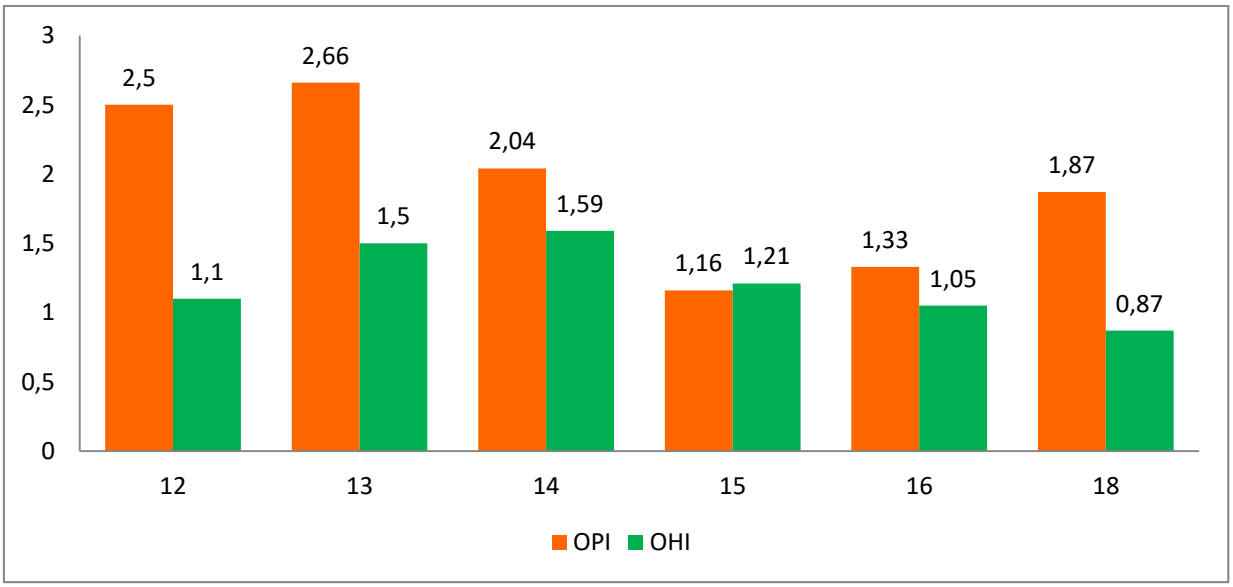


Fig. 14. Mean value of the plaque index according to age

In patients treated with fixed orthodontic technique, a positive moderate correlation was found between OPI and duration of treatment (r = 0.391; p <0.001) (Table 5), and it can be said that 15.3% of the changes in the plaque index are due to the duration of treatment (Table 6).

Table 5. Linear regression analysis of the correlation between treatment duration and OPI

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10,261	1,361		7,539	,000
	OPI	2,733	,584	,391	4,679	,000

a. Dependent Variable: Duration of treatment (months)

Table 6. Correlation analysis between treatment duration and OPI

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,391[a]	,153	,146	8,62372

a. Predictors: (Constant), OPI

The analysis of the change in OPI according to the follow-up stages showed that as the duration of treatment increased, the mean value of the index also increased ($p < 0.001$) (Fig. 15). At the beginning of treatment at 1st month of follow-up, OPI had the lowest values (1,435 ± 1,026), with a steady upward trend at 6 months after braces placement and in the retention phase of treatment (1,846 ± 1,367 for the 6th month and 2,727 ± 1,376 for the retention phase).

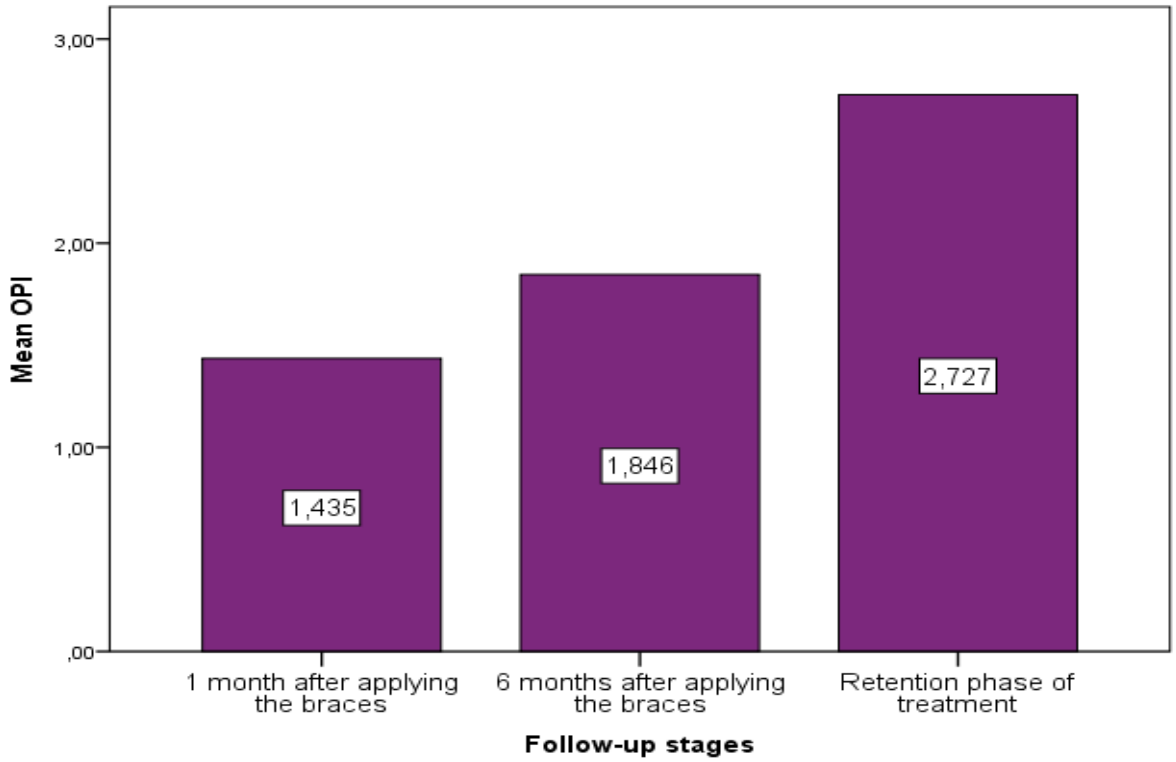


Fig. 15. Mean OPI values by follow-up stages

Although in patients with ceramic braces lower values of the plaque index were found compared to those with metal braces (1.36 to 1.96), the difference was insignificant ($p > 0.05$) (Fig. 16).

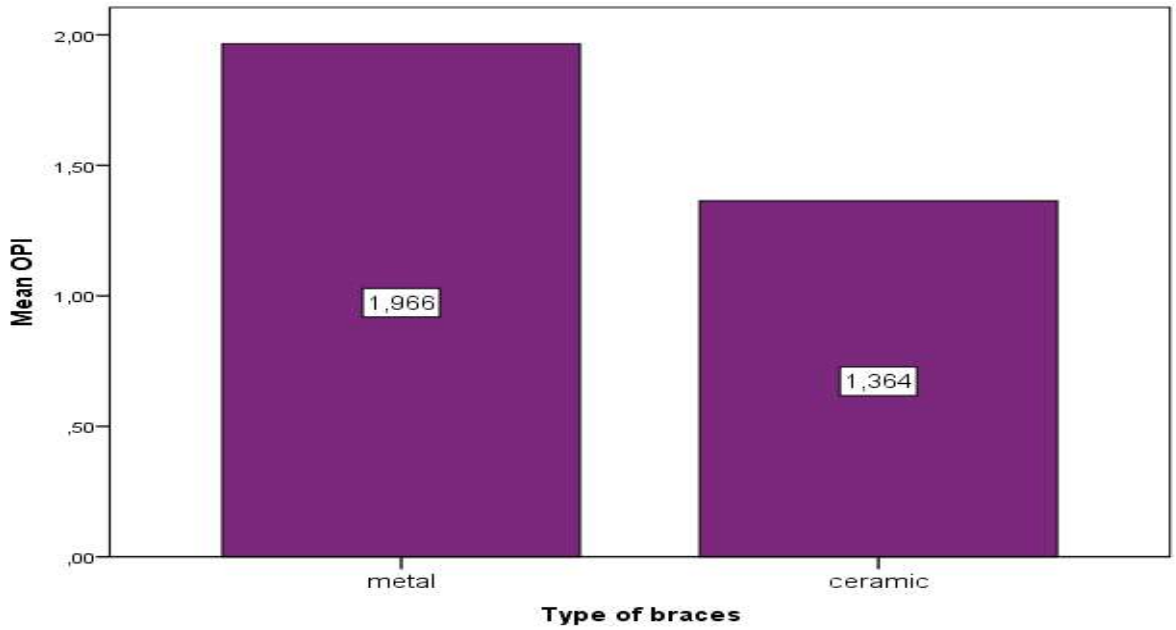


Fig. 16. Mean value of OPI according to the type of braces

Patients who did not cooperate in the orthodontic treatment process had elevated plaque index values ($p < 0.001$) (Fig. 17).

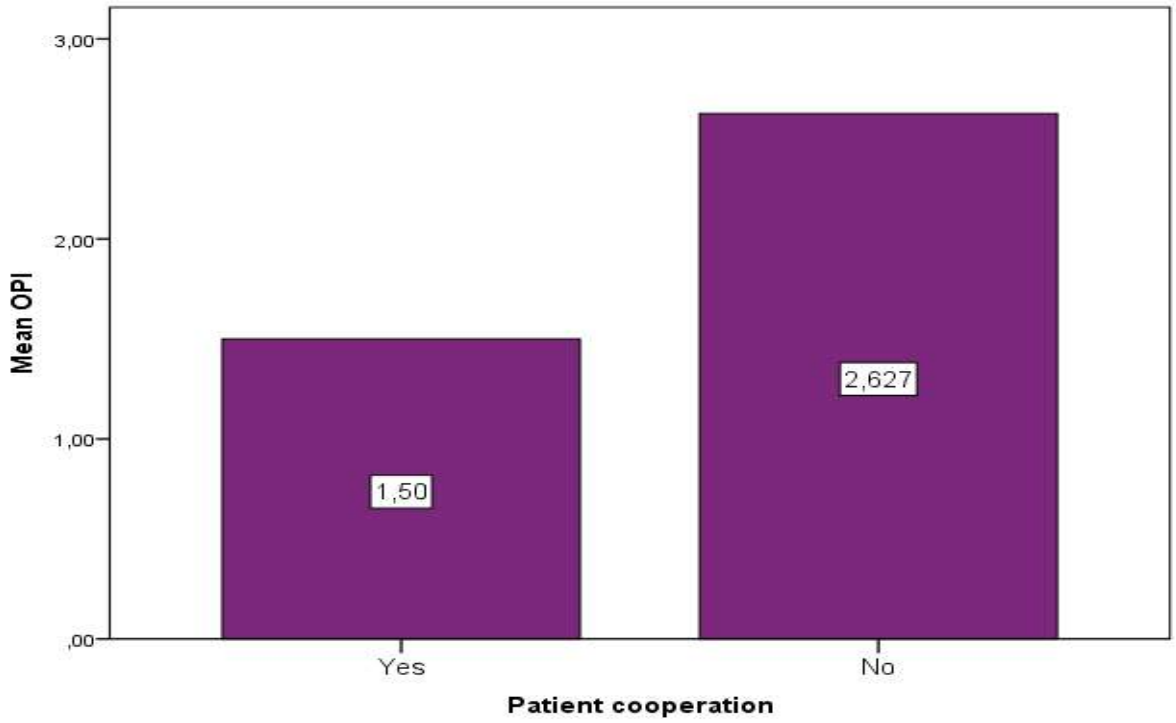


Fig. 17. Mean value of the plaque index according to the patient's cooperation

Fig. 18 shows an example of a lack of patient cooperation and elevated plaque index values (OPI = 3). A 12-year-old male patient who underwent orthodontic treatment for 7

months. The staining shows poor oral hygiene, both in the upper jaw, where the braces are placed, and in the lower jaw, in which braces are to be placed soon.

Fig. 18. Elevated plaque index in a patient who does not cooperate in the process of orthodontic treatment

Despite the patient's cooperation, improper oral hygiene also leads to the accumulation of dental plaque, especially on the upper jaw in the area around the braces (Fig. 19).

Fig. 19. Improper oral hygiene of a patient with orthodontic treatment

Fig. 20 presents a patient who cooperates in the process of orthodontic treatment and fulfills all recommendations for oral hygiene.

Fig. 20. Пример за сътрудничество на пациента и поддържането на добра орална хигиена

2.1 Discussion on task 2

The results of a study conducted by Hamdan et al. (118) showed that 56% of orthodontists rarely and 7% never removed braces due to poor oral hygiene of the patient. According to the literature, white carious lesions do not disappear after removing the braces and improving oral hygiene. Studies by Mattousch TJ et al. (182) showed that although in two-fifths of the cases the changes showed some improvement, most white carious lesions were irreversible and the condition of 15% of patients even worsened after two years, during the retention phase. The gradual changes in mineralization are highest in the first 6 months after the removal of the fixed orthodontic technique. White carious lesions visible after this time do not disappear. Orthodontic therapy is inextricably linked with the adequate conduct of oral hygiene activities. The task of the dentist is to inform the patient about proper oral hygiene in order to prevent the negative consequences of orthodontic therapy. It is important to identify patients with poor oral hygiene and to implement prophylactic programs before starting orthodontic therapy. Treatment should not be initiated unless there is a possibility of alternatives to the treatment plan and the patient is not motivated or cooperative (120). The presence of white carious lesions affects the patient's perception of treatment results.

Clinically white carious lesions can develop rapidly, appearing at 4 weeks after starting treatment in the presence of poor oral hygiene. (60) Demineralization has been reported to be more common in patients undergoing fixed orthodontic treatment. However, their frequency has been reported to vary widely, from 2% to 97% in various epidemiological studies, (46, 122, 138, 243), which can be explained by the techniques used to detect and characterize them, including visual inspection, photographs, fluorescent methods and modern diagnostic tools such as DIAGNOdent, QLF and diFOTI (138). Methods using quantitative laser fluorescence are more sensitive, resulting in a higher rate of lesion spread than conventional visual clinical techniques. On average, such demineralized lesions were found in 15.5% ~ 40% of patients before orthodontic treatment and in 30% ~ 70% during treatment (138). Based on a recent meta-analysis, in 14 studies on the development of white carious lesions, the incidence of new carious lesions that developed during orthodontic treatment was 45.8% and prevalence 68.4%. It is concluded that the incidence of white carious lesions is quite high and alarming in patients undergoing orthodontic treatment, which requires the attention of both patients and specialists to effective measures to prevent caries (267).

Therefore, before undergoing orthodontic treatment, these lesions must be diagnosed and registered by means of standardized photographs, taking into account magnification, lighting, etc. (46). White carious lesions prior to orthodontic treatment are considered a risk factor for the development of new lesions, (122) along with poor oral hygiene, excessive juice consumption, frequent intake of fermentable carbohydrates, and duration of treatment (122, 144). Richter et al. reported the development of three new lesions in 22 months, with at least five caries in 33 months of treatment (234).

There is a major change in the bacterial composition of the plaque in the oral cavity after fixing orthodontic appliances, with higher concentrations of acidogenic and aciduric bacteria in the biofilm, the most important of which are Streptococcus mutans and Lactobacilli. High concentrations of acidogenic bacteria are greater in orthodontic patients than in other patients

(175), leading to faster caries progression. White carious lesions may appear within 1 month after placing the braces around them; carious lesions usually develop for at least 6 months. They usually appear on the vestibular surfaces of the teeth around the braces, especially in the gingival area (182), and are most common in the labio-gingival area of the upper lateral incisors, and the distal teeth of the upper jaw are the rarest place for white carious lesions. Men are affected more often than women (60). A significant increase in the prevalence of these lesions around the body of the braces, between the braces and the arches, in the gingival areas and the middle third of the vestibular surfaces of the teeth under the orthodontic arches has been reported (189, 289). Tufekci et al. reported a sharp increase in the number of white carious lesions during the first 6 months of treatment, increasing at a slower rate to 12 months. Therefore, a reassessment of oral hygiene is required during the first month of treatment (272).

3. Study the level of gingival inflammation in children with fixed orthodontic technique and compare with the control group

The gingival status in both groups of patients was examined with the same index. When assessing the gingival status, it was found that there is a significant difference between the mean GI values, as in children with fixed orthodontic technique there is a greater number of bleeding units than in healthy controls (respectively 0.91 (0-2.50) to 0.14 -1.10) ($p < 0.001$) (Fig. 21).

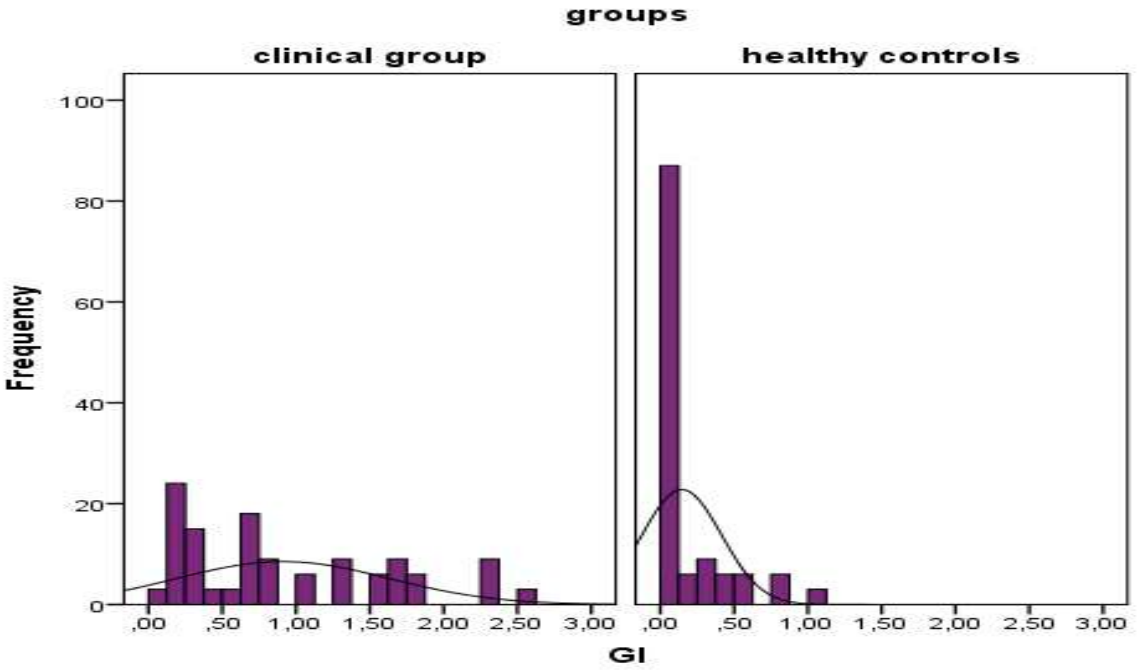


Fig. 21. Distribution according to the gingival index

In the analysis of the gingival index by gender, it was found that in both study groups the mean GI value in boys was lower ($p < 0.05$), with a significant difference between girls and boys in the two study groups ($p < 0.001$) ($p < 0.001$) (Fig. 22).

A significant difference in the mean GI values was also found in regard to the age of the children, as in the group of healthy controls there was a tendency to decrease the GI with increasing age (p <0.001) (Fig. 23).

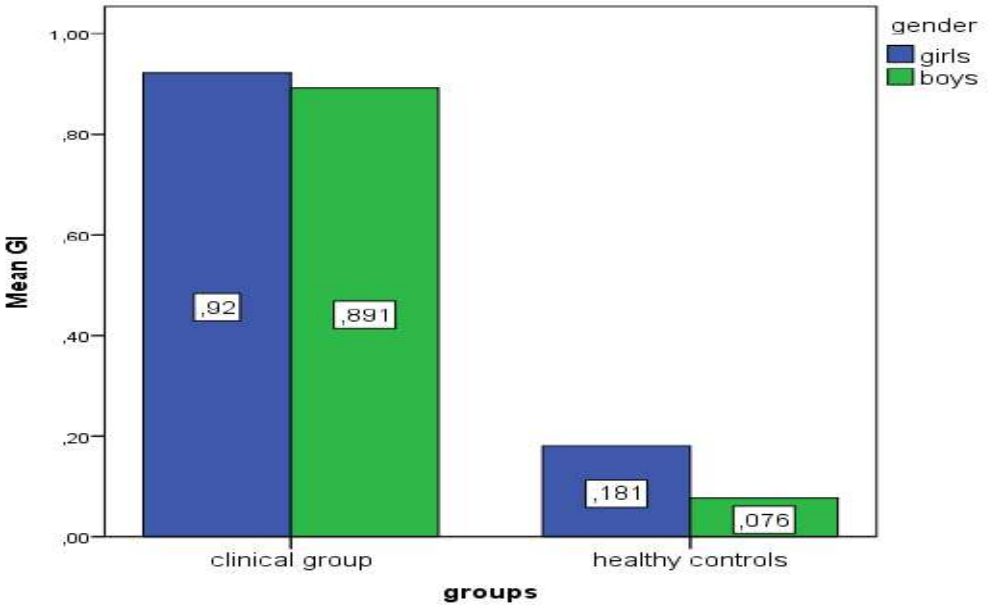


Fig. 22. Mean GI value according to the studied groups and gender

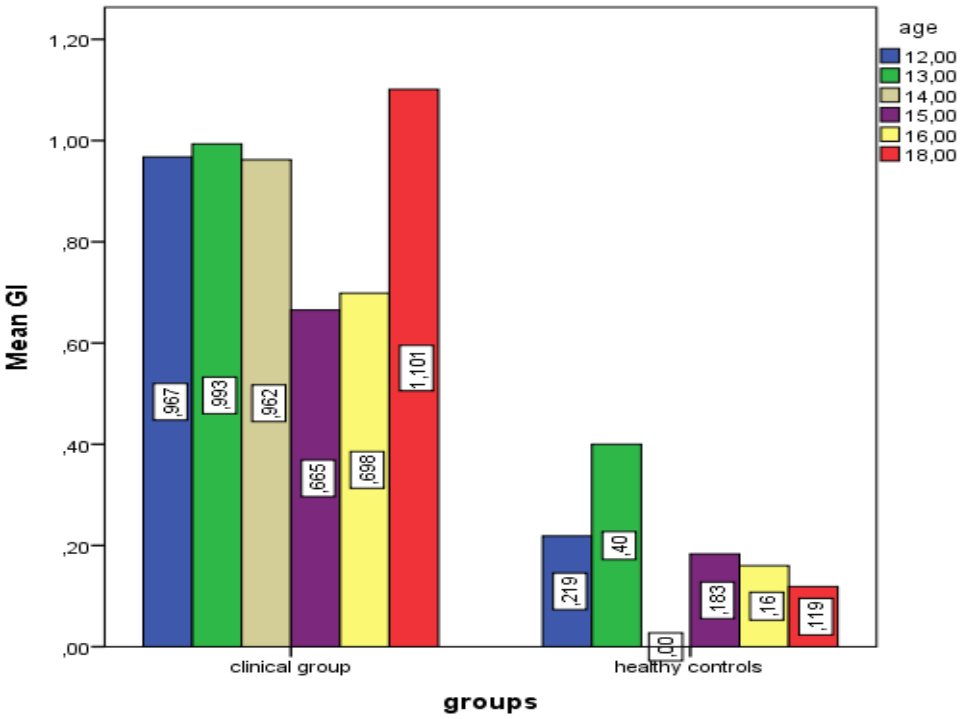


Fig. 23. Mean GI value according to the studied groups and age

In the analysis of the relationship between the duration of orthodontic treatment and the gingival index, a positive moderate correlation was found (r = 0.320; p <0.001), as the GI value increased with increasing duration of treatment (Table 7 and Table 8).

Table 7. Linear regression analysis of the relationship between treatment duration and GI

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11,711	1,294		9,049	,000
	GI	4,148	1,117	,320	3,715	,000

a. Dependent Variable: Duration of treatment (months)

Table 8. Correlation analysis between treatment duration and GI

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,320[a]	,102	,095	8,87889

a. Predictors: (Constant), GI

Analysis of the change in GI according to the follow-up stages showed that as the duration of treatment increased, the mean value of the index also increased (p = 0.004) (Fig. 24). At the beginning of treatment on the 1st month of follow-up, the GI had the lowest values (0.795 ± 0.737), with a steady upward trend at 6 months after braces placement and in the retention phase of treatment (respectively 0.767 ± 0.516 for the 6th month and 1.259 ± 0.798 for the retention phase).

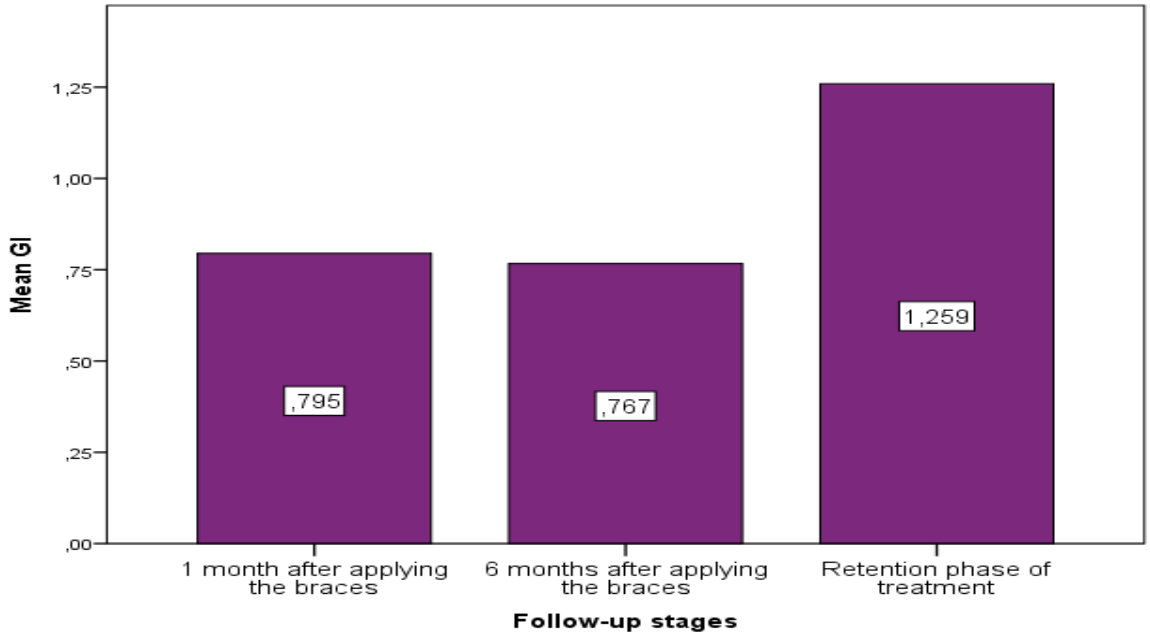


Fig. 24. Mean GI values by follow-up stages

Fig. 25 presents the average GI values according to the type of braces used for orthodontic treatment. Patients treated with metal braces had higher GI values than treated with ceramic braces (0.976 and 0.244, respectively) (p = 0.001).

Patients who did not cooperate had three times higher GI values (p <0.001) (Fig. 26).

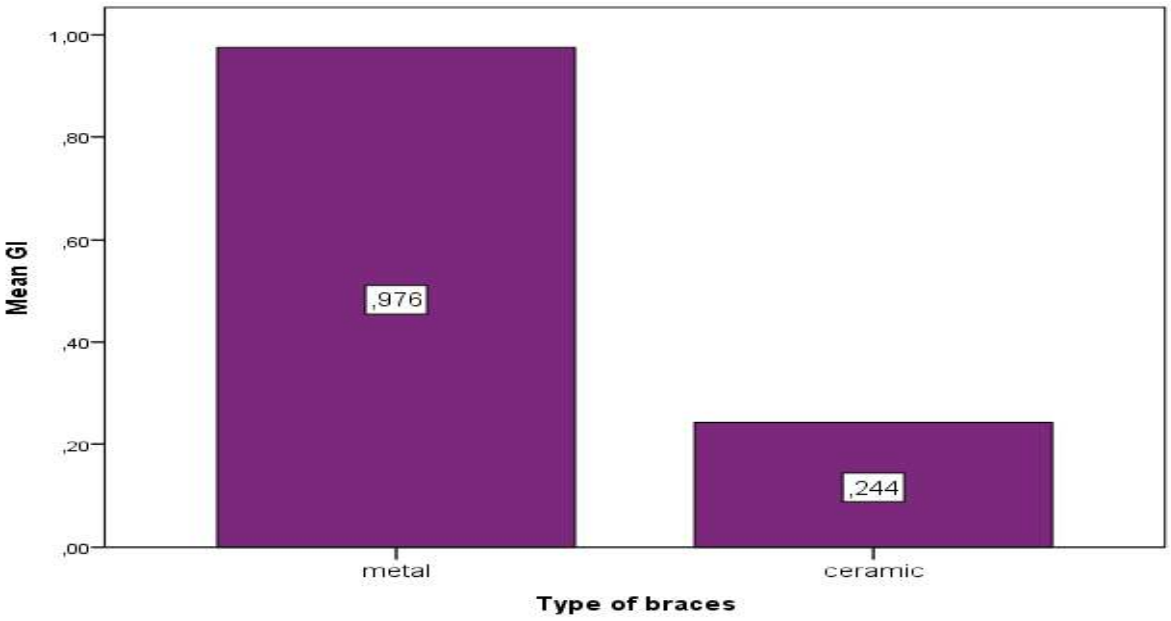


Fig. 25. Mean GI value according to the type of braces

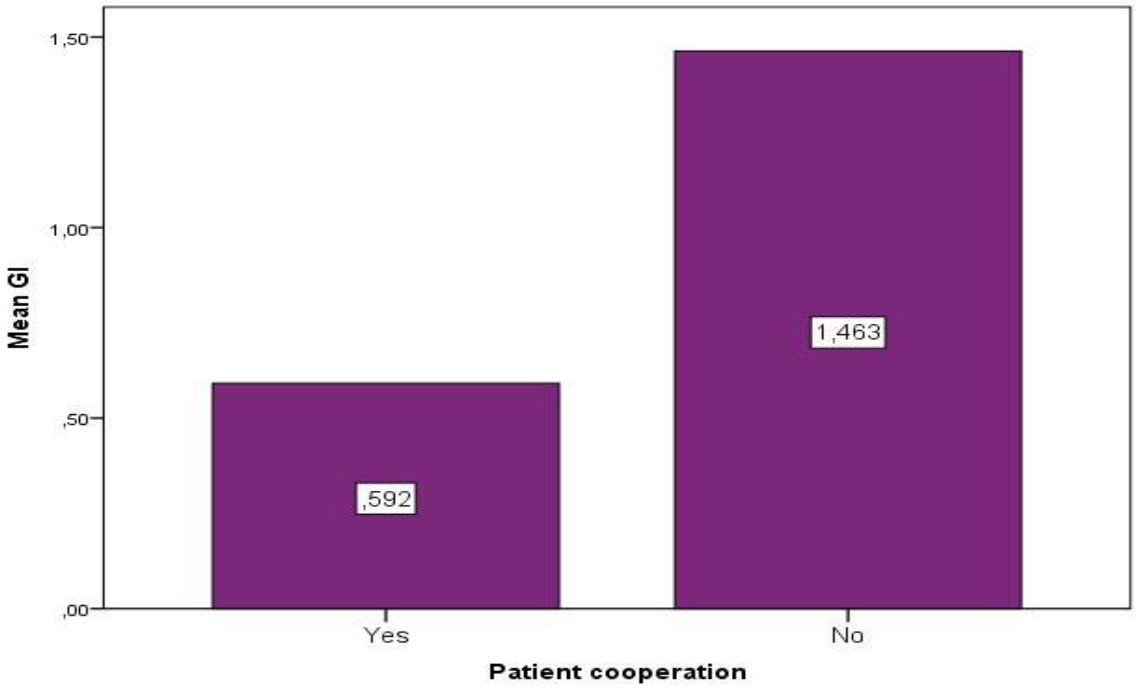


Fig. 26. Mean GI value according to the patient's cooperation in the treatment process

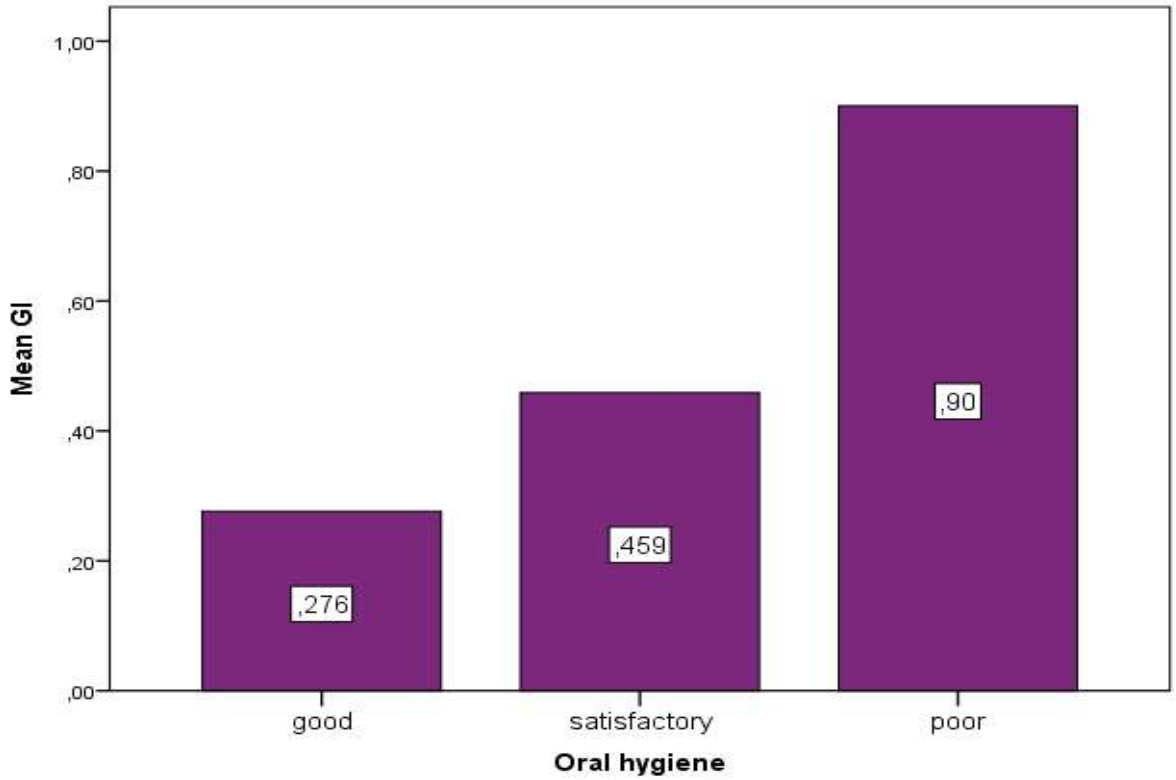


Fig. 27. Relation between GI and oral hygiene

There was a significant difference ($p<0.001$) (Fig. 27) and a positive moderate correlation between GI and oral hygiene ($r = 0.368$; $p <0.001$), which showed that the worse the oral hygiene, the greater the GI value is (Table 9 and Table 10).

Table 9. Linear regression analysis of the relationship between oral hygiene and GI

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1,733	,060		28,895	,000
	GI	,437	,071	,368	6,173	,000

a. Dependent Variable: Oral hygiene

Table 10. Correlation analysis between oral hygiene and GI

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,368[a]	,135	,132	,73565

a. Predictors: (Constant), GI

Fig. 28 presents an example of a patient with orthodontic treatment who has bad behavioral habits, creating a precondition for complications.

Regarding oral health in patients with fixed orthodontic technique, the gingival index is a clinical indicator of a confirmatory nature regarding the patient's status. The most commonly used index is Loë and Silness.

Fig. 28. Presence of inflammation, gingival hyperplasia in response to inflammation and presence of recession in teeth 21 and 13

3.1 Discussion on task 3

Accumulation of dental plaque around orthodontic appliances can lead to periodontal diseases and dental caries (168), after fixation of the orthodontic appliance inflammation of the gingiva is initiated in almost all orthodontic patients. Fortunately, this inflammation is transient and reversible, without leading to loss of attachment (26).

Orthodontic treatment is a therapeutic approach with a dual effect on periodontal tissues. Sometimes it is strongly indicated for improving the health of the periodontium, and sometimes it has harmful consequences and can be followed by a number of periodontal complications. Recent studies have shown that the most important etiological factor of gingival and periodontal disease is the accumulation of dental biofilm around the gingival margin (124).

The results show significantly increased values of the plaque and gingival index. A higher number of bleeding units was found in patients wearing fixed orthodontic appliances. Plaque accumulation can be associated with numerous elements of fixed orthodontic techniques, such as arches, bands and ligatures, which make maintaining good oral hygiene extremely difficult. Fixed orthodontic appliances hamper the effective removal of the dental biofilm, the proper hygiene of the oral cavity and thus adversely affect gingival health (235). Difficulties in plaque control and elevated plaque index lead to the development of gingivitis, which can be significantly aggravated within 21 days (259). This was also shown in our study by increasing the values of the gingival index and the high percentage of bleeding sites in patients with fixed orthodontic appliances.

Our results are in agreement with the research of Ristic and his colleagues (235) and the result of Naranjo et al., who report that the placement of fixed orthodontic appliances will affect the environment through the accumulation of biofilm in the zone of braces (201).

Like any other medical treatment, the balance between the expected benefits and the associated risks must remain positive. In braces treatment, the main iatrogenic effects are gingivitis and enamel demineralization (221, 277). These adverse effects affect 50 to 70% of patients treated with a fixed orthodontic technique (115). Gingivitis and enamel demineralization are also associated with the diversification of the bacterial biofilm accumulated in close proximity with the elements of the fixed orthodontic technique (184). Changes in the quantity and quality of the bacterial flora have been identified (211). From a quantitative point of view, colonization on the tooth surfaces and near the body of the braces turns out to be faster. In addition, all elements of the fixed orthodontic technique create highly retentive surfaces.

Not to be underestimated is the fact that in the area of the first permanent molars (where the rings are most often positioned), along with the increased amounts of dental biofilm, there is also mechanical trauma to the gingival tissues and this aggravates the clinical picture. In our study, patients are most positive for bleeding in the area of the sixth teeth.

4. Assessment of the severity of white carious lesions in patients undergoing treatment with a fixed orthodontic technique

The assessment of the severity of white carious lesions in patients undergoing orthodontic treatment was performed using the Gorelick index, with a mean value of 0.90 ± 0.85 (0-2.0). The majority of children with fixed orthodontic technique have healthy teeth surfaces (41.5%), and the relative share of children with extensive white lesions (31.7%) is relatively high (Fig. 29).

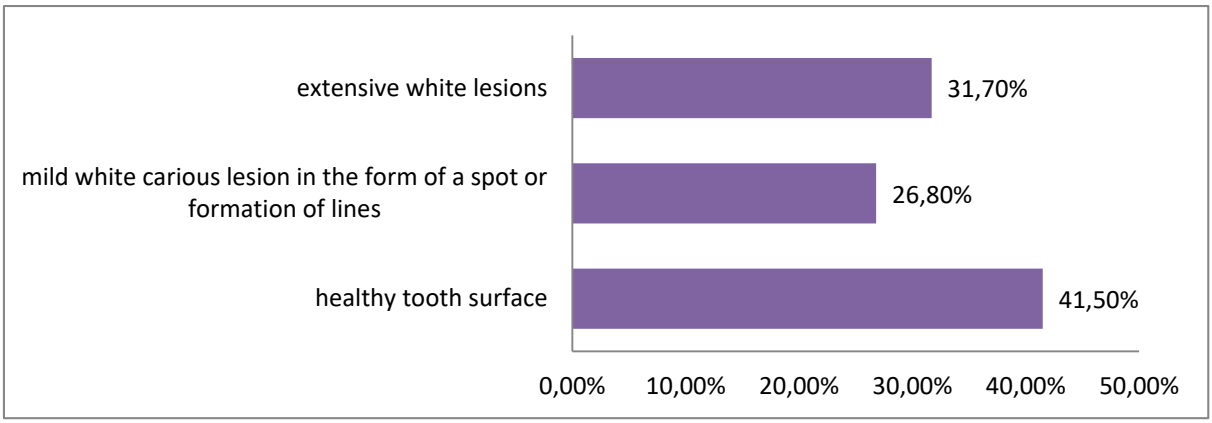


Fig. 29. Relative share of children according to the severity of white carious lesions (Gorelick index)

There was no significant difference in the Gorelick index by gender, although in girls the relative share of those with extensive white carious lesions prevails (33.33%). In boys the children with healthy tooth surface (42.86%) and those with mild white carious lesion in the form of a spot or formation of lines (28.57%) predominate (Fig. 30).

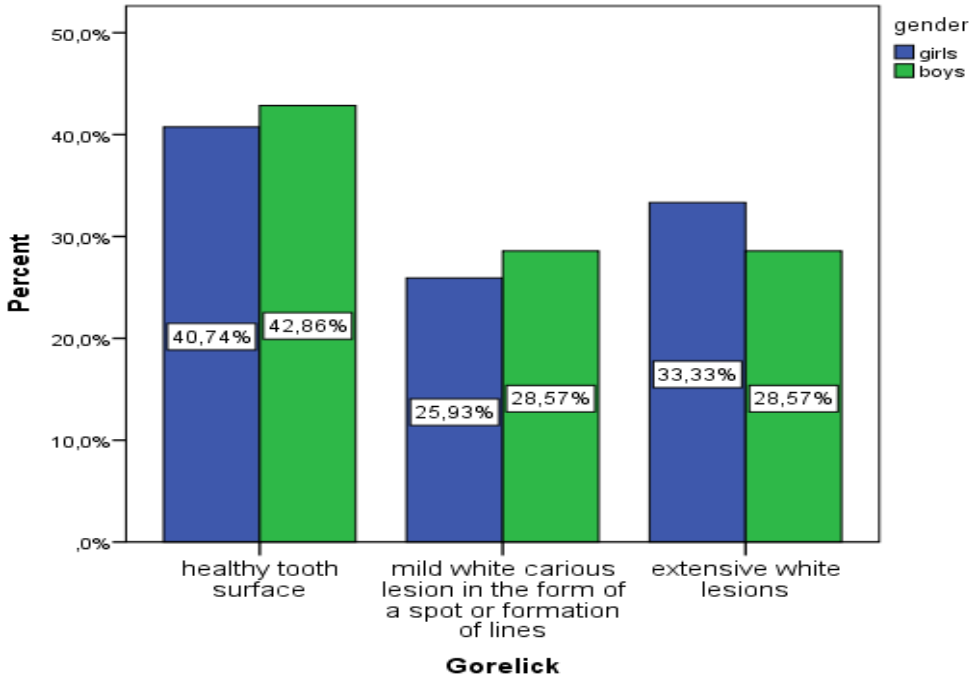


Fig. 30. Distribution according to the gender and the Gorelick index

There was no significant difference in the age of the children according to the Gorelick index, although extensive carious lesions predominated in children aged 14 years (30.77%) and aged 16 years (23.08%). The weakly expressed white carious lesion in the form of a spot or formation of lines has the highest relative share in children in the age group of 12 years (27.27%) and in children of 13 years (9.09%) (Fig. 31).

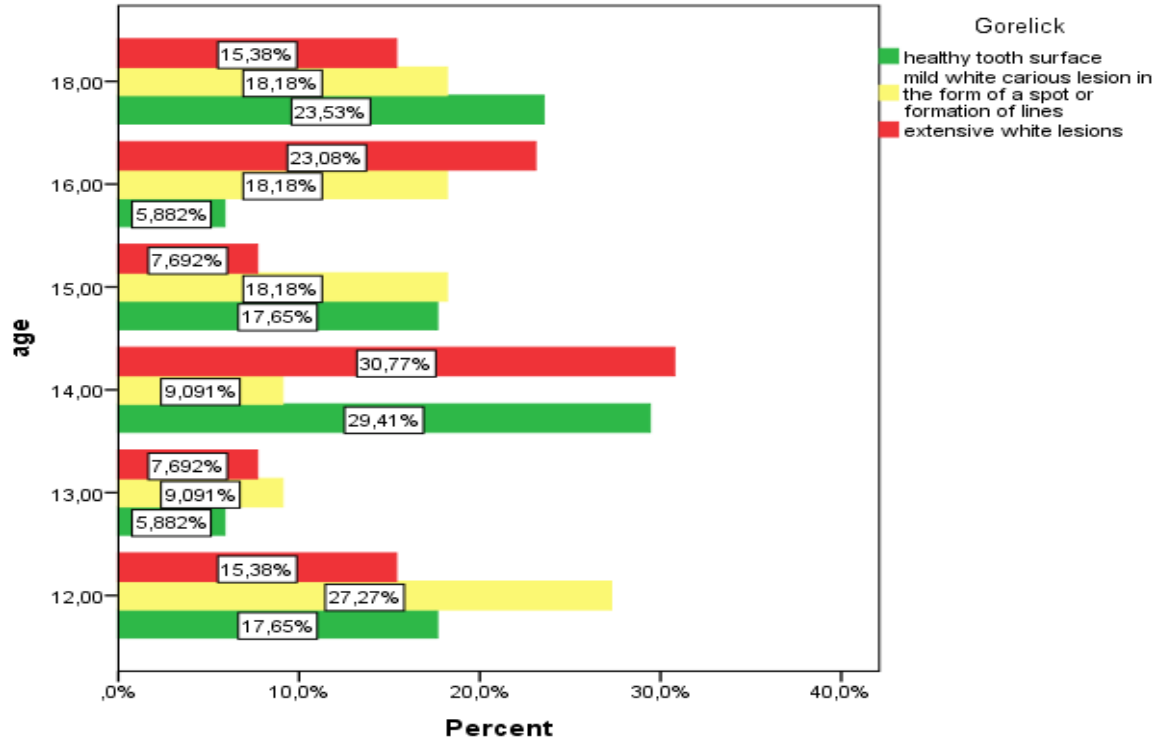


Fig. 31. Distribution by age and Gorelick index

In the analysis of the relation between the duration of treatment and the Gorelick index, it was found that there was a significant difference ($p < 0.001$) (Fig. 32) and a strong positive correlation ($r = 0.571$; $p < 0.001$), which showed that with increasing duration of orthodontic treatment, the Gorelick index and the severity of white carious lesions also increase (Table 11 and Table 12). It can be said that in 32.6% of the cases of children with extensive carious lesions the main factor for their formation is the duration of treatment.

Table 11. Linear regression analysis of the relation between treatment duration and Gorelick index

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9,851	1,012		9,736	,000
	Gorelick	6,246	,816	,571	7,653	,000

a. Dependent Variable: Duration of treatment (months)

Table 12. Correlation analysis of the relation between treatment duration and Gorelick index

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,571[a]	,326	,321	7,69295

a. Predictors: (Constant), Gorelick

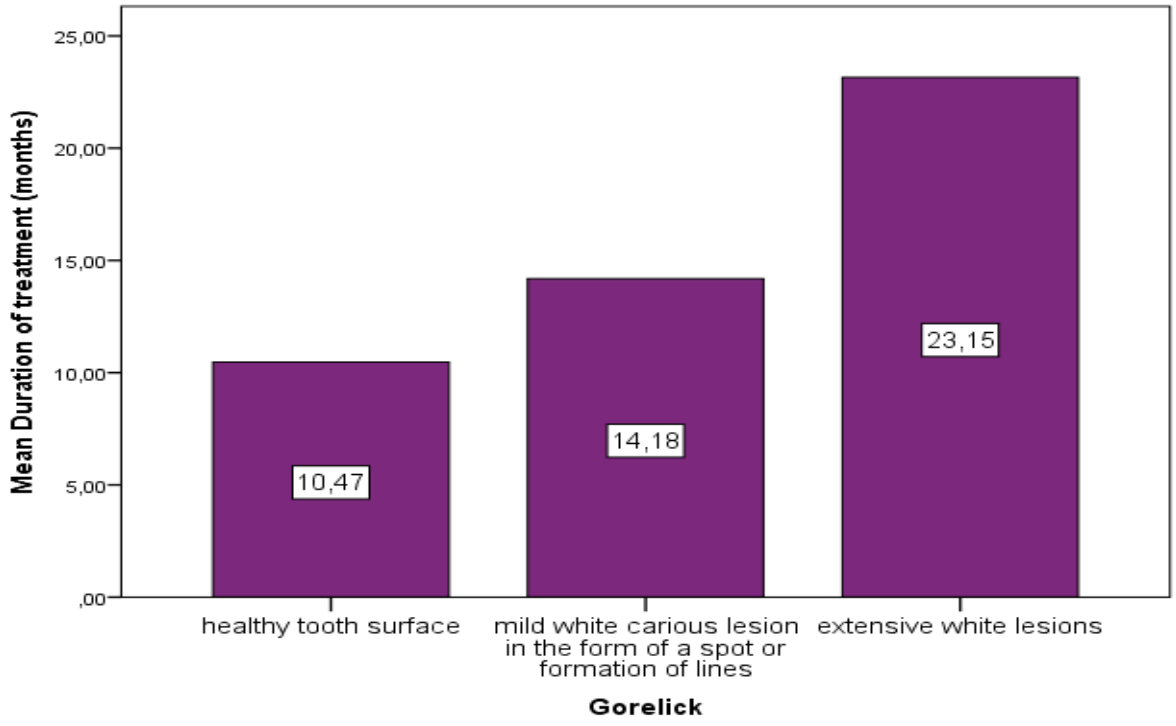


Fig. 32. Gorelick index according to the duration of treatment

The analysis of the change of the Gorelick index according to the follow-up stages shows that with the increase of the duration of the treatment the relative share of the patients in the considered groups also increases ($p < 0.001$) (Fig. 33). At the start of treatment at 1st month of follow-up, the Gorelick index had the highest relative proportion of healthy tooth surface (58.82%), with a steady trend toward an increase in the relative proportion of extensive white carious lesions at 6 months and during the retention phase of treatment (30.77% at 6 months and 63.64% for the retention phase, respectively).

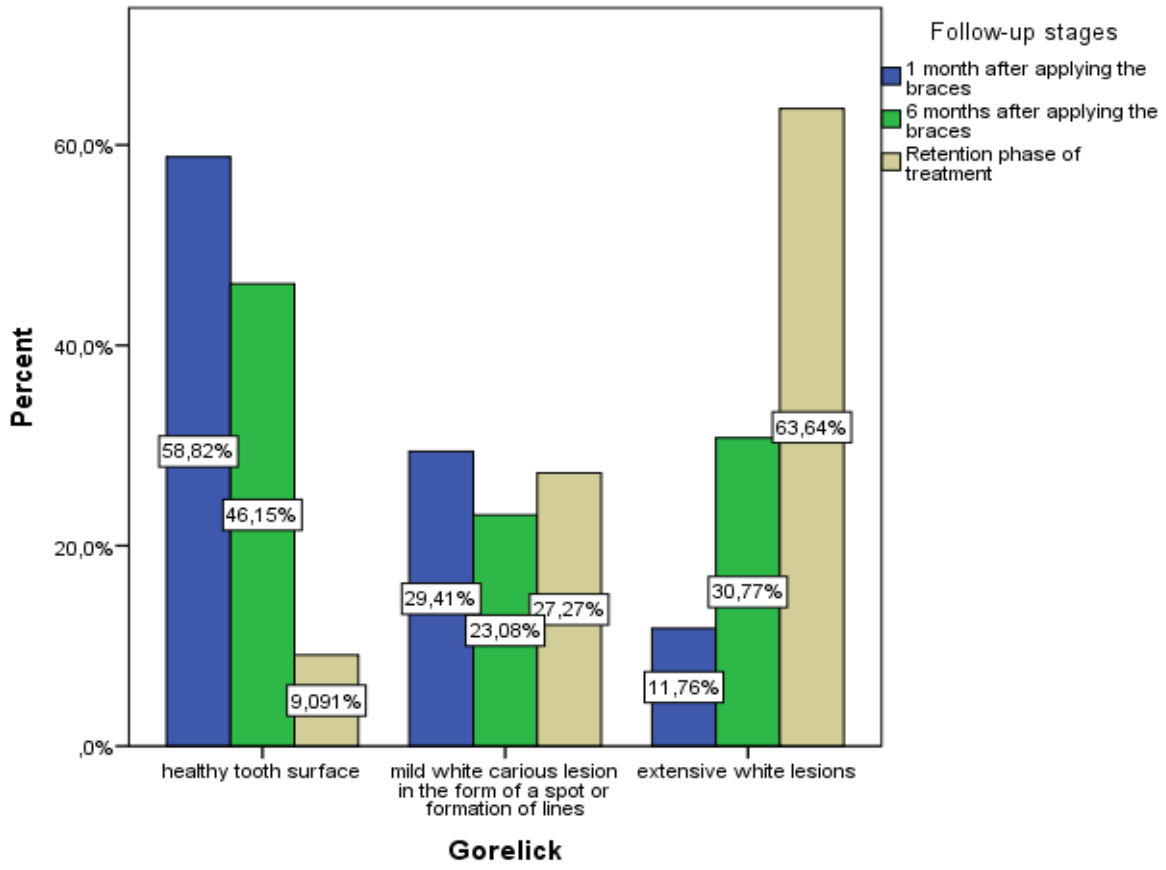


Fig. 33. Gorelick index according to the follow-up stages

When assessing the relation between the Gorelick index and the type of braces, it was found that there is a significant difference ($p = 0.002$), which shows that in patients treated with ceramic braces the relative share of those with healthy tooth surfaces prevails, while extensive carious lesions observed in children treated with metal braces (Fig. 34). A moderate correlation was found between the type of braces used and the Gorelick index ($r = -0.303$; $p = 0.001$) (Table 13).

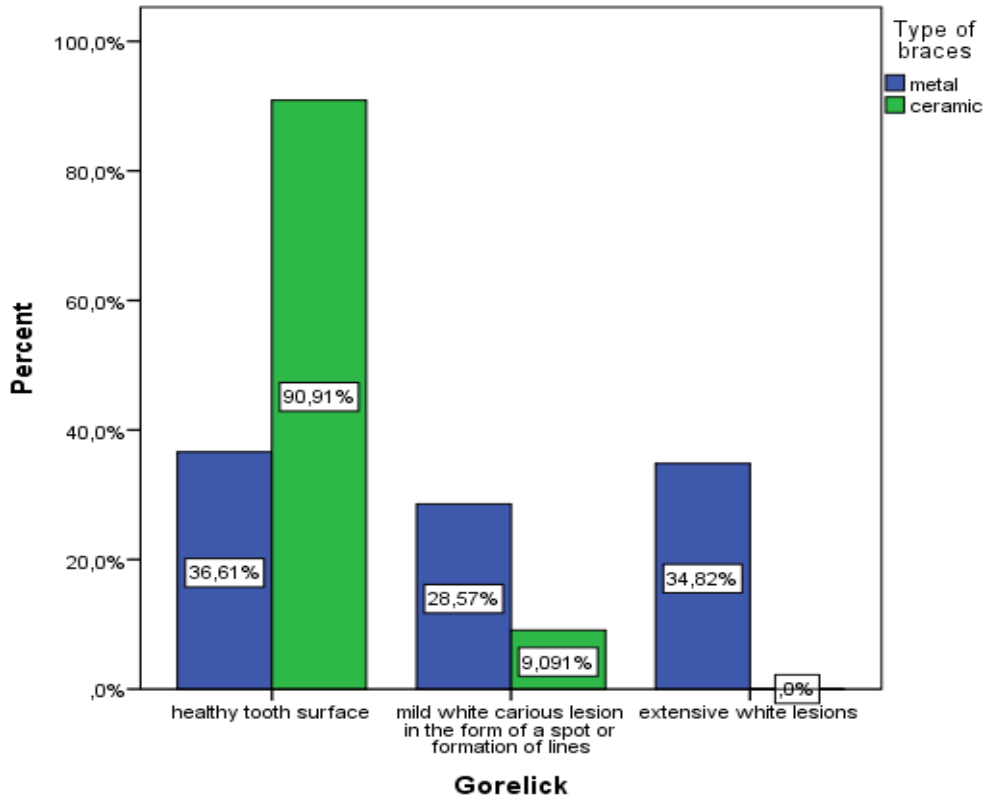


Fig. 34. Distribution according to the type of braces and Gorelick index

Table 13. Correlation analysis between the type of braces and Gorelick index

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Spearman Correlation	-,303	,055	-3,500	,001[c]
N of Valid Cases		123			

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.
c. Based on normal approximation.

Patient cooperation also affects the Gorelick index, with a significant difference ($p<0.001$) and a moderate correlation between the patient's lack of cooperation during orthodontic treatment and extensive white lesions ($r = 0.375$; $p <0.001$) (Fig. 35 and Table 14). 50% of patients who cooperate well in the treatment process have a healthy tooth surface (Gorelick =0). In patients with a Gorelick index = 2 (extensive white lesions), the relative proportion of non-cooperative patients is significant (60%).

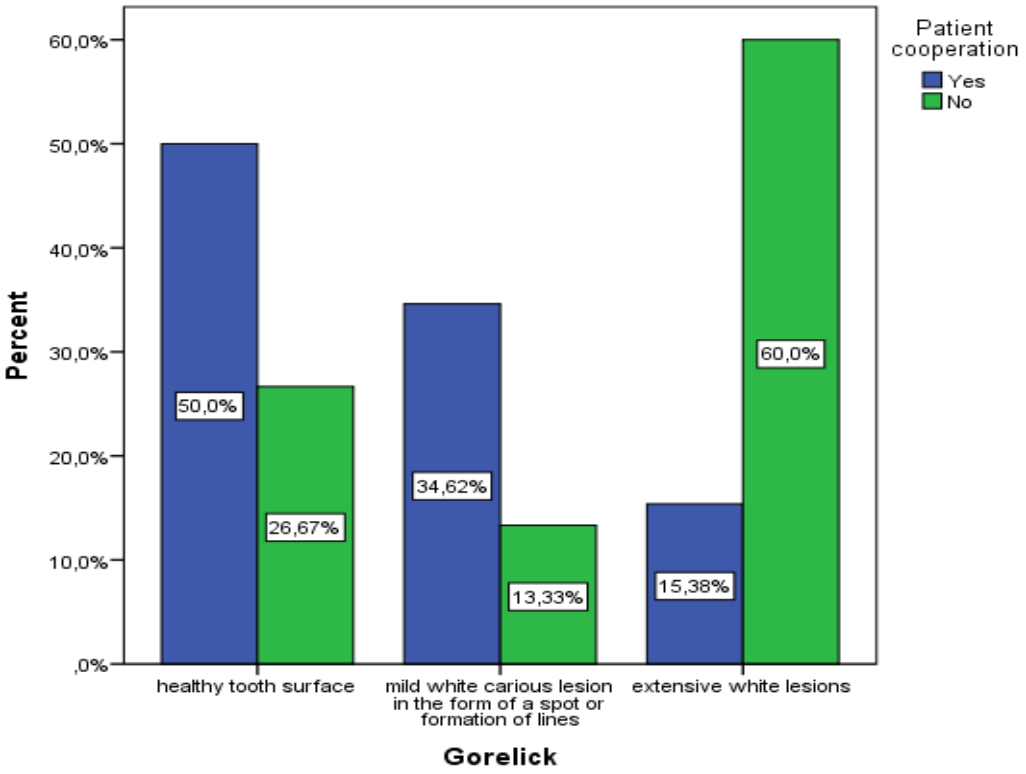


Fig. 35. Distribution of patients according to their cooperation and Gorelick index

Table 14. Correlation analysis between the patient's cooperation in the treatment process and the Gorelick index

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Spearman Correlation	,375	,087	4,443	,000[c]
N of Valid Cases		123			

Wearing another fixed orthodontic appliance before treatment with fixed orthodotic technique also correlates weakly with the Gorelick index (r = 0.210; p = 0.020) (Table 15).

Table 15. Correlation analysis between wearing another fixed appliance before treatment with a fixed orthodontic technique and Gorelick index

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Spearman Correlation	,210	,086	2,364	,020[c]
N of Valid Cases		123			

Fig. 36. Gorelick index 2 with carious lesions D_{1b} in a patient with orthodontic treatment lasting 13 months.

Fig. 36 shows a patient with fixed orthodontic treatment lasting 13 months. There are non-cavitated white carious lesions in the area of the braces (Gorelick = 2), on the lower jaw - visible plaque accumulation. Before the braces placement, the patient was treated with another fixed appliance - Pendulum.

4.1. Discussion on task 4

Despite the significant reduction in the prevalence and severity of caries observed worldwide in recent decades, (38, 62) dental caries remains a public health challenge (224). In 2010, it was the most common condition, affecting 35% of the world's population or 2.4 billion people worldwide (141). Given its multifactorial etiology, various factors may contribute to a higher risk of its development. In this sense, the use of fixed orthodontic appliances is discussed as a risk factor for dental caries, as they mediate the accumulation of biofilms and make it difficult to perform traditional oral hygiene measures (267). In addition, the retentive surfaces of braces, bands, arches and other elements limit the natural mechanisms for self-cleaning of the oral cavity from saliva (267). A recent systematic meta-analysis review summarizes the prevalence and incidence of non-cavitated carious lesions during orthodontic treatment (267). A total of 14 studies published up to March 2015 were included. The authors found an average prevalence of 68.4% (data obtained from 9 studies) and an average frequency of 45.8% (data obtained from 7 studies). In addition, the authors conclude that some factors increase the incidence of initial lesions, such as poor oral hygiene, younger age of the patient, male patients, and longer duration of treatment.

The occurrence of white carious lesions in several studies was examined by intraoral photographs taken before and after orthodontic treatment to document patients (12, 60, 91, 138, 144, 234). To the best of our knowledge, there is no longitudinal study accepting appropriate clinical criteria for the detection of white carious lesions in orthodontic patients. The study of such lesions in orthodontic patients is performed through clinical studies performed after cleaning and drying the teeth (227). The authors show that the longer the duration of orthodontic treatment, the greater the prevalence and severity of active carious lesions. However, only longitudinal studies can provide evidence of a causal relationship due to the time component (123).

Another study evaluated the relation between the usage of fixed orthodontic appliances and the appearance of active lesions over a period of one year. Significantly higher risk of caries

is observed in patients undergoing fixed orthodontic therapy compared to persons without orthodontic appliances. This is the first longitudinal study evaluating the relation using the appropriate clinical criteria and conditions to detect non-cavitated carious lesions during both follow-up periods (baseline and follow-up).

The results are also consistent with a study conducted by Wang et al. (283), which included 57 patients with fixed orthodontic appliances. Patients in the experimental group are part of a preventive program that includes training and motivation, visualization of the patient's dental plaque, removal of oral hygiene index, training in the use of orthodontic and interdental brushes and floss. Both indices, PI and GI, were examined during follow-up examinations, which were conducted every three weeks for six months. Patients are remotivated and instructed on how to properly perform oral hygiene. At the beginning of the study, there were no statistically significant differences in PI and GI values between the control and experimental groups. However, the examinations revealed a statistically significant difference in PI and GI values between the groups, which means that the prevention program was effective. The authors conclude that the oral health of patients treated with a fixed orthodontic technique can be improved by implementing measures such as training and motivation, conducting controlled brushing, and reassessing oral hygiene techniques, along with ongoing patient motivation. Good oral hygiene and appropriate means of maintaining it give good results in terms of oral health, but the importance of instructions and maintenance of motivation should not be overlooked.

Ay et al. (29) prove the thesis, that verbal instructions are insufficient to achieve a satisfactory level of oral hygiene - orthodontists and dentists must make efforts to improve the oral hygiene of orthodontic patients. The authors conducted a study with 150 orthodontic patients, divided into five groups and compared the effectiveness of verbal motivational methods for maintaining oral hygiene, with or without auxiliary means. After four weeks, there were significant differences in gingival index values between the study groups. During the study, there was a statistically significant decrease in the values of the plaque index and Papilla bleeding index in the patients of the studied groups, which proves that the applied program for prevention of gingivitis in children treated with fixed orthodontic technique had a positive effect on the quality of performing hygiene, as well as on the condition of the gingiva. The values of the examined parameters are significantly lower in comparison with the studied parameters of the patients from the control group.

Motivation, compliance with all measures proposed by the prevention program and their implementation, patience, perseverance, practice and mastery of techniques for oral hygiene prevent gingival diseases and allow successful application of acquired knowledge and skills both after orthodontic treatment and throughout life.

5. Assessment of the specific caries risk profile of patients with fixed orthodontic technique

According to the caries risk profile, the children from the studied groups are divided into two groups: children with low caries risk and children with high caries risk. The children in the control group have a higher relative share of high caries risk (61.11% high risk and 28.57% low risk, respectively), while the children treated with fixed orthodontic technique also

have a higher caries risk, but with a significant lower relative share than controls (71.43% were high risk to 38.89% low risk, respectively) (p <0.001) (Fig. 37).

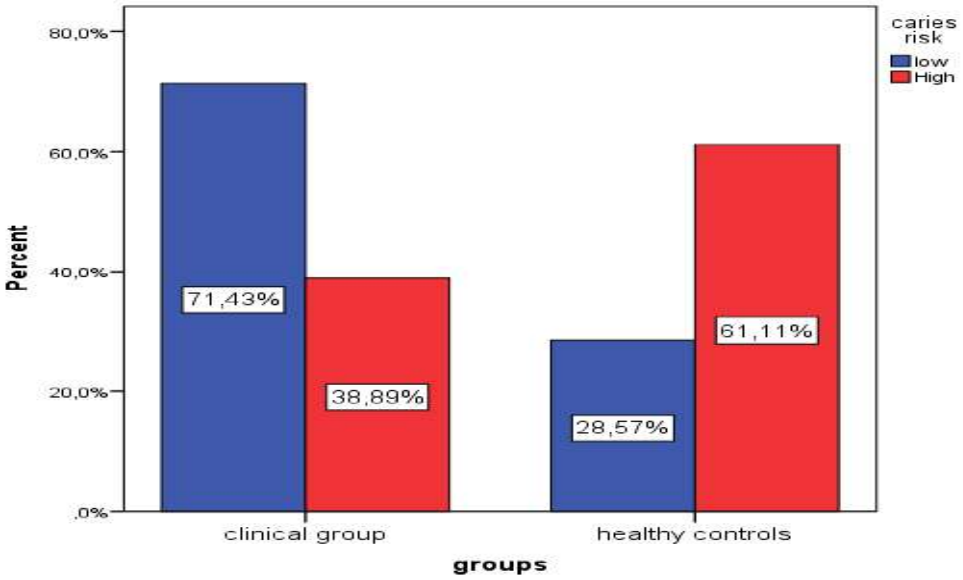


Fig. 37. Distribution according to caries risk and the studied groups

When assessing the relation between caries risk and the gender of the children in the two study groups, it was found that there was a significant difference between the genders in the clinical group (p = 0.028) (Fig. 38). It can be said that males are at risk for high caries risk (OR = 2.25 (1.04-4.85); p <0.05).

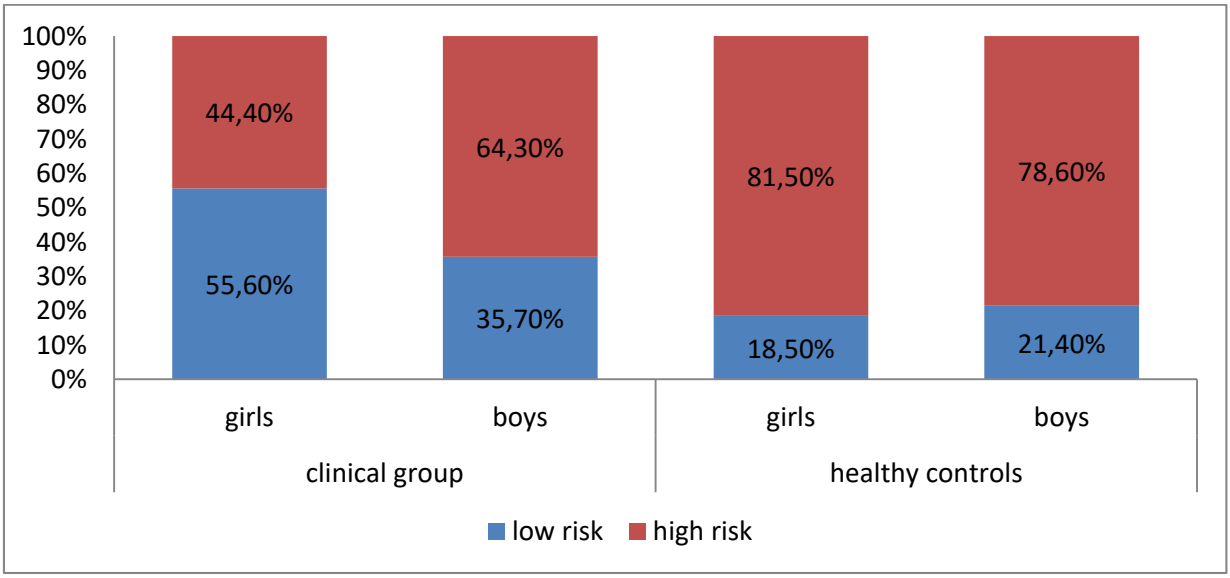


Fig 38. Caries risk according to gender and study group

A significant difference in caries risk was also found with regard to the age of the examined children in the clinical group (p = 0.029), where only in children aged 15 the relative share of low caries risk prevails (83.3%), while in children in the age group groups 13 years, 16 years and 18 years the relative share of high caries risk prevails, and in the others the

distribution is equal. In children from the control group, the relative share of high caries risk at all ages predominates (Fig. 39).

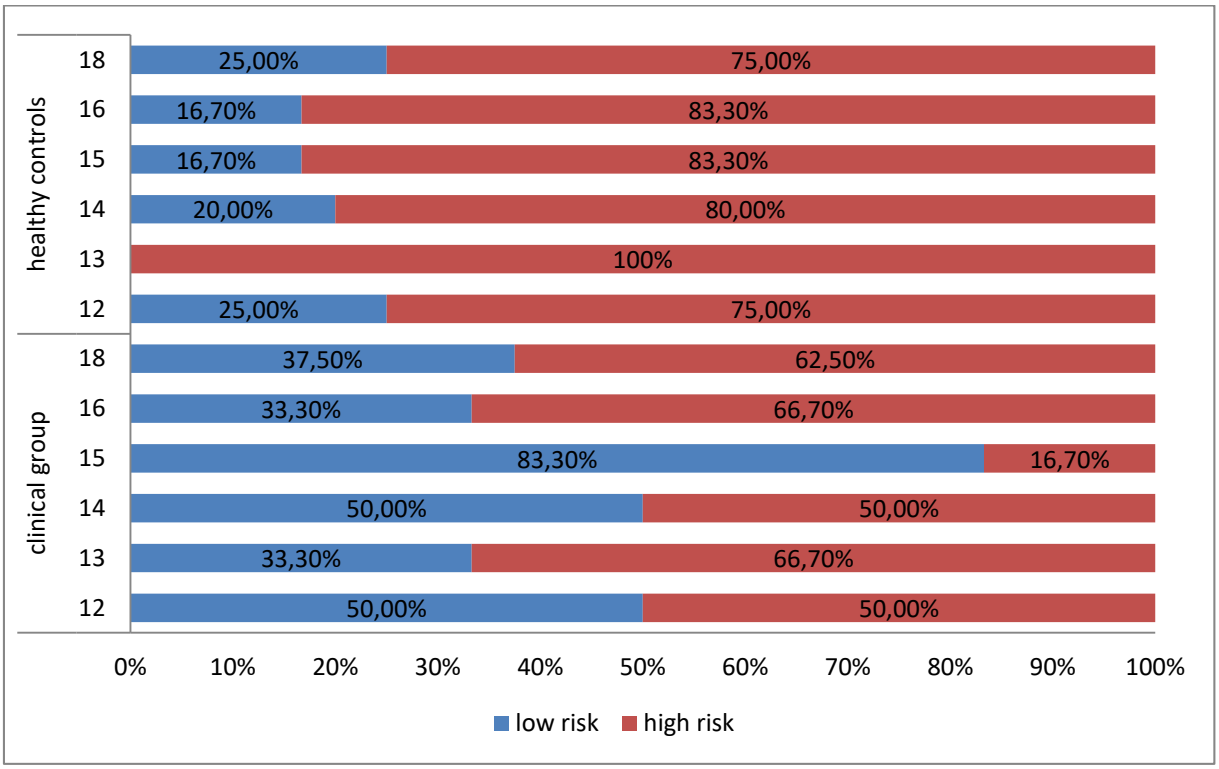


Fig. 39. Caries risk according to age and study group

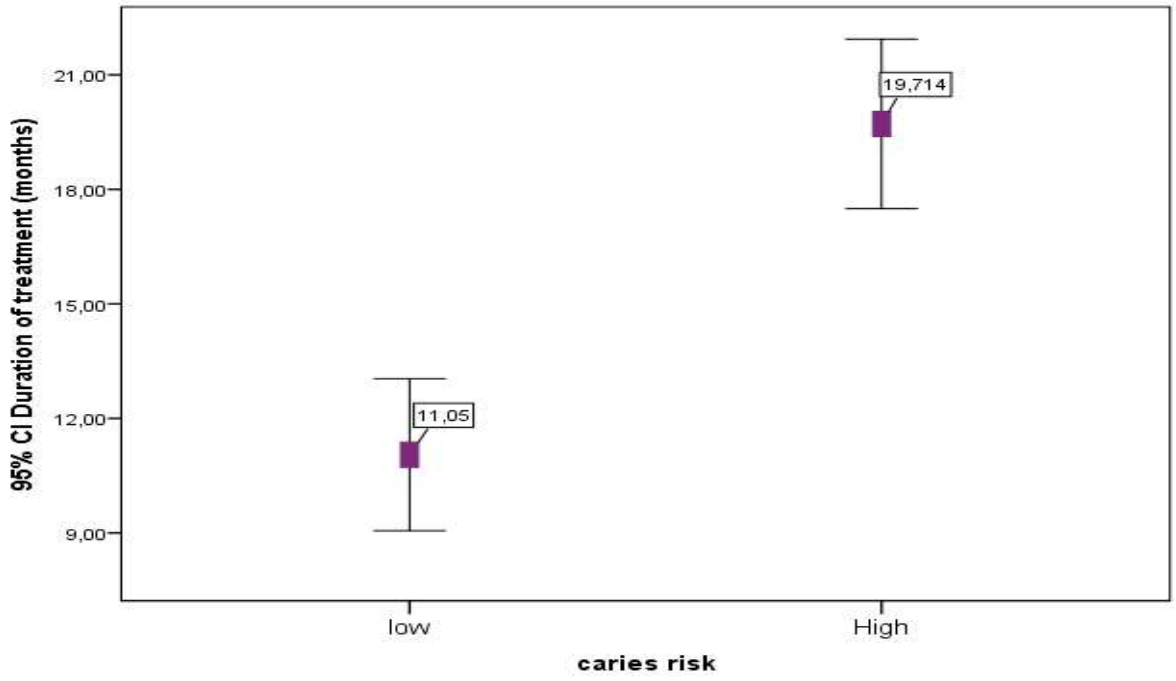


Fig. 40. Caries risk and average duration of orthodontic treatment

It was found that there is a significant difference in caries risk according to the duration of treatment with a fixed orthodontic technique ($p < 0.001$). Children with a duration of 11.05 months ± 7.7 months have a low caries risk, while children with an average duration of treatment of 19.71 months ± 8.82 months have a high caries risk (Fig. 40).

From the point of view of the follow-up stages, a significant difference was also found in terms of caries risk ($p < 0.001$) (Table 16). In the first month of braces there is a high relative share of children with low caries risk (76.5%), while in the 6th month and during the retention phase children with high caries risk predominate (respectively 61.5% in the 6th month and 81.8% for the retention phase).

Table 16. Caries risk according to the follow-up stages

			Follow-up stages			Total
			1 month after braces placement	6 months after braces placement	Retention phase of treatment	
Caries risk	low	Count	39	15	6	60
		% within Follow-up stages	76,5%	38,5%	18,2%	48,8%
	high	Count	12	24	27	63
		% within Follow-up stages	23,5%	61,5%	81,8%	51,2%
Total		Count	51	39	33	123
		% within Follow-up stages	100,0%	100,0%	100,0%	100,0%

A strong relation between caries risk and follow-up stages was also found ($r = 0.489$; $p<0.001$), which showed that caries risk increased during treatment (Table 17).

Although no significant difference in caries risk was found according to the type of braces used, it can be said that the use of metal braces carries a slightly higher caries risk (52.68% for metal braces and 36.36% for ceramic braces, respectively) (Fig. 41).

Table 17. Correlation analysis between caries risk and follow-up stages

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Spearman Correlation	,489	,075	6,158	,000[c]
N of Valid Cases		123			

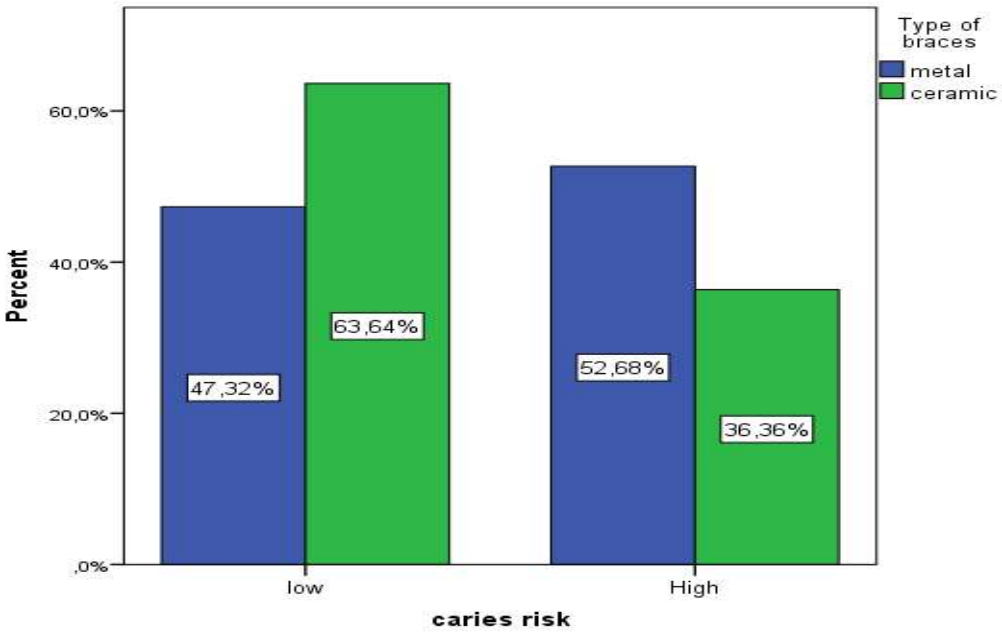


Fig. 41. Caries risk according to the type of braces

The patient's lack of cooperation during orthodontic treatment was associated with a high caries risk, with a significant difference ($p < 0.001$) and moderate dependence ($r = 0.437$; $p < 0.001$). Lack of cooperation increased the risk of caries more than 7 times during orthodontic treatment (OR = 7.56 (3.17-17.97); $p < 0.001$) (Fig. 42 and Table 18). Of the patients with good cooperation, 65.38% are at low caries risk and 34.62% - with high. In non-cooperative patients, the relative share of high caries risk is significant (respectively 80% are at high caries risk and 20% are at low).

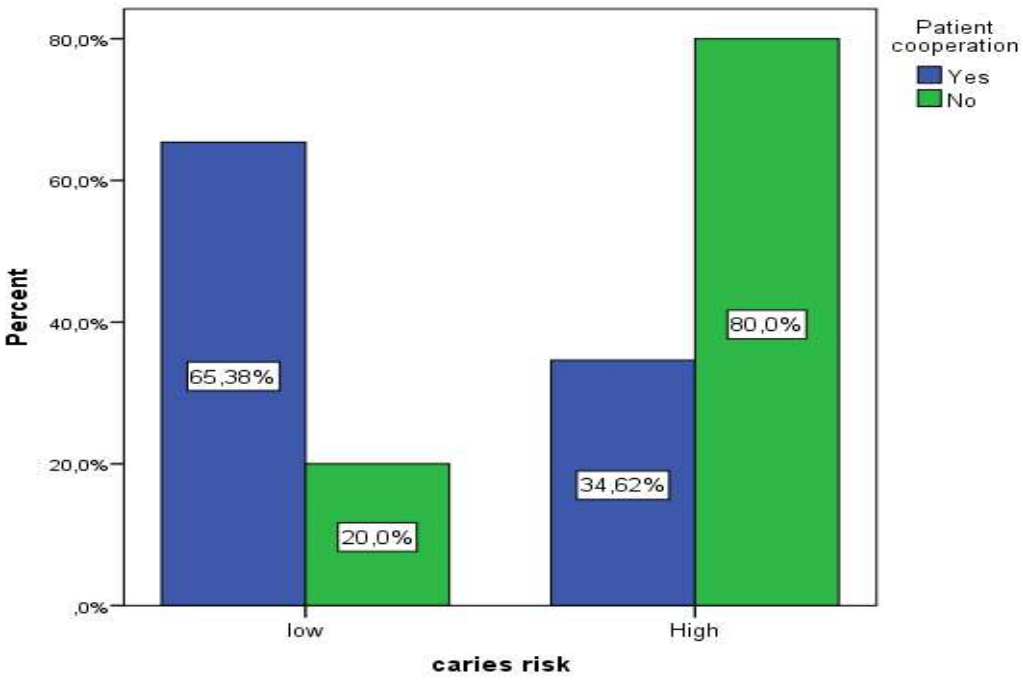


Fig. 42. Caries risk according to the patient's cooperation

Table 18. Correlation between caries risk and patient cooperation during treatment

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Spearman Correlation	,437	,078	5,349	,000[c]
N of Valid Cases		123			

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.
c. Based on normal approximation.

On Fig. 43 is presented a patient with fixed orthodontic treatment lasting 18 months, who does not cooperate in the treatment process, has poor oral hygiene, does not perform examinations on schedule, as a result of which there is a high risk of caries and developed gingivitis.

Fig. 43. Patient with white carious lesions according to Gorelick index 3 and high caries risk

5.1. Discussion on task 5

Orthodontic therapy carries a risk of complications. The literature shows that dental caries is the most common complication found by orthodontists. Fixed appliances can further predispose, initiate or intensify this process, as they limit salivary flow and self-cleaning and provide places to retain food debris (59). Excessive application of adhesive around orthodontic braces also creates preconditions for bacterial colonization. Stainless steel is characterized with a high surface tension, which predisposes to the accumulation of more dental plaque on the surface of the braces. After the placement of the appliances, changes in the dental plaque are observed: increase in the amount of accumulated food residues, Streptococcus mutans and Lactobacillus and lower plaque pH.

Difficulties in removing dental plaque from the area of the braces and the increased accumulation of biofilm increase the risk of developing demineralization on the vestibular surface of the teeth (61), ie. in the area where caries does not usually develop in orthodontically untreated patients. Insufficient oral hygiene leads to the creation of a metabolically active biofilm, which disturbs the balance between the processes of demineralization and remineralization, which leads to the formation of white carious lesions. Early enamel lesion (white spot lesion, initial lesion) is a reversible form of caries. It has the appearance of a white or brown spot on the surface of the tooth. It is characterized by subsurface demineralization. Changes in the refractive index of demineralized enamel are the reason for its visible opacity (59, 210). The differences in the refractive index (RI) of the enamel (1.62), water (1.33) and air (1.0) differ in visual examination. In this way, it is possible to clinically assess the degree of

demineralization. A lower degree of demineralization is evidenced by its visualization only after drying, and demineralization is significantly visible without drying.

Characteristic changes in patients treated with a fixed orthodontic technique were described as early as the 1970s, when Zachrisson BU and Zachrisson S. examined a group of patients undergoing fixed appliance therapy to determine the relationship between caries intensity and oral hygiene during treatment (292, 293). Other studies show that white carious lesions are most common on the first molars, upper lateral incisors, and lower canines and premolars. In most cases, the lesions are like thin banded lesion surrounding the base of the bracket or extending between the braces and the gingival margin (210). They have a regular shape, sharply separated from the surrounding enamel and appear asymmetrically in places characterized by difficulty in performing oral hygiene procedures (around the braces, the marginal gingiva and in the area of ligatures, arches, cannulas, etc.) (238, 265).

The formation of carious lesions on the enamel takes at least 6 months (85, 172). They may be clinically visible 4 weeks after the start of orthodontic treatment (173, 210). In clinical conditions, according to the literature, during the first 6 months of orthodontic therapy, there is rapid increase in the number of lesions is observed (44, 210).

The widely recommended primary method for the diagnosis of enamel carious lesions is usually visual examination (204, 228) using the International Caries Detection and Assessment System (ICDAS) (129).

6. Algorithm for prevention of white carious lesions in patients with fixed orthodontic technique depending on the level of oral hygiene

In addition to the results of clinical trials, a short survey was conducted on the eating and hygiene habits of patients undergoing orthodontic treatment with a fixed technique. The results were summarized and served as a basis for the creation of an algorithm for prevention and follow-up of white carious lesions in patients with fixed orthodontic technique depending on the level of oral hygiene.

In the analysis of hygiene habits, we found that there is no significant difference in the behavior of boys and girls, but it can be said that girls brush their teeth more often (Fig. 44). The largest relative share of both boys (65.12%) and girls (56.72%) indicate that they brush their teeth twice a day - usually in the morning after sleep and in the evening before sleep. Over ¼ (27.91%) of boys and over 1/3 (38.81%) of girls indicate that they brush their teeth three or more times a day, which suggests that they do so after each meal.

The analysis of the hygiene habits of the examined children with orthodontic treatment according to age shows that there is a difference in their behavior ($p < 0.05$), as in children aged 12, as well as those aged 15, 16 and 17 prevails the relative share of those who brush their teeth once a day (respectively 16.67% for 12 years, 33.33% for 15 years, 16.67% for 16 years and 16.67% for 17 years). On the other hand, the rest have a higher frequency of children who brush their teeth two or more times a day (22.73% of children aged 13 brush their teeth twice a day, 31.58% of children aged 14 brush their teeth three or more times a day and 15.15% of 18-year-old children brush their teeth twice a day) (Fig. 45).

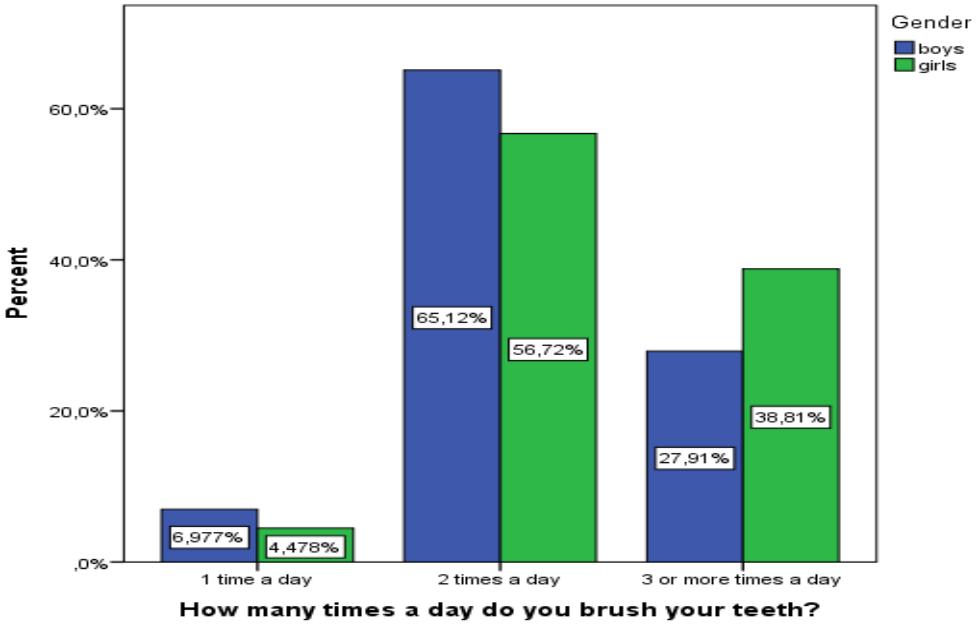


Fig. 44. Frequency of brushing teeth by gender

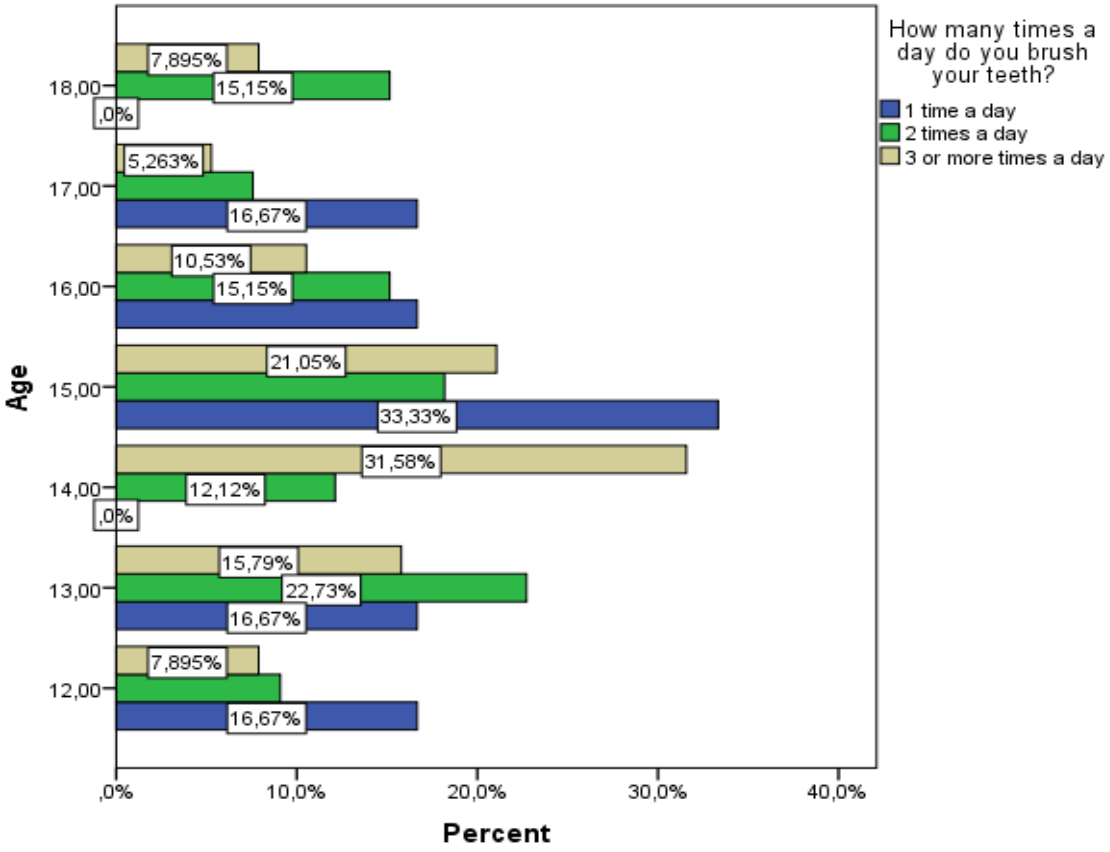


Fig. 45. Frequency of brushing teeth according to age

The analysis of the duration of brushing shows that girls (71.43%) and children aged 12 (11.59%), 13 (21.74%) and 14 (21.74%) brush their teeth the longest (2-3 min) ($p < 0.05$) (Fig. 46 and Fig. 47). At the age of 16, the shortest duration of brushing was found (40.0% brush

their teeth for 1 minute), after which the duration of brushing began to increase again. This trend persists for both boys and girls.

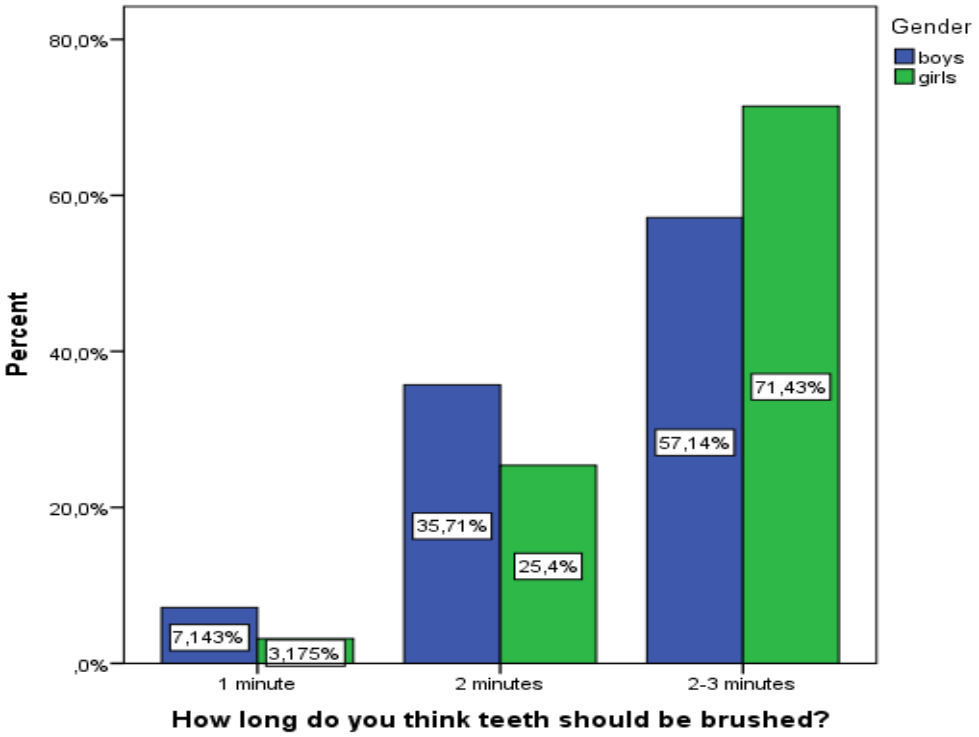


Fig. 46. Duration of brushing teeth according to gender

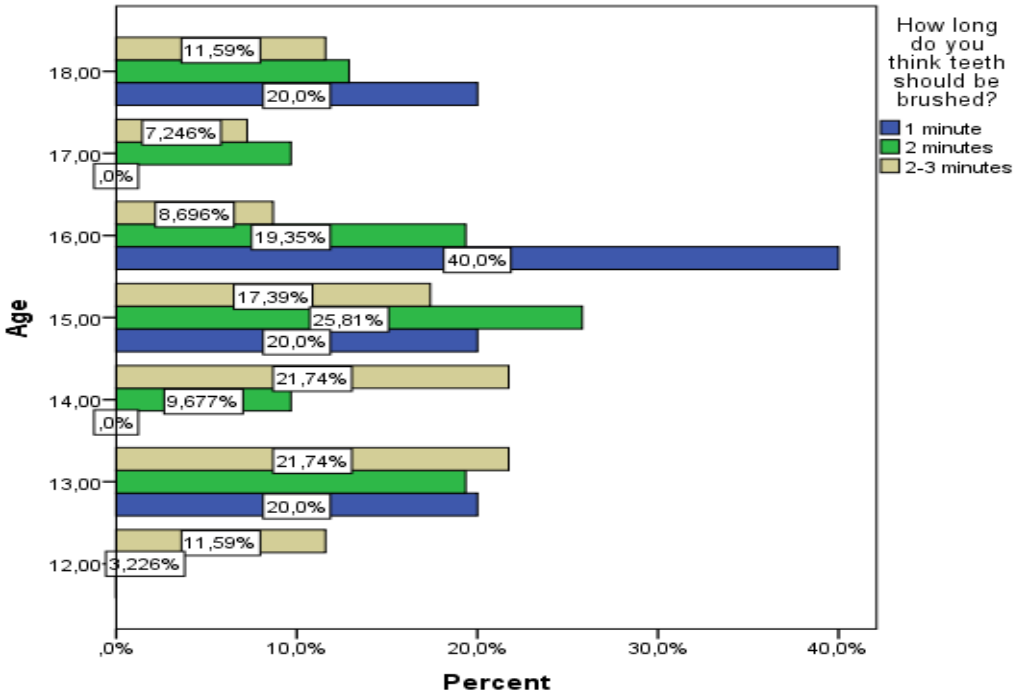


Fig. 47. Duration of brushing teeth according to age

There is no difference in the frequency of visits to the dentist for professional oral hygiene by gender and age, and in all cases the visit to the doctor once every 6 months prevails.

There is no significant difference in hygiene habits according to the duration of orthodontic treatment, with children predominating who brush their teeth twice a day, lasting about 2-3 minutes and perform professional oral hygiene once every 6 months.

Fig. 48 presents a case of a 17-year-old girl with white carious lesions, Gorelick =3, severe gingivitis of the lower jaw in the frontal segment, fracture of tooth 41 after partial orthodontic treatment and poor oral hygiene. The results of orthodontic treatment in the absence of cooperation from the patient in this case have led to deterioration of dental health.

Fig. 48. Clinical case of a 17-year-old girl after orthodontic treatment with a fixed technique and lack of cooperation in the treatment process

Change in eating habits was found in 62.7% of the surveyed children, with no difference according to gender and age (Fig. 49 and Fig. 50).

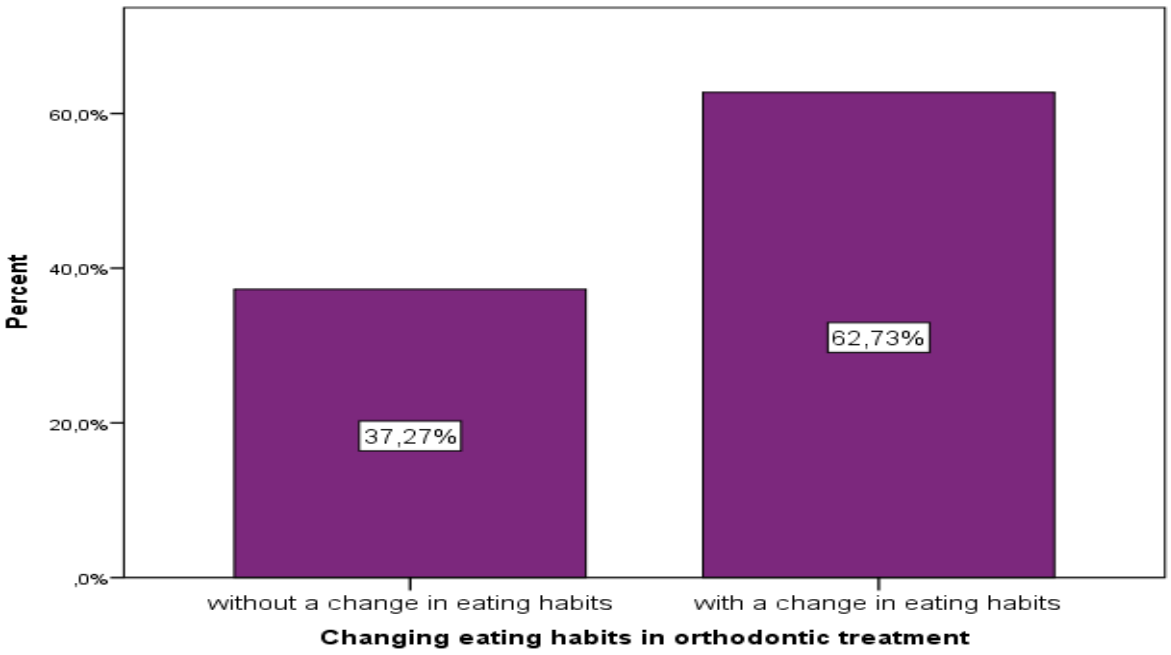


Fig. 49. Distribution of children according to the change of eating habits

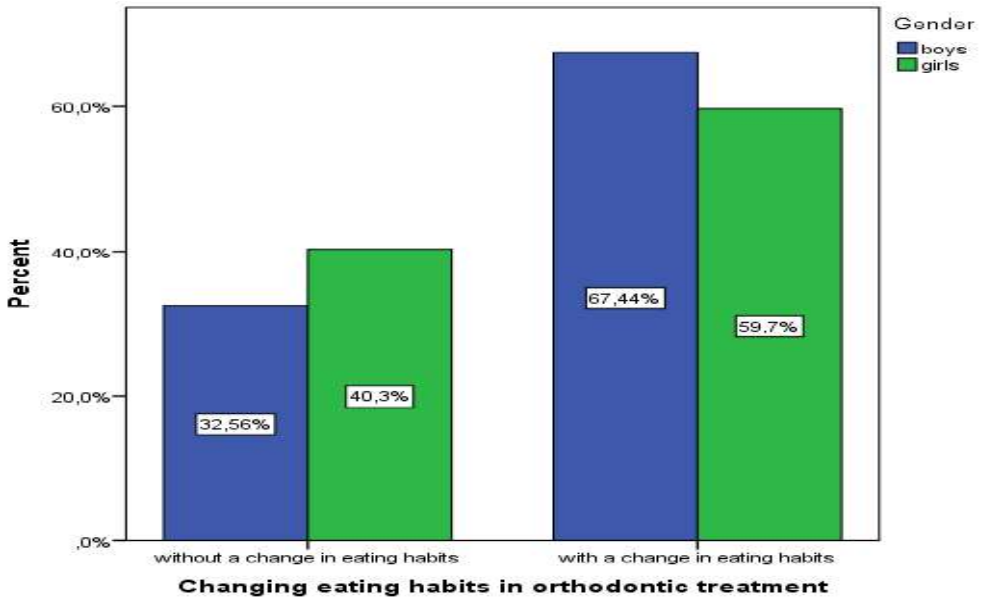


Fig. 50. Distribution of children according to the change of eating habits and gender

Fig. 51 presents the distribution of children with and without change in eating habits by age. The largest is the relative share of children aged 17, who change their eating habits during treatment with fixed orthodontic appliances (75%). In the other age groups it was found that with increasing age the relative shares of patients who change their eating habits in the course of orthodontic treatment gradually increase (respectively at 12 years - 40%, at 13 years - 54.55%, at 14 years - 65%, at 15 - 68.18%, at 16 - 66.67% and at 18 years - 69.23%).

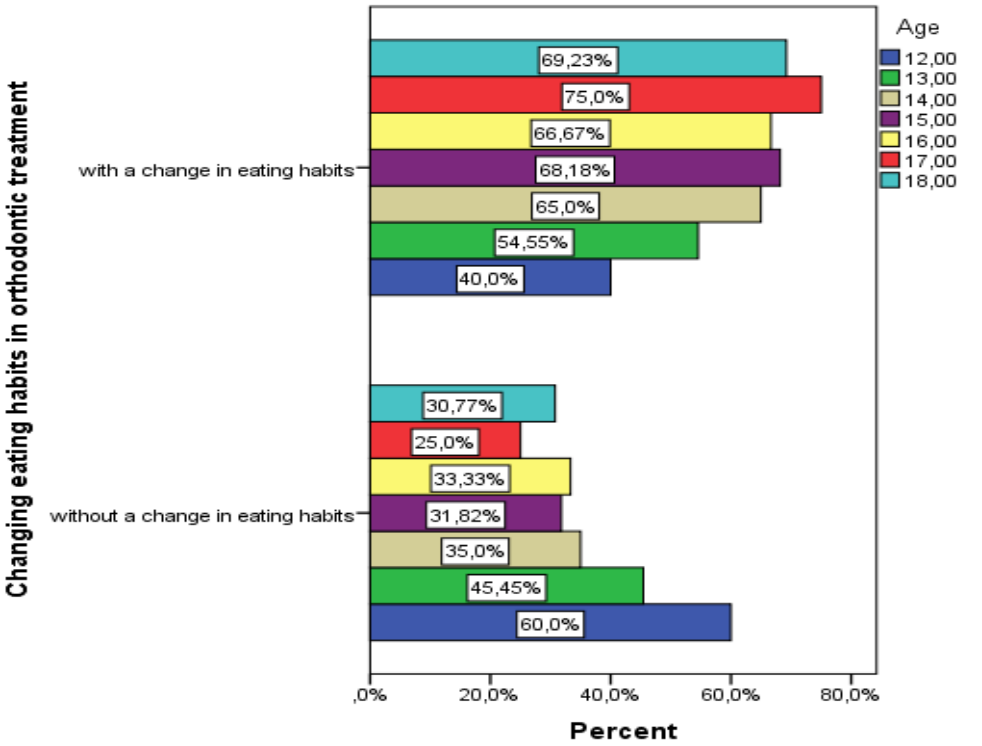


Fig. 51. Distribution of children according to the change of eating habits and age

On the other hand, despite the lack of difference, there is a tendency to decrease the relative share of children who change their eating habits according to the duration of treatment (in children with a duration of about 18 months of treatment, with a change in eating habits are 20.9%, and in those 19.4% of children undergoing orthodontic treatment for less than a year, the relative shares are evenly distributed (respectively 51.35% have not changed their eating habits, and 59.7% include considerations in their diet).

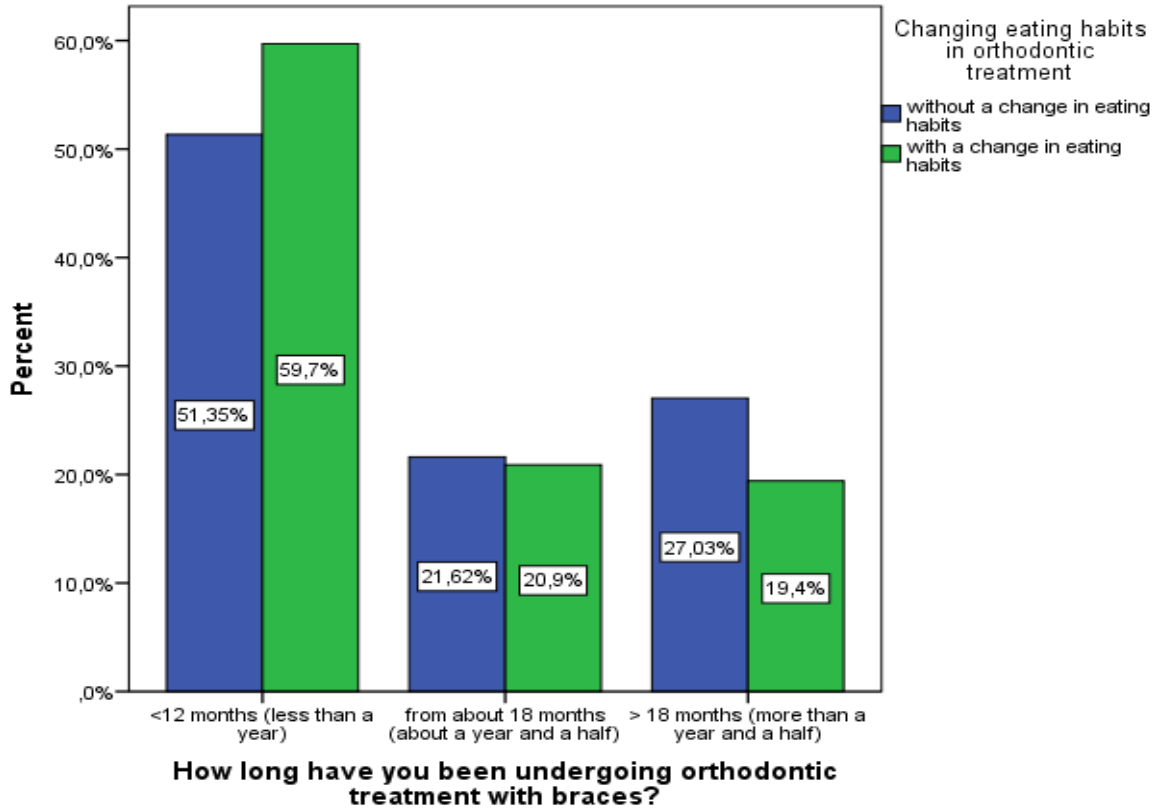


Fig. 52. Distribution of children according to the change in eating habits and duration of treatment

In children with a duration of treatment up to 18 months with the highest relative share are those who fully follow the recommendations given by the dentist, while in those with a longer duration - over 2/3 (69.2%) avoid only solid foods ($p < 0.05$) (Table 19).

The majority of the surveyed children indicate that they consume fruits and vegetables more often (64.5% and 72.9%, respectively) (Fig. 53). More than ¾ (76.20%) state that they consume sugar once a week, and 74.10% consume carbonated sweetened drinks less often.

Table 19. Change in the type of habits during the orthodontic treatment according to its duration

		Changing the type of eating habits during the orthodontic treatment				Total
		avoid solid foods	avoid sticky carbohydrate foods	avoid foods with added sugar	All of the above	
How long have you been undergoing orthodontic treatment with braces?	<12 months (less than a year)	16	5	2	17	40
		40,0%	12,5%	5,0%	42,5%	100,0%
	from about 18 months (about a year and a half)	4	2	1	7	14
		28,6%	14,3%	7,1%	50,0%	100,0%
	> 18 months (more than a year and a half)	9	0	0	4	13
		69,2%	0,0%	0,0%	30,8%	100,0%
Total		29	7	3	28	67
		43,3%	10,4%	4,5%	41,8%	100,0%

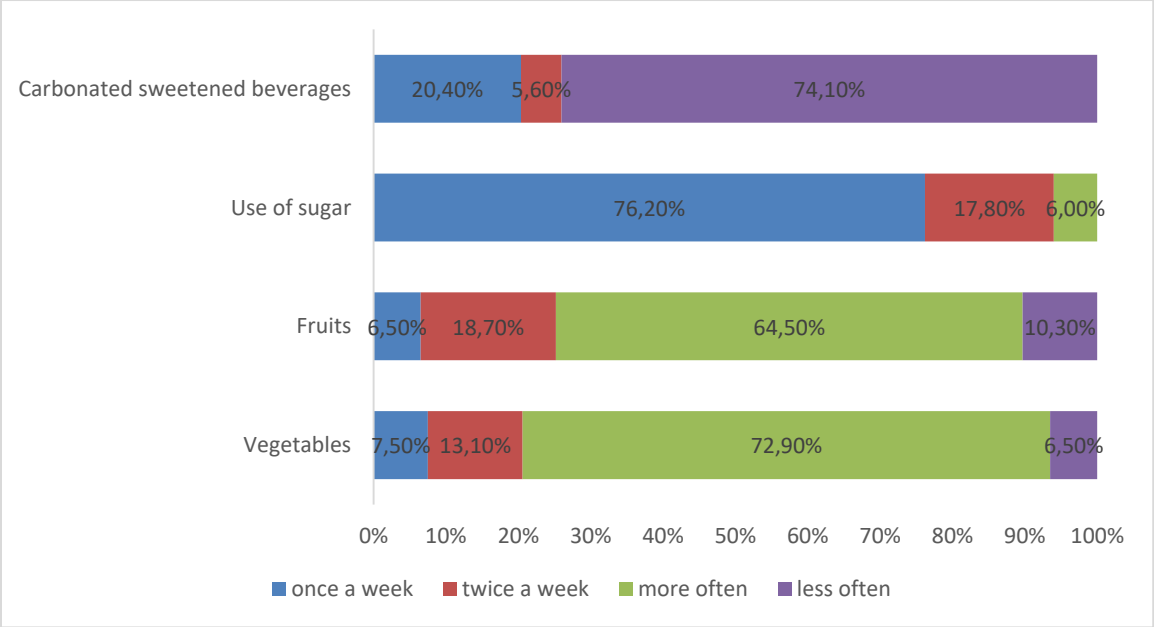


Fig. 53. Consumption of certain foods

Less than half of the surveyed children (45.9%) indicate that they rarely consume fruit juices, and 25.7% consume fruit juice once a day (Fig. 54).

More than half of the children surveyed who underwent orthodontic treatment (57.0%) reported consuming food with added sugar twice a week or less often. The remaining 43.0% consume such foods once a day or more often. Similar results are observed with the consumption of foods and beverages high in carbohydrates, 57.1% consume such foods and beverages twice a week or less often, and 42.9% consume them once a day or more often.

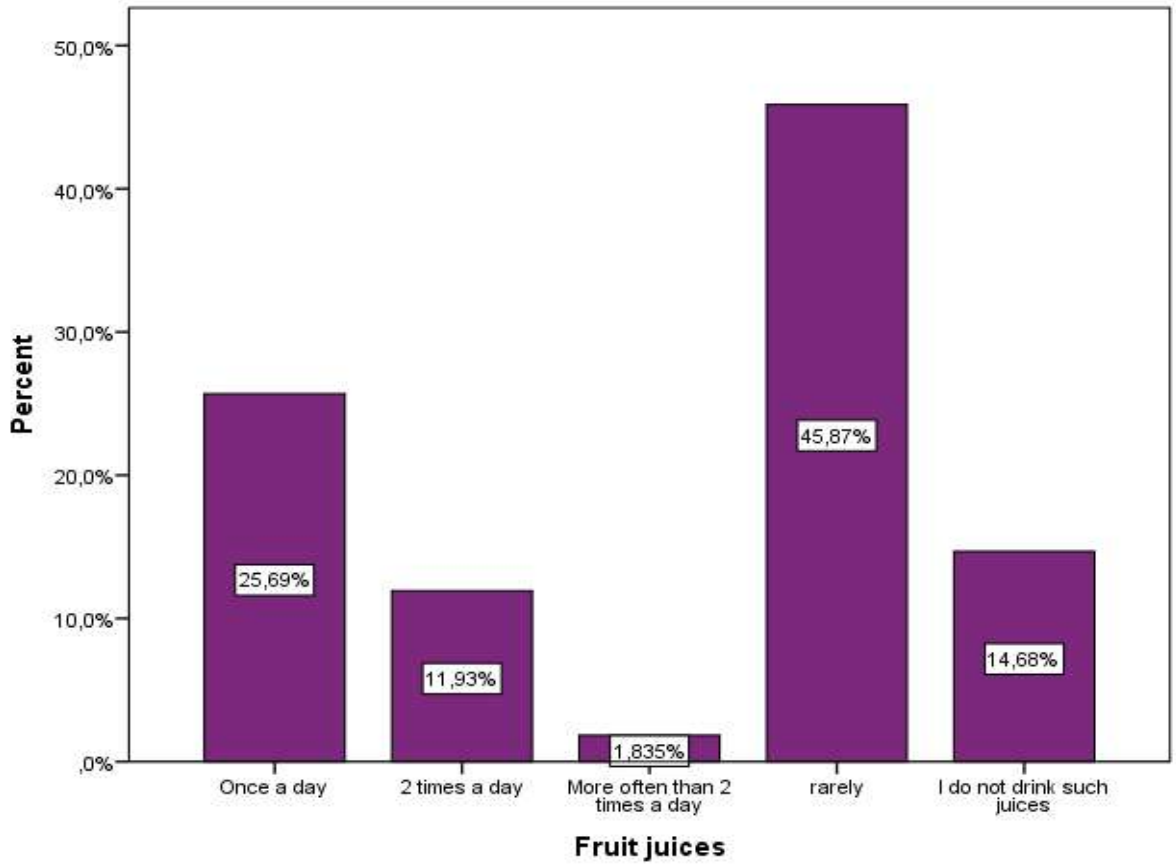


Fig. 54. Consumption of fruit juices

A significant difference was found in the gender of the children (p = 0.005), as in boys who are undergoing orthodontic treatment up to 18 months all the recommendations of the dentist are followed, while all boys with a duration of treatment over 1.5 years avoid only solid foods. In girls with a duration of treatment up to 12 months 57.7% avoid solid foods, while those with a longer duration follow all the recommendations of the dentist (50.0% and 66.7%, respectively) (Table 20).

An inversely strong relation was found between the change in the type of eating habits and the duration of orthodontic treatment according to the male sex (r = -0.635; p <0.001) (Table 21). At the beginning of treatment, 64.3% of the boys followed all the dentist's recommendations, while after 18 months all the boys avoided only solid foods (Table 20).

Table 20. Change in the type of habits in orthodontic treatment according to its duration and the gender

Gender			Changing the type of eating habits during the orthodontic treatment				Total
			avoid solid foods	avoid sticky carbohydrate foods	avoid foods with added sugar	All of the above	
boys	How long have you been undergoing orthodontic treatment with braces?	<12 months (less than a year)	1	3	1	9	14
			7,1%	21,4%	7,1%	64,3%	100,0%
		from about 18 months (about a year and a half)	2	1	1	4	8
			25,0%	12,5%	12,5%	50,0%	100,0%
		> 18 months (more than a year and a half)	7	0	0	0	7
			100,0%	0,0%	0,0%	0,0%	100,0%
	Total		10	4	2	13	29
			34,5%	13,8%	6,9%	44,8%	100,0%
girls	How long have you been undergoing orthodontic treatment with braces?	<12 months (less than a year)	15	2	1	8	26
			57,7%	7,7%	3,8%	30,8%	100,0%
		from about 18 months (about a year and a half)	2	1	0	3	6
			33,3%	16,7%	0,0%	50,0%	100,0%
		> 18 months (more than a year and a half)	2	0	0	4	6
			33,3%	0,0%	0,0%	66,7%	100,0%
	Total		19	3	1	15	38
			50,0%	7,9%	2,6%	39,5%	100,0%
Total	How long have you been undergoing orthodontic treatment with braces?	<12 months (less than a year)	16	5	2	17	40
			40,0%	12,5%	5,0%	42,5%	100,0%
		from about 18 months (about a year and a half)	4	2	1	7	14
			28,6%	14,3%	7,1%	50,0%	100,0%
		> 18 months (more than a year and a half)	9	0	0	4	13
			69,2%	0,0%	0,0%	30,8%	100,0%
	Total		29	7	3	28	67
			43,3%	10,4%	4,5%	41,8%	100,0%

Table 21. Correlation analysis between the change in eating habits and the duration of orthodontic treatment by gender

Пол			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
boys	Interval by Interval	Pearson's R	-,647	,113	-4,406	,000[c]
	Ordinal by Ordinal	Spearman Correlation	-,635	,132	-4,274	,000[c]
	N of Valid Cases		29			
girls	Interval by Interval	Pearson's R	,255	,161	1,582	,122[c]
	Ordinal by Ordinal	Spearman Correlation	,256	,160	1,591	,120[c]
	N of Valid Cases		38			
Total	Interval by Interval	Pearson's R	-,120	,123	-,976	,333[c]
	Ordinal by Ordinal	Spearman Correlation	-,103	,125	-,833	,408[c]
	N of Valid Cases		67			

White carious lesions in patients undergoing orthodontic treatment should be managed using a multifactorial approach. The most important strategy is to prevent demineralization and biofilm formation (195).

Fig. 55 schematically presents the algorithm for monitoring the patients with white carious lesions performing treatment with fixed orthodontic technique.

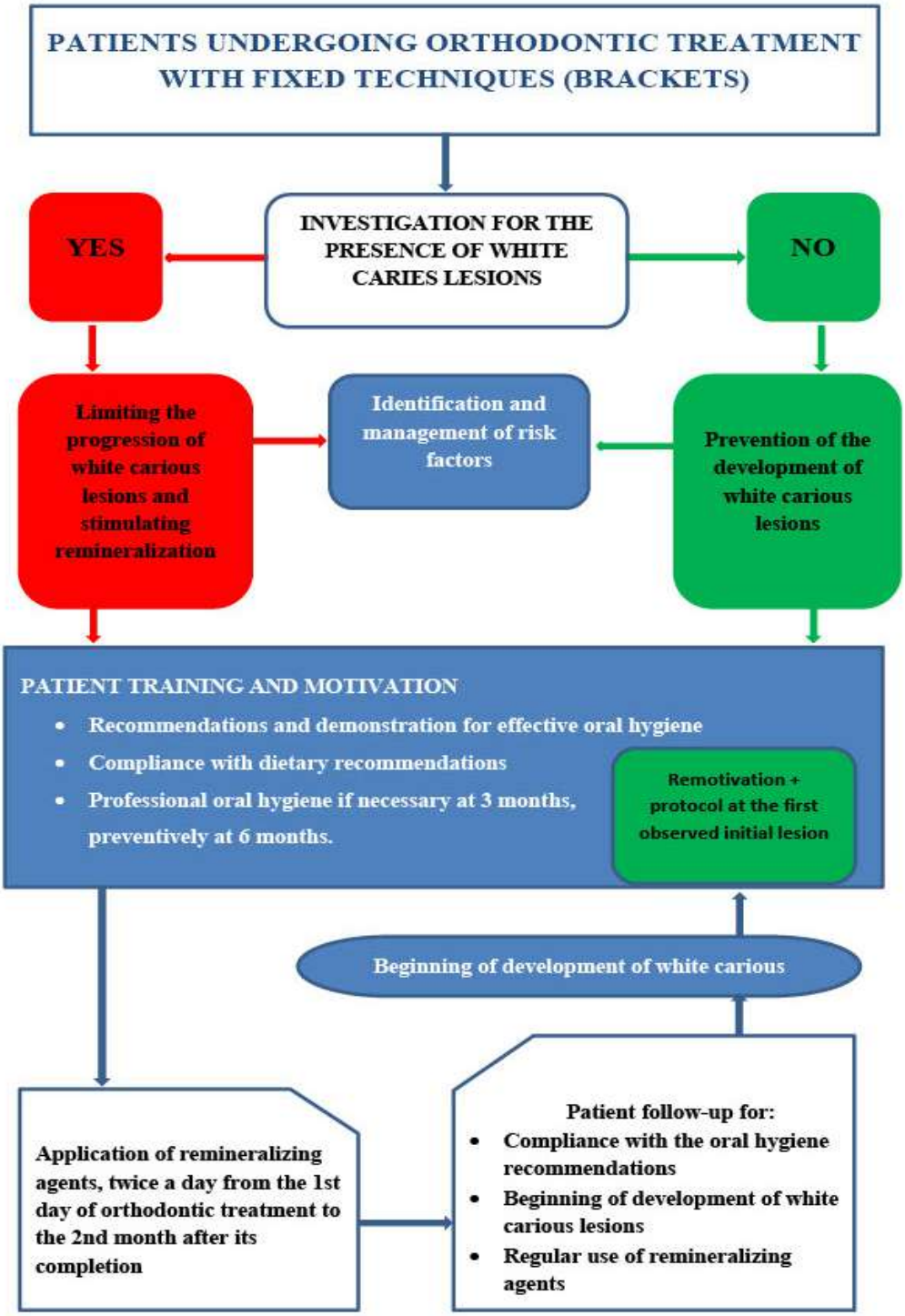


Fig. 55. Algorithm for prevention and follow-up of patients performing treatment with fixed orthodontic technique

Prevention must first begin with training and motivation the patient to maintain oral hygiene and eat foods with low cariogenic potential. Effective oral hygiene is the basis of preventive measures in patients undergoing treatment with a fixed orthodontic technique. It is recommended to mechanically control and remove plaque by properly brushing the tooth surfaces, at least twice a day, with a toothpaste containing fluoride of at least 1450 ppm, especially in the areas close adjacent to orthodontic appliances. During follow-up visits, the patient's motivation should be reassessed and, if deemed necessary, professional oral hygiene should be performed and the patient should be remotivated (Fig. 55).

Professional oral hygiene reduces the bacterial load, increases the efficiency of brushing and facilitates the cleaning of the oral cavity by the patient. Professional oral hygiene at 3 months in high-risk patients and at 6 months in low-risk patients reduces the risk of developing white carious lesions and helps maintain good oral hygiene. Methodology:

- Cleaning of all soft and hard deposits on the tooth surfaces with the help of brushes, toothpaste and, if necessary, ultrasonic scaling is performed.
- Polishing the tooth surfaces with toothpaste or air-flow with glycine beads so as not to further abrasion the surface of the initial lesion.

In the early stages of treatment with a fixed orthodontic technique, plaque control becomes difficult. In addition to mechanical control, it is recommended to prescribe plaque inhibitors for 4-8 weeks. In addition to its plaque-inhibiting effect, chlorhexidine has been shown to have another advantage: it reduces the number and severity of traumatic mucosal lesions during the first 4 weeks of treatment with a fixed orthodontic technique (251).

The frequency of brushing, the age of the patient, the duration of treatment, prior to wearing another fixed device and the activity of the process are the main factors that influence the evolution of the lesion in the direction of progression, stationary or regression. The peculiarities of the diet (preference for liquid and slurry food) at the beginning of treatment make patients at risk for the initiation of white carious lesions.

As a result of what has been said so far, the obtained results, literature data and the proposed algorithm, protocols for prevention of white carious lesions according to the risk and occurrence of the lesion have been prepared.

Table 22. Protocols for the prevention of white carious lesions

PREVENTION PROTOCOLS		
LOW RISK	**HIGH RISK AND / OR BAD COOPERATION BY THE PATIENT**	**PROTOCOL AT THE FIRST OBSERVED INITIAL CARIES LESSION**
• Use of fluoride toothpaste (minimum 1450 ppm) - 2 times a day • Professional oral hygiene every 6 months • Professional application of fluoride varnish every 6 months • Rinsing with mouthwash containing 0.2% chlorhexidine for 14 days - 30 minutes before or after using fluoride toothpaste Avoid sugar consumption	• Use of fluoride toothpaste (minimum 1450 ppm) - 2 times a day • Professional oral hygiene every 6 months • Fluoride varnish every 3 months • Rinsing with mouthwash containing 0.2% chlorhexidine for 14 days - 30 minutes before or after using fluoride toothpaste Avoid sugar consumption	• Use of fluoride toothpaste (minimum 1450 ppm) - 2 times a day • Professional oral hygiene every 6 months • Fluoride varnish every 3 months • Professional application of MI Varnish - 4 consecutive applications, one every week If the above measures are applied adequately, but there is a progression of white carious lesions and lack of cooperation on the part of the patient, early removal of the orthodontic appliance is envisaged.

MI Varnish is a bioavailable varnish that contains calcium, phosphate and fluorine. Contains RECALDENT TM (CPP-ACP). It consists of 2% Recaldent and 5% sodium fluoride. This unique combination offers the necessary protection for patients of all ages to prevent tooth decay and effectively controls hypersensitivity during orthodontic treatment. It stays on tooth surfaces longer than other fluoride varnishes and contains high levels of fluoride and calcium released into the oral cavity.

After professional oral hygiene, the tooth surfaces are dried and isolated. The varnish is mixed in the single dose and applied with a disposable brush. After administration, patients should not eat for 4 hours.

Motivation brochures have been prepared for the motivation of patients, which are aimed at two main groups - children undergoing orthodontic treatment with a fixed technique and their parents (Appendix 3).

The motivational brochure for maintaining good oral hygiene, aimed at children, includes guidelines for proper brushing and the use of mouthwash (Appendix 4):

- Brush your teeth with an orthodontic toothbrush + fluoride toothpaste for 3 minutes. The teeth are carefully brushed on all surfaces. Do not wash the braces themselves, but the sides around them.

Fig. 56. Visual presentation of cleaning with an interdental brush

- The interdental brush cleans the teeth between every two braces, under the arch and the space above the braces (tooth-crown) (Fig. 56).
- Use of mouthwash. Rinse with 15 ml. from it for 30 seconds. After cleaning and rinsing your teeth with mouthwash, it is not recommended to eat or drink anything, so it is good to use it mainly in the evening. This procedure takes no more than 6-7 minutes, and the result is a beautiful smile with naturally white and healthy teeth for a long time.

During treatment with a fixed orthodontic appliances, brushing the teeth must be maintained in the MORNING and EVENING and, if possible, after the main meals. Braces are additional retention areas in the mouth where food is retained. If it is not cleared, it remains where it "decomposes" and leads to an increased acidic environment in the mouth, which favors the formation of future caries and inflammation of the gums.

The information included in the motivation brochure for parents is rather aimed at their acquaintance with the ways of cleaning teeth (Appendix 5):

- Toothbrush - teeth should be cleaned with fluoride toothpaste 2 times a day (morning and evening). A soft toothbrush is used, which is held at an angle of 45 ° to the tooth surface, starting from the space between the arch and the gum.
- Interdental brush - It cleans the tooth surface around the bracket and the interdental space. Cleaning between the teeth at the beginning before moving them may not be possible, but after the braces and the arch connecting them have remained in the mouth for at least a week, the passage of the interdental brush between the teeth should be possible. The interdental brush is not a substitute for the ordinary one, but a supplement to it!
- Mouthwash - Rinse with 15ml. from it for 30 seconds. After cleaning and rinsing the teeth with mouthwash, it is not recommended to eat or drink anything, so it is good to apply mainly in the evening.

- Control visits - Follow your doctor's recommendations. Apply remineralization regularly. Once every 6 months, professional cleaning is performed in low-risk patients, and in those with high risk - every 3 months.

Recommendations for nutrition during treatment with braces aimed at children include (Appendix 6):

- Cut down on some foods that are difficult to chew, such as nuts, hard candy, chewing gum, hard fruits and vegetables, you should cut your apples, for example, instead of eating them directly. This will reduce the risk of loosening the braces.
- Exclude most candies, cornflakes, snacks and chips, because pieces of them easily remain around the braces and increase the risk of caries.
- Reduce the consumption of drinks that can stain your braces, especially if they are ceramic.
- How should you choose your food when wearing braces?
    - Avoid too hard (candy, nuts, popcorn, chips) or sticky foods (Turkish delight, chewing candy and chewing gum, etc.), placing various objects in the mouth.
    - Cut raw fruits and vegetables into pieces before eating and avoid eating them directly.
    - What should you avoid? Biting nails, chewing pens etc. can damage the braces, or even break some of them. If you exercise, you need to be careful and protect your braces. The best way is through the use of mouth guards that are placed on the teeth.
    - The braces retain food and it is good to wear a toothbrush. After each meal, brush your teeth to clean the food debris. The most unpleasant in this regard are lettuce, cabbage, parsley, citrus fruits, beef, etc.
- Allowed food - Avoid foods with added sugar
    - Fruits, cut into pieces
    - Dairy products and dairy-based desserts
    - Especially in the first days of treatment - shakes and smoothies
    - Light foods (mashed potatoes, cream soups, risotto, spaghetti, tender meats, etc.)

"Acid" foods have the ability to damage teeth - especially their enamel. In this way, caries is formed. Weakened enamel can also lead to various problems, such as hypersensitivity and discoloration of the teeth (white spots). Examples of foods with high acidity are lemons, tomatoes and others.

The following nutrition recommendations are included in the parent brochure (Appendix 7).

- Allowed food
    - Cream soups with chopped ingredients, or grated on a grater.
    - Mashed potatoes - if it is too thick, dilute it with a little milk. For more energy, add shredded cheese or finely chopped boiled chicken or ham.
    - Rice is suitable with both vegetables and minced meat.
    - Bananas have a proven beneficial effect on the body. As a bonus, you can take them both cut into pieces and in the form of shake.
    - Dairy products and dairy-based desserts without added sugar. As for desserts, avoid ready-made packaged bars and waffles. Bet on mousses and creams that do not require much chewing.

    - Fruits and vegetables - cut into pieces.
- Braces - list of prohibited products:
    - Nuts, dried fruits, hard biscuits can damage the orthodontic appliance
    - Chewing gums, lollipops, candies, ice cream, drinks that contain large amounts of sugar
    - Thick meats (eg beef)
    - Hard fruits and vegetables (carrots, apples, etc.)
    - Popcorn, chips
    - Citrus fruits
    - Leafy vegetables
    - Chewing candies
- Problems:
    - Once the braces are placed, the teeth will be sensitive, this is normal. If the elements of the device rub the lips or cheeks, you may need to buy wax for your child, which sticks to these parts. It can be found in the pharmacies. If necessary, give him a painkiller. A sparing diet is obligatory.
    - If part of the appliance breaks, peels off or is lost, please call the orthodontist immediately for an hour, unless your next appointment is within a day or two. Always keep all parts and carry them with you when you meet the orthodontist. Remember that a fracture means a longer treatment.

Enamel demineralization around fixed orthodontic appliances is a common complication during and after orthodontic treatment. These lesions are managed by educating and motivating the patient to follow good oral hygiene. Other methods are also recommended, such as antiseptics, remineralizing agents, infiltration, etc. However, good oral hygiene is the most important preventive measure in patients with a fixed orthodontic technique to prevent the development of white carious lesions.

6.1. Discussion on task 6

A beneficial role in the prevention of white carious lesions, documented in the literature, is the use of fluoride. Fluoride ion (especially in low concentrations) prevents dental caries by modifying bacterial metabolism in dental plaque. This is achieved by inhibiting certain enzymatic processes, by inhibiting the production of acids, by changing the composition of the bacterial flora and/or metabolic activity of microorganisms, and by reducing the demineralization and promoting the remineralization of carious lesions that are in the early stages (69).

In this regard, fluoride varnishes are effective in reducing the incidence of caries in permanent teeth. Fluoride varnishes are proving to be a safe method of prevention. The advantages of fluoride varnishes over other topical fluoride forms include the protection of the enamel in the absence of patient cooperation and the continuous release of fluoride over a long period of time. According to some authors, the application of fluoride varnish leads to a 44.3% reduction in enamel demineralization in patients undergoing orthodontic treatment (291).

Azarpazhooh and Limeback (30) reported after a 3-year follow-up period that applying fluoride varnish every 6 months for high- and medium-risk groups proved to be the most cost-effective measure. Other studies recommend administration every 90 days (every 3 months) for adequate prevention (280). The application of fluoride varnish every 6 weeks during orthodontic treatment has been shown to be effective in some other studies (44). In vivo study of Perrini et al. demonstrates that periodic application of fluoride varnishes in patients undergoing treatment with a fixed orthodontic technique may provide some protection against the development of white carious lesions, which may not be statistically significant if patients maintain excellent oral hygiene (226).

A single application of fluoride varnish immediately before the start of orthodontic treatment does not provide any additional preventive advantage over good dental hygiene with the use of fluoride toothpastes, in terms of the development of white carious lesions and gingivitis in patients with low to medium caries risk . According to the literature, patients are often applied fluoride varnish immediately before orthodontic treatment with a fixed technique. The efficacy of this technique remains to be elucidated (149).

Enamel demineralization can be prevented by products containing casein phosphopeptides and amorphous calcium phosphate (CPP-ACP). Recent studies have shown that this is achieved by the protein casein, which carries calcium and phosphate ions "glued" to it in the form of ACP (252). This CPP-ACP complex delivers bioavailable calcium and phosphate ions. It is believed that the anti-caries activity of CPP-ACP relies on the incorporation of nanocomplexes in dental plaque and on the tooth surface, thus serving as a reservoir for calcium and phosphate. CPP-ACP binds to the bacterial wall and tooth surfaces (66). In the case of an intraoral acid attack, calcium and phosphate ions are released, reaching a supersaturated state of ions in the saliva, and then precipitate as a calcium phosphate compound on the tooth surface (128). In addition, casein phosphopeptides can help increase the pH value. It can also prevent bacterial adhesion to tooth surfaces and inhibit biofilm formation (64). When CPP-ACPs are present in the lesion, they release weakly bound calcium and phosphate or calcium, phosphate and fluoride ions, which are then deposited in the crystal lattice to form hydroxyapatite or fluorohydroxyapatite (64). Several in vitro and in situ studies have shown that CPP-ACP-containing products reduce demineralization and promote remineralization (64, 103, 176, 195).

Remineralizing creams (MI Paste Plus) with the addition of fluoride 900 ppm can be applied for the prevention of white carious lesions.

There are several clinical studies demonstrating the efficacy of CPP-ACP in the prevention and regression of white carious lesions during orthodontic treatment. Robertson et al. (236) showed that CPP-ACP + fluoride (MI Paste Plus) had a preventive effect compared to placebo. Two other studies showed no difference between CPP-ACP, fluoride gel (5% NaF) (274) or fluoride varnish (Fluor Protector) (285). The mechanism of action of CPP-ACP is thought to pave the way for better ion diffusion, leading to remineralization of the entire body of the lesion, not just the surface layer. In such studies, the duration of use was relatively short, as most of the regression of post-orthodontic white carious lesions was thought to occur immediately after braces were removed. (53). Some studies have shown that daily application

of remineralizing cream is more effective in stationing lesions than using fluoride toothpaste. The application of CPP-ACP may give better results than a fluoride mouthwash in terms of remineralization of post-orthodontic white carious lesions (20, 89, 143, 170, 274).

Therefore, the ability of CPP-ACP to prevent caries in the long run remains to be elucidated. Clinical studies are not convincing enough to conclude established recommendations for the use of the cream (195).

Chlorhexidine is the most commonly used antiseptic in dental medicine, which has proven its effectiveness in the control and management of biofilm in gingivitis. Chlorhexidine is a positively charged molecule that binds to negatively charged sites on the bacterial cell wall (230). It is able to destabilize bacterial cell walls within 20 seconds (230).

Once the cell wall is damaged, chlorhexidine passes intracellularly and attacks the cytoplasmic membrane. Damage to the delicate semipermeable membrane causes leakage of components, leading to cell death (230). Chlorhexidine inhibits the adhesion of microorganisms to the surface, thus preventing the growth and development of biofilms. This is especially necessary in the oral cavity, as biofilms protect microorganisms and facilitate bacterial adhesion to tooth surfaces (230).

Chlorhexidine is available in the form of mouthwash, gels or varnishes. It affects the cariogenic microflora and reduces the number of S. mutans. Chlorhexidine varnishes are more effective than gels and mouthwashes. Some studies have shown the effectiveness of chlorhexidine varnishes in reducing the incidence of caries during orthodontic treatment, while others have not proven the effectiveness of a varnish containing 40% chlorhexidine (133, 154, 209).

After removal of the orthodontic appliances, regression of white carious lesions was observed due to natural remineralization of saliva and improvement of oral hygiene parameters (114). This improvement depends on the severity of the lesions and the occurrence of about 6 months after removal of the orthodontic appliance, but this period is not enough and these lesions must be treated.

The first choice for the elimination of white carious lesions is remineralization, combined with the maintenance of good oral hygiene by the motivated patient throughout the treatment period. For this purpose, several products are available for professional and home use in various forms: mouthwashes, varnishes, creams, pastes and chewing gums. These products contain fluoride and/or casein phosphopeptide-amorphous calcium phosphate, with varying degrees of efficacy in the scientific literature (31, 43, 45, 46, 196). Denis et al. support these measures for lesions with a score of 0 and 1 according to the ICDAS classification (72). In lesions 2 according to the ICDAS classification, these measures are not effective in remineralizing the lesions to their full depth, and more invasive techniques such as infiltration, (72) whitening, and microabrasion (114) need to be applied. Products with high fluoride concentrations are not recommended for the treatment of lesions in the front, as they lead to a change in tooth color (144). It should be borne in mind that there is a lack of reliable scientific data to support remineralizing agents as a stand-alone means of prevention, as well as infiltration, to deal with white carious lesions that have developed during orthodontic treatment, and therefore more research are needed (260).

Concluding remarks

1. The orthodontic treatment with a fixed technique is a risk factor for higher caries and poor oral hygiene in adolescents.
2. The duration of orthodontic treatment with a fixed technique is associated with higher caries, deterioration of oral hygiene and the development of gingivitis.
3. Male gender is a risk factor for elevated EDI and GI and Gorelick indices, as well as OPI and OHI indices.
4. Metal braces carry a higher risk of developing white carious lesions and gingival inflammation.
5. The duration of orthodontic treatment is associated with deterioration of oral hygiene due to loss of motivation and cooperation from the patient.
6. No difference was found in the sex and age of the patients in terms of the severity of the white carious lesions.
7. A risk factor for aggravating white carious lesions during orthodontic treatment is the duration of treatment, metal braces and the patient's lack of cooperation.
8. Lack of cooperation and poor oral hygiene from the patients, which undergoing treatment with a fixed orthodontic technique determine the higher degree of gingival inflammation.
9. The high caries risk in orthodontic patients correlates with the patient's lack of cooperation, inadequate plaque control and non-compliance with dietary change recommendations.
10. The algorithm created by us provides guidelines for prevention and follow-up of white carious lesions in patients with fixed orthodontic technique. Prevention protocols have been developed and proposed according to the degree of risk.

Conclusion

The health of the oral cavity depends on the healthy behavior of the individual. Assessment of oral health during the first months of treatment, intensive oral hygiene training, and often repetitive motivation can be considered as techniques for improving individual health behavior. This allows management of demineralization during fixed orthodontic therapy and reduces its prevalence, similar to that in orthodontically untreated patients. The presence of new white spot lesions in some patients in both groups may be attributed to a lack of cooperation.

As a result of the analysis of the set tasks, we made the following conclusions:

Conclusions on Task 1: *To study the prevalence of white carious lesions in patients with fixed orthodontic technique*

- The mean age of the children in both groups was 14.7 years ± 2.1 years, with girls predominating (65.9%).
- The mean EDI value is 0.18 ± 0.17 (0-0.44).
- There is no difference in gender, although for boys the index has a slightly higher value (0.18 for girls to 0.19 for boys, respectively).
- The mean EDI values were found elevated in children aged 16 years (0.272) and 12 years (0.218), and the lowest mean value was observed in children aged 15 years (0.138).
- As the duration of treatment increases, the risk of developing white carious lesions increases.
- In the first month of follow-up, the EDI index had the lowest values (0.135 ± 0.166), with a steady upward trend.
- Children with metal braces have significantly higher EDI index values.
- Over 1/3 (36.6%) of the children who undergo treatment with fixed orthodontic technique do not cooperate in the treatment process and have a higher EDI index.
- The worse the childrens` oral hygiene is during the orthodontic treatment, the greater the prevalence of white carious lesions.

Conclusions on Task 2: *To study the level of plaque accumulation in children with fixed orthodontic technique and to compare with the control group*

- The mean value of the OPI index is 1.91 ± 1.33 (0-4.0), and in children from the control group the plaque index is 1.22 ± 0.75 (0-3.0).
- In the boys from the clinical group there is more accumulated plaque (respectively 1.68 to 2.36)
- There was a significant difference in the plaque index in the different age groups, where the most obvious difference is in the age of 12 years (OPI 2.5 to OHI 1.1), 13 years (OPI 2.66 to OHI 1.5), 18 years (OPI 2.04 to OHI) 1.59) and 14 years (OPI 1.87 to OHI 0.87).
- In the first month of follow-up, the OPI index had the lowest values (1,435 ± 1,026), with a steady upward trend in the sixth month after the placement of the braces and in the retention phase of treatment.

- Patients who do not cooperate in the orthodontic treatment process have elevated plaque index values.

Conclusions on Task 3: *To study the level of gingival inflammation in children with fixed orthodontic technique and to compare with the control group*

- A higher number of bleeding units was observed in children with fixed orthodontic technique than in healthy controls (0.91 (0-2.50) to 0.14 (0-1.10), respectively).
- In the two study groups, the mean GI value in boys was lower.
- In the group of healthy controls there is a tendency to decrease GI with increasing the age.
- The change in GI according to the follow-up stages shows that as the duration of treatment increases, the mean value of the gingival index also increases.
- Patients treated with metal braces had higher GI values than treated with ceramic braces (0.976 and 0.244, respectively).
- Patients who do not cooperate have three times higher GI values.
- The worse the oral hygiene, the higher the GI value.

Conclusions on Task 4: *To assess the severity of white carious lesions in patients undergoing treatment with fixed orthodontic technique*

- The mean value of the Gorelick index is 0.90 ± 0.85 (0-2.0).
- The majority of children with fixed orthodontic technique have healthy dental surfaces (Gorelick = 0) (41.5%), and the relative share of children with extensive white lesions (Gorelick = 2) is relatively high (31.7%).
- In girls the relative share of those with extensive white carious lesions (Gorelick = 2) prevails (33.33%), while in boys prevails the children with healthy tooth surfaces (Gorelick = 0) (42.86%) and those with white carious lesions in the form of spot or line (Gorelick = 1) (28.57%).
- Extensive carious lesions (Gorelick = 2) predominate in children aged 14 years (30.77%) and aged 16 years (23.08%).
- As the duration of orthodontic treatment increases, so does the Gorelick index and the severity of white carious lesions.
- In 32.6% of cases of children with extensive carious lesions, the main factor for their formation is the duration of treatment.
- In the first month of follow-up, the Gorelick index had the highest relative proportion of healthy tooth surface (58.82%), with a steady upward trend in the relative proportion of extensive white carious lesions at six months and during the retention phase of treatment (respectively 30.77% at 6 months and 63.64% for the retention phase).
- In patients treated with ceramic braces, the relative share of those with healthy tooth surfaces prevails (Gorelick = 0), while extensive carious lesions (Gorelick = 2) are observed in children treated with metal braces.

- 50% of patients who cooperate well in the treatment process have a healthy tooth surface (Gorelick = 0). In patients with a Gorelick index = 2 (extensive white lesions), the relative share of non-cooperative patients is significant (60%).

Conclusions on Task 5: *To assess the specific caries risk profile of patients with fixed orthodontic technique*

- The children from the control group have a higher relative share of high caries risk (61.11% high risk and 28.57% low risk, respectively), while the children treated with fixed orthodontic technique also have a higher caries risk, but with a significant lower relative share than in controls (respectively 71.43% are high risk to 38.89% low risk).
- Predominantly males are with high caries risk.
- The relative share of low caries risk prevails among children aged 15 (83.3%), while the relative share of high caries risk prevails among children in the age group 13, 16 and 18, and the distribution is even among the others.
- Children with a duration of 11.05 months. ± 7.7 months have a low caries risk, while children with an average duration of treatment of 19.71 months. ± 8.82 months have a high caries risk.
- In the first month of follow-up, a high relative share of children with low caries risk was observed (76.5%), while in the sixth month and during the retention phase, children with high caries risk prevailed (61.5% at 6 months and 81.8%, respectively for the retention phase).
- Lack of cooperation increases the risk of caries more than 7 times during orthodontic treatment.
- Of the patients with good cooperation, 65.38% have a low caries risk and 34.62% have a high risk. The relative share of high caries risk in non-cooperating patients is significant (80% are at high caries risk and 20% are with low caries risk).

Conclusions on Task 6: *To create an algorithm for prevention of white carious lesions in patients with fixed orthodontic technique depending on the level of oral hygiene*

- The largest relative share of both boys (65.12%) and girls (56.72%) indicate that they brush their teeth twice a day - usually in the morning after sleep and in the evening before sleep.
- At the age of 16, the shortest duration of brushing was found (40.0% brush their teeth for 1 minute), after which the duration of brushing began to increase again. This trend persists for both boys and girls. This is explained by older age and better cooperation, as well as the motivation to conduct the overall orthodontic treatment.
- Change in eating habits was found in 62.7% of the surveyed children, with no difference according to gender and age.
- The largest is the relative share of children aged 17 who change their eating habits during treatment with fixed orthodontic technique (75%).
- More than half of the children surveyed who underwent orthodontic treatment (57.0%) reported consuming food with added sugar twice a week or less often.

- Boys who undergo orthodontic treatment for up to 18 months follow all the recommendations of the dentist, while all boys with a duration of treatment over 1.5 years avoid only solid foods. This shows the loss of motivation on the part of the patient during orthodontic treatment to cooperate and follow the recommendations, and shows the need to create a prevention program and protocols for the management of white lesions.
- In girls with a treatment duration of up to 12 months 57.7% avoid solid foods, while those with a longer duration follow all the recommendations of the dentist (50.0% and 66.7%, respectively). This testifies to the increased aesthetic requirements of the female sex and the motivation to complete a successful orthodontic treatment.

Plaque control during orthodontic treatment is a challenge. The iatrogenic effects of this treatment are carious lesions and gingivitis. Therefore, training and motivation for oral hygiene is a key factor for the success of treatment. Regarding the literature, many preventive strategies have been developed to optimize behavioral habits in terms of hygiene during treatment. Most publications related to this topic do not focus on the educational methods used, but rather on the equipment and preventive measures provided by the orthodontist.

Contributions

I. Original for the country:

1. The dissertation provides for the first time in Bulgaria up-to-date data on the oral health of children undergoing orthodontic treatment with a fixed technique.
2. For the first time, a detailed analysis of the prevalence and severity of white carious lesions was performed with specially selected indices in patients undergoing treatment with fixed orthodontic technique.
3. For the first time in the risk profile of patients undergoing orthodontic treatment with a fixed technique, the behavioral factors regarding eating habits and oral hygiene were also studied.

II. With practical application:

1. A risk profile has been developed for the development of white carious lesions in patients undergoing treatment with fixed orthodontic technique.
2. An algorithm for prevention and follow-up of patients undergoing orthodontic treatment with a fixed technique has been developed and proposed.
3. Protocols for prevention of white carious lesions have been developed and proposed, which are for children with low risk, for children with high risk and / or poor cooperation, as well as at the beginning of the development of white carious lesions.
4. Informative motivational materials have been developed for children conducting orthodontic treatment with a fixed technique, as well as for their parents regarding eating habits and maintaining effective oral hygiene.

III. Confirmatory:

1. It has been proven that there is connection between orthodontic treatment with a fixed technique and increased caries, gingival inflammation and the accumulation of dental plaque.
2. The duration of orthodontic treatment, metal braces and male gender have been shown to be negative in terms of oral health.
3. It has been proven that in patients with good cooperation better results are achieved in terms of the overall course of treatment, maintenance of good oral hygiene and prevention of caries and gingival inflammation.

List of publications related to the dissertation

1. Dimova E., Doichinova L., Andreeva-Borisova R. Dentists` Awareness of white spot lesions during treatment with fixed orthodontic appliances, Medinform 2020; 7(1):1156-1164
2. Димова Е., Дойчинова Л. Методи за диагностика и лечение на бели кариозни лезии при пациенти с фиксирана ортодонтска техника. Дентална медицина, 1/2019, 9-17
3. Димова Е., Дойчинова Л. Бели кариозни лезии при пациенти с фиксирана ортодонтска техника. Дентална медицина, 1/2019, 3-8