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# “Effectiveness of Quantitative Light Fluorescence (QLF) in Predicting Occlusal Dental Caries”

**Gulyamov Doniyor Taxirovich**

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**Author: Gulyamov D.T.** *PhD, Assistant, Department of Prevention of Dental Diseases*
*Tashkent State Dental Institute*

**Reviewers:**

**Taxirova K.A.** *Doctor of Medical Sciences, Professor, Head of the Department of Hospital Therapeutic Dentistry, Tashkent State Dental Institute*

**Eronov Yo.A.** *Associate Professor,*
*Department of Pediatric Dentistry,*
*BUKHMI, M.D., D.Sc.*

The monograph is devoted to the application of Quantitative Light-induced Fluorescence (QLF) technology for the early detection and prognostication of dental caries. It presents the results of a comparative assessment with traditional diagnostic methods (ICDAS, visual–tactile examination, bitewing radiography) and provides practical recommendations for clinical practice.

Keywords: QLF, dental caries, ICDAS, Cariview, VOPI, early diagnosis.

**CO**NTENTS

**CHAPTER 3.**

## LIST OF ABBREVIATIONS

DMFT-Decayed, Missing, Filled Teeth — an index of affected, extracted, and filled teeth

Bitewing-Bitewing radiography

WHO - World Health Organization

QLF- (Quantitative Light Fluorescence)

ICDAS- (International Caries Detection and Assessment System)

QS- (QLF Scoring) - QLF assessment system

QS-occlusal- QLF occlusal surface assessment system for chewing teeth

FS - chewing surface of the molar

FC – fissure caries

RF (Red fluorescence)

ZF – Green Fluorescence

IHM - Molar Hygiene Index

MM - primary molar

GIC - glass ionomer cement

FN – sodium fluoride

NMFF – sodium monofluorophosphate

str.Mutans, SM – streptococcus mutans

## INTRODUCTION

The prevalence of dental caries worldwide is decreasing with the increase in fluoride use, while the relative prevalence of non-cavitary caries lesions is increasing [10,16,26,56,80]. Clinical features of occlusal caries typically appear on imaging and radiographic examinations only after the lesion has progressed significantly due to the anatomical pattern of the lesion extending from pits and fissures down into the dentin. [6,11,15,24,27,48,67,123] Epidemiological studies reviewed have shown a shift in caries prevalence from occlusal surfaces to proximal surfaces. Two recent meta-analyses evaluated the effectiveness of imaging and radiography for detecting carious lesions and reported low sensitivity but high specificity for early proximal caries detection. This suggests that conventional methods have a higher risk of failing to detect proximal lesions. Therefore, in caries-susceptible populations, there is a risk of progression of non-cavitary lesions to irreversible tooth destruction before these lesions are detected. These changes require early detection and evaluation of lesions, while accurate diagnoses are necessary for appropriate further treatment [36,59,87]. To predict the development of dental caries and its prevention, it is necessary to assess the caries activity [74,55]. It is well known that the use of caries activity tests is very useful, and the development of a reliable and valid method is necessary for a more accurate assessment of the risk of caries development [6,73,140]. One of the approaches to solving the problem of early detection and evaluation of lesions is a dental diagnostic technique called quantitative light fluorescence (QLF), with the help of which oral abnormalities such as initial and progressive dental caries, bacterial activity on teeth can be detected, quantitatively analyzed and monitored over time.

Quantitative light fluorescence (QLF) technology can quantify the degree of fluorescence change upon irradiation with visible blue light whose wavelength is 405 nm by measuring the loss of fluorescence.[37,80,121].

It has been established that the loss of fluorescence in the examined teeth strongly correlates with the loss of minerals in the lesions. [28,83,119]. An unbalanced state of the microbial community leads to the formation of pathogenic dental plaque, which exhibits cariogenic or periodontopathogenic properties depending on the predominant bacteria, their metabolites and the host response [71, 28]. Therefore, it is necessary to focus on the detection of pathogenic dental plaque and the prediction of its pathogenic level for the prevention and treatment of oral diseases. Some dental plaques have been found to exhibit red fluorescence when irradiated with blue light with a wavelength of 405 nm [43,94]. This optical phenomenon may be explained by the endogenous metal-free fluorescent porphyrin, such as protoporphyrin IX as the main component, produced by some oral microorganisms, which exhibit strong fluorescence in the red region of the spectrum when excited by violet light in the range of 400 to 420 nm [36,49,69]. According to previous studies using QLF technology, the red fluorescence can be attributed to mature plaque, which makes it easier to detect plaque without additional staining procedure [82,97]. In addition, the red fluorescence of plaque shows a significant correlation with caries and gingivitis and may indicate its pathogenicity [79,102]. Recent in vivo studies confirmed that the red fluorescence of 2-day plaque is significantly associated with gingival inflammation [96]. These results highlight the need for detection and monitoring of red fluorescent (RF) plaque as an indicator of oral disease risk. Previous studies have shown that the intensity of red fluorescence in plaque potentially correlates with its pathogenicity, confirming the presence of oral diseases or measuring disease severity [78,92,100,101,102].

HYKo et al. showed that QLF technology has a higher level of reliability than radiographic examination for detecting early stages of dental caries in vitro [107]. However, clinical studies are needed that evaluate caries lesions using red fluorescence as a parameter for detecting and assessing the severity of occlusal caries.

The aim of the study was to evaluate the effectiveness of using quantitative light fluorescence technologies to predict the risk of developing caries on the occlusal surface of teeth.

**Research objectives:**

To assess the level of cariogenicity of plaque on the occlusal surface of permanent molars;

To analyze the effectiveness of traditional methods of caries diagnostics;

To study the activity of caries on the occlusal surface of permanent molars using innovative technologies;

To conduct a comparative analysis of the effectiveness of traditional methods of caries diagnostics and quantitative light fluorescence (QLF) technologies;

Scientific novelty.

For the first time:

It has been established that there is a discrepancy between the results of determining the degree of caries activity, taking into account the assessment of the condition of hard tissues in the area of the pits of permanent molars using visual-tactile and quantitative light fluorescence methods;

It has been proven that the level of dental plaque cariogenicity is associated with an increase in red fluorescence, which determines the clinical effectiveness and reliability of quantitative light fluorescence technology;

As a result of a comparative analysis of the cariogenicity of dental plaque using the VOPI, Cariview methods and the Qray computer program, a relationship was revealed

between the volume of dental plaque and the development of caries on the occlusal surface.

A comparative assessment of the clinical effectiveness of quantitative light fluorescence, ICDAS-2 and Bitewing bitewing radiography for caries diagnosis is given.

An optimal method for using quantitative light fluorescence for diagnosing caries in the early stages of its development is proposed.

Scientific and practical significance of the research results

The obtained results will expand practical knowledge on the effectiveness of using QLF technology for assessing biofilm and carious lesions on the occlusal surface of teeth.

Reliable information on caries activity has been established, allowing for improved diagnosis accuracy and the quality of further treatment.

The most effective method for increasing the efficiency of early diagnosis of caries and its prevention is proposed.

The obtained data will be used in the educational and scientific-practical activities of dental faculties of medical universities and dental clinics of the Republic of Uzbekistan.

**Testing the work**

The main provisions of the dissertation were presented at the international scientific and practical conference "Dentistry and current problems of maxillofacial surgery" (Tashkent 2018); at the Republican scientific and practical conference "DAYS OF YOUNG SCIENTISTS" (Tashkent, 2020); at the international congress "67th ORCA

Congress" (Sardinia 2020, Italy); at the international symposium "CUTTING EDGE-SCIENCE 2022" (Shawnee 2022, USA); at the international congress "69th ORCA Congress" (Sardinia 2022, Italy); at a meeting of the department of prevention of dental diseases of the Tashkent State Dental Institute (Tashkent, April 2022), at the interdepartmental conference of the departments of hospital therapeutic dentistry and pediatric therapeutic dentistry of the Tashkent State Dental Institute (Tashkent, May 2022); at a meeting of the Scientific Seminar under the Scientific Council (2022).

# CHAPTER 1. LITERATURE REVIEW

## 1.1. Modern methods for assessing the early diagnosis of dental caries

In everyday practice, dentists are faced with the task of determining the need for preventive dental interventions or a combination with restorative dental measures, taking into account the severity and activity of carious lesions [12,16,19,65,85].

Domestic and international literature has scientifically proven that early-stage caries lesions are reversible. Minimally invasive treatment requires early detection and assessment of caries, taking into account the risk of recurrence. Accurately identifying enamel caries in the early stages using traditional diagnostic methods is challenging [22].

In search of new and more effective treatments to delay or prevent caries development, researchers are designing and conducting clinical trials targeting high-risk groups with predictable caries incidence over a limited period of time. In children and adolescents, the strongest predictors of caries incidence appear to be baseline levels of caries activity (current caries, e.g., KPU, KPU, caries lesions on first molars) [Sobhi M.A. 2018; Terekhova T.N. et al. 2018] [40,41].

Ekstrand Kim Rud, Gimenez Thais (2018) [72] provide an assessment of the overall reproducibility and accuracy of the International Caries Detection and Assessment System (ICDAS) for assessing coronary caries lesions and a study of the use of ICDAS-related systems for assessing coronary caries lesion activity. Specific search strategies were adopted to identify studies published before 2016. For the first objective, the authors selected studies that assessed primary coronary caries lesions using the ICD as a reference standard. A total of 54 studies were included. The meta-analysis summarized the results regarding reproducibility and accuracy (correlation with histology, summary receiver operating characteristic (SROC) curves, and

diagnostic odds ratio (DOR)). The latter 2 were expressed at D1/D3 levels. In addition, the heterogeneity of the studies was assessed. The reproducibility values (pooled) were > 0.65. The ICDAS generally showed good overall performance, as most areas under the SROC were >0.75 at D1 and >0.90 at D3; DOR ≥6. A meta-analysis pooled the results based on the same methodology and parameters as above. To assess the validity of these systems, longitudinal results regarding caries progression were described. On average, the caries activity scoring systems showed moderate values in terms of reproducibility and overall performance. Active caries lesions were more likely to progress than inactive ones after 2 years. [35,47,68,94,102]

Other predictors of dental caries risk typically include oral hygiene levels, the amount of cariogenic microorganisms in plaque and saliva, fluoride history, sucrose intake, and parental socioeconomic level.

In the article by Johnson, MF (2004) [87], a brief review of the existing literature is provided to examine the most useful and relevant prognostic factors for predicting future caries occurrence. The relative advantages of identifying high-risk subjects based on these factors, either individually or in combination, will be examined in terms of statistical efficiency. Particular attention is paid to the advantages of covariance adjustment in the context of survival-based methods of caries data analysis. Furthermore, with the advent of more sophisticated diagnostic procedures (e.g., quantitative light fluorescence) for screening and monitoring caries activity in study subjects, there is the potential to detect earlier states of lesion initiation and progression (or regression), which consequently increases experimental sensitivity to treatment effects. The validity of risk assessment and outcome measurements based on these new diagnostic tools compared to more traditional methods is discussed (Johnson, MF2004)[87].

New approaches to caries diagnosis require the use of new criteria that will allow us to identify not only carious cavities with destruction of hard dental tissues ("cavitated lesions"), but also to determine the demineralization of enamel or dentin before the formation of a carious cavity.

Kim, H.-E., Cho, Y.-K., Kim, et al (2018) [91] believe that early detection and diagnosis of incipient caries are the key to achieving a favorable prognosis. Monitoring pathological changes based on clinical data leads to an accurate prognosis. Therefore, this clinical study investigated the mineral changes of incipient carious lesions using quantitative light-induced fluorescence-digital (QLF-D) after professional fluoride treatment in children, and the improvement in lesion severity was assessed based on the fluorescence loss (ΔF) value obtained by QLF-D. This study examined 90 incipient enamel lesions on primary teeth of 27 children aged 4 to 10 years. QLF-D images were acquired before and after application of 1.23% acidified phosphate-fluoride gel for 1 min, and the 0- and 4-week ΔF (ΔF(0) and ΔF(4), respectively) and lesion recovery rate (RΔF) were assessed. Receiver operating characteristic curve analysis was used to calculate the ΔF(0) cutoff value at which lesion recovery with fluoride treatment was still possible. The authors concluded that the patterns of ΔF recovery at 4 weeks post-fluoride application differed depending on the ΔF(0) values. Incipient lesions with ΔF(0) values less than -13.00 recovered at 4 weeks post-fluoride application ($P < 0.001$) and had a mean RΔF of 19.27%. The obtained results indicate that the cutoff value ΔF(0) can be determined to predict the remineralization effects after fluoride application and provide patients with quantitative prognostic data.

Researchers from Nihon University (Abogazalah, N., Ando, M. 2017) [48] provide an analysis of the state of modern caries diagnostics in their article. The reviewed epidemiological studies show a shift in caries prevalence from occlusal

surfaces to proximal surfaces. Two recent meta-analyses assessed the effectiveness of visual examination and radiography for detecting carious lesions and reported low sensitivity but high specificity for early proximal caries detection. This suggests that conventional methods have a higher risk of failing to detect proximal lesions. Consequently, in caries-susceptible populations, there is a risk of non-cavitated lesions progressing to irreversible tooth decay before these lesions are detected. This article provides an overview of the effectiveness of unconventional and emerging methods for proximal caries detection. In vitro and in vivo studies identified through a Medline search using keywords, including methods for approximating caries, using fluorescence light and caries, and transillumination and caries, were reviewed in detail. Non-traditional methods known to be used for caries approximation and presented in this article include cone-beam computed tomography, fiber-optic transillumination, fiber-optic transillumination digital imaging, near-infrared digital imaging, optical coherence tomography, laser fluorescence, ultrasound, and LED reflection and refraction. The advantages of each caries diagnostic method are demonstrated.

The CAMBRA® Caries Risk Assessment System (CAMBRA®) was developed in California. The purpose of this article is to summarize the science behind the methodology, the history of CAMBRA's development, and the results of clinical application. The CAMBRA Caries Risk Assessment (CRA) tool has been used at the University of California, San Francisco (UCSF) for 14 years, and outcome studies have been conducted on thousands of patients from age 6 years to adulthood. Three outcome assessments, each conducted on different patient cohorts, demonstrated a clear association between CAMBRA-CRA risk levels of low, moderate, high, and extreme with cavitation or dentin lesion (as assessed by radiography) at follow-up. This validated risk prediction tool has been updated over time and is now routinely used at UCSF and other institutions worldwide as part of

normal clinical practice. The CAMBRA-CRA tool for children aged 0 to 5 years has demonstrated similar predictive validity and is in routine use. Adding chemotherapy (antibacterial plus fluoride) to a traditional restorative treatment plan based on caries risk status has been shown to reduce caries increment by approximately 20-38% in adult patients at high caries risk. Chemotherapy used for high-risk patients is a combination of daily antibacterial therapy (0.12% w/v chlorhexidine gluconate mouth rinse) and twice-daily use of a high-concentration fluoride toothpaste (5000 ppm F), both for home use. These outcome assessments provide evidence for the confident use of these CRA tools. Caries can be managed by adding chemotherapy based on the assessed caries risk level, in combination with the necessary restorative procedures. For high- and extreme-risk patients, a combination of antibacterial and fluoride therapy is necessary. Fluoride therapy should be supplemented with antibacterial therapy to reduce the bacterial burden, modify the biofilm, and ensure prevention rather than continued progression of caries. (Featherstone JDB Chaffee, B W. 2018)[74].

A study (Analoui et al. 2000) [52] was devoted to the comparison of sound reflectance spectra and carious enamel. The development of dental caries is associated with mineral loss and changes in the enamel structure. In this study, sound reflectance spectra and carious enamel were measured and compared to investigate its usefulness in the detection and analysis of dental caries. One hundred and twenty human enamel cores with a diameter of 3 mm, free of fluorosis, tetracycline stain, hypoplasia, fractures and restorations, were prepared. The enamel surfaces were then ground and polished. The specimens were placed on a suitable holder with black or white background, without fluorescence. The raw spectra were measured using a spectrophotometer with closed diffuse illumination. The spectra are measured from 380 to 780 nm at 5 nm intervals. All measurements were corrected to compensate for the illumination spectrum. The specimens were divided into two groups and exposed

to a demineralizing solution for 48 and 96 hours, respectively. The reflectance spectra of the specimens were measured after lesion induction. All specimens were separated and analyzed by transverse microradiography (TMR), where lesion depth and mineral loss (ΔZ) were measured. The dimensionality of the multispectral data was reduced by transforming them into L*a*b* color coordinates and principal component analysis (PCA). Multiple linear regression analysis showed a low correlation between L*a*b* and lesion depth and mineral loss. PCA analysis showed a higher correlation coefficient compared to L*a*b*. The preliminary results of this study suggest that multispectral measurements and tooth surface analysis may be useful in predicting the depth and severity of early carious lesions.[99,108]

A new study by a group of American scientists (Ajaj, M.-T., Al-Khateeb, S.N., Al-Batayneh, O.B. 2020) [49] presents the results of a study of the effect of acidic etchants at various low concentrations on the remineralization of white spot lesions (WSLs). WSLs were prepared on the buccal surface of 100 intact premolars using methylcellulose gel/lactic acid. The samples were then placed in a remineralizing solution in addition to fluoride application twice daily for 5 minutes. These changes were quantified weekly using a quantitative light-induced fluorescence (QLF) system. When changes in fluorescence luminescence approached zero, each specimen was etched with one of the following acids: 5% phosphoric acid, 10% phosphoric acid, 5% polyacrylic acid, or 10% polyacrylic acid for 15 seconds, rinsed, dried, and reinserted into the remineralizing solution. Two specimens were randomly selected from each group for transverse microradiography (TMR) and scanning electron microscopy (SEM). In summary, the 10% polyacrylic acid group showed the most significant improvement in fluorescence enhancement compared to the second phase of remineralization. It also showed partial loss of surface minerals without affecting enamel thickness, as did phosphoric acid. Furthermore, 10% polyacrylic acid creates the largest number and smallest pore size compared to phosphoric acid, thereby

enhancing remineralization more effectively than phosphoric acid without damaging the outer enamel layer. Clinical significance: The results of this study may improve WSL remineralization from the lower portion of the lesion instead of depositing it on the outermost layer of the lesion, leaving better enamel quality. 10% polyacrylic acid enhances remineralization more effectively than phosphoric acid without damaging the outer enamel layer.

Many dentists in clinical practice are well aware that diagnosis based on traditional methods can vary for the same tooth condition. To overcome this limitation, additional diagnostic tools are required. QLF technology is a viable method for detecting residual caries and is increasingly used to detect residual caries at the dentin level. A study by Korean researchers used Qraypen technology (AIOBIO, Seoul, Korea) to examine the usefulness of QLF technology in diagnosing controversial cases. Case 1: A 31-year-old man presented with pain in his left mandibular first molar. The existing restoration and severe dental caries were maximally removed using traditional visual and tactile senses. The treatment area was photographed with Qraypen. The authors concluded that endodontic treatment was preferable based on the Qraypen findings in combination with diagnostic information. Case 2: A 67-year-old man presented with discomfort in his right mandibular first molar. Most of the existing restoration and carious debris were removed. Black discoloration was observed around and within the crack line, but no red fluorescence was present. Based on the results of these studies, we concluded that a minimally invasive dentistry approach was appropriate. Therefore, the use of QLF technology is more objective and accurate than other methods for determining the end point of removal and identifying healthy marginal dentin for successful restoration (Lee, J.-W., Lee, E.-S., Kim, B.-I. 2019) [105].

Brazilian scientist Leal SC (2018) [99] provides an analysis of spubmed, Scopus, and Embase data sources from 2000 to 2016. The search strategy was developed to identify randomized clinical trials, cross-sectional studies, cohort studies, comparative studies, validation studies, and evaluation studies that tested standardized caries risk assessment (CRA) models. There were no restrictions regarding the age of the patients, but caries data had to be recorded using the decayed, missing, filled tooth/surface (DMFT/S) indices or the International Caries Detection and Assessment System (ICDAS). Data extraction and synthesis: Two authors independently assessed articles for inclusion, performed data extraction, and methodological quality of the articles using a customized quality assessment tool developed by the National Heart, Lung, and Blood Institute and the International Research Triangle Institute for Observational Cohort and Cross-sectional Studies. To compare between studies, caries values were organized into two tables, from which sensitivity, specificity, and 95% confidence intervals were calculated. A total of 1,239 articles were retrieved, of which 32 were included. The most frequently studied CRA model was the Karyogram. Sixteen studies were conducted on children and 12 on adults. The results showed a statistically significant relationship between the risk determined by the model and the actual caries status and development of new caries lesions. Regarding the quality of the studies included in the review, 19 were categorized as good quality, while eight and five were rated as fair and poor, respectively. Based on seven studies, the sensitivity of the Karyogram ranged from 41.0 to 75.0, and its specificity ranged from 65.8 to 88.0. The authors believe there is insufficient evidence to confirm that CRA models are effective in determining patients' actual caries risk or predicting their likelihood of developing new caries lesions. Furthermore, the validity of standardized CRA models remains limited.

## 1.2. International Caries Detection and Assessment System ICDAS-2 occlusal surface of teeth

Nowadays, modern dental treatment facilities have become significantly more extensive, and the resources of dental clinics have improved. However, a significant rate of caries complications is still observed after not always successful treatment. [Abduazimova L.A., Rizaev E.A. et al. 2018 [1]; Khalilov I.Kh., Khudanov B.O., Daminova Sh.B. 2017 [43]

The main factors influencing the development of dental caries, such as microorganisms, plaque, and carbohydrates, have long been proven. However, a late or incorrect diagnosis can also be a factor in the development of dental caries.

Chinese authors Sun P, Chen W, X Yi, Gao PP, Yang D M.(2018) [137] present the results of a study and comparison of the sensitivity of early childhood caries detection using the International Caries Detection and Assessment System (ICDAS)-II and WHO criteria. This study enrolled 449 three-year-old children from four kindergartens in Beijing. Both ICDAS-II and WHO criteria were used to estimate the prevalence of caries in these subjects. The decayed, missing, and filled teeth (dmft) index scores were calculated. In the ICDAS-II system, four cutoff points (D1, D2, D3, and D4) were used to distinguish between healthy and decayed teeth: D1 (score 0 as sound, score 1-6 as caries); D2 (0-1 sound, 2-6 caries); D3 (0-2 sounds, 3-6 caries) and D4 (0-3 sounds, 4-6 caries). SPSS software was used to analyze the data to determine the significance of differences. The prevalence of caries using ICDAS-II was 76.6% (344/449), 71.3% (320/449), 52.8% (237/449) and 46.1% (207/449) for D1-D4, respectively; the corresponding mean dmft values were $4.95 \pm 4.85$, $4.41 \pm 4.77$, $2.54 \pm 3.69$ and $1.97 \pm 3.10$. The sites with the highest caries prevalence were the occlusal surface of the mandibular molars in groups D1 and D2 and the proximal surface of the anterior maxillary teeth in groups D3 and D4. In contrast, the caries

prevalence was 48.8% (219/449) and the mean dmft was 2.27 ± 3.54 using the WHO criteria, which was significantly lower than the detection rates using the ICDAS-II (D1-D2) (P = 0.00). This suggests that the ICDAS-was system is a more sensitive method for detecting caries in young children. Thus, the ICDAS-might system may be better at detecting incipient caries and be of particular value in the prevention of caries in early childhood.

Baltacioglu Ismail Hakki, Orhan Kaan (2017) [56] The authors note that although many studies have used digital intraoral imaging, only a few studies have used photooptical methods for caries diagnosis. Moreover, there are a number of limitations in terms of observers (experience and specialty) and the caries lesion itself. Therefore, the aim of this study was to evaluate the diagnostic capabilities of near-infrared light (NILT) and PSP-Bitewing radiographs and to compare interobserver and interobserver differences in addition to the observers' experience level for the detection of early interproximal caries lesions in vivo. A total of 52 untreated posterior teeth with and without early interproximal carious lesions were included in the study. Radiographs using digital phosphor plates (PSP-Bitewing) and NILT were used to clarify the diagnosis. An oral and maxillofacial radiologist and a consultant in restorative dentistry evaluated the images twice. A separate assignment was made for clinical validation and restoration. Kappa coefficients were calculated to assess both intra- and inter-observer agreements for each assessment method. The results obtained from the PSP-Bitewing and NILT were compared with clinical validation using receiver operating characteristic (ROC) analysis. No significant differences were found between PSP-Bitewing and NILT radiography for detecting early interproximal carious lesions with high mean Az values. Both intra- and inter-observer agreements were relatively higher for the NILT assessment. Az values increased with repeated assessments for both caries detection methods. The authors concluded that the NILT examination has adequate sensitivity and diagnostic accuracy for detecting early

interproximal caries lesions and can be considered the method of choice for caries detection without the use of ionizing radiation.

American scientists (Fontana, M., Platt, JA, Eckert, 2014) [76] in their article consider the possibility of the ICDAS system as a control in predicting the need for caries treatment using a sealant. This study assessed the detection and monitoring of carious lesions using a transparent sealant for 44 months. Sixty-four children aged 7 to 10 years with at least 2 permanent molars with an International Caries Detection and Assessment System (ICDAS) score of 0-4 (and caries of less than half of the dentin, radiographically) were examined using ICDAS, DIAGNOdent and quantitative light-induced fluorescence (QLF) before sealant placement and 1, 12, 24 and 44 months (except QLF) after it. Focal radiographs were taken annually. DIAGNOdent and QLF were able to distinguish between the initial ICDAS before and after sealant placement. There was no significant evidence of ICD progression at 12 months, but there was little evidence of a slight increase at 24 and 44 months (14% and 14%, respectively), with only 2% ICD ≥ 5. In addition, there was little evidence of radiographic progression (at 12 months = 1%, 24 months = 3%, and 44 months = 9%). Sealant retention rates were excellent at 12 months = 89%, 24 months = 78%, and 44 months = 70%. The small risk of sealant repair increased significantly with increasing baseline ICDAS, DIAGNOdent, and QLF scores. However, regardless of lesion severity, sealants were 100% effective at 12 months and 98% effective at 44 months when treating occlusal surfaces with ICDAS 0-4 (i.e., only 4 of 228 teeth progressed to ICDAS ≥ 5 associated with sealants requiring repair and did not penetrate half or more of the dentin radiographically). This study suggests that occlusal surfaces without frank cavitation (ICDAS 0-4) sealed with a clear sealant can be monitored using ICDAS, QLF, or DIAGNOdent, which may help in predicting the need for caries treatment using a sealant.

Another group of authors present a paper conducted under the auspices of the European Academy of Paediatric Dentistry. The aim of the study was to compare the effects of a fluoride denture alone, topical CPP-ACP cream used as a denture, and a combination of both agents (fluoride denture followed by CPP-ACP cream) on early carious lesions (ECL) in primary anterior teeth of children over a 6-month period. In this single-blind, randomized clinical trial, children (n = 114, aged 4-5 years) at high risk for developing caries and having at least one ECL (ICD-2) on primary anterior teeth were divided into three groups. Subjects used different products twice daily: fluoride toothpaste (500 ppm F, n = 42), CPP–ACP cream (10% w/v, n = 35), and fluoride toothpaste followed by CPP–ACP cream (n = 37). Changes in lesions were monitored using QLF, comparing baseline to 3 and 6 months of treatment. Results: Changes in QLF consistent with an increase in minerals (ΔF/fluorescence, lesion area) occurred in all three groups (baseline vs 3 months or 6 months, $P \leq 0.05$ for all three groups). Differences between treatment groups were not statistically significant ($P > 0.05$). The study found that topical CPP-ACP cream used alone produced effects similar to fluoride toothpaste; However, the combination of the two drugs did not provide additive benefits compared with either agent used alone.

In another study by representatives of the European Academy of Paediatric Dentistry Jaisingh, R., Shanbhog, R., Nandlal, B., Thippeswamy, M. (2017) [86] the objective was to evaluate the effect of 10% cerium chloride intervention on pre-demineralized human enamel subjected to de- and remineralization cycles. This was an in vitro comparative study of 60 human enamel specimens, which were divided into control and test groups. The specimens were then subjected to a demineralization cycle followed by intervention with the respective treatment solutions (control group: placebo solution; test: 10% cerium chloride) for 30 C under constant stirring, and then to a 2nd demineralization cycle followed by remineralization using artificial saliva. After the first and second demineralization cycles (days 4 and 8) and the

remineralization cycle (day 22), the samples were assessed for fluorescence using a quantitative light-induced fluorescence chamber. The data obtained were analyzed using a paired t-test and ANOVA. Results: When comparing the fluorescence values and the mean difference in lesion area between the first demineralization cycle and the remineralization cycle and the second demineralization cycle and the remineralization cycle, a statistically significant decrease in the loss of fluorescence values and lesion area was found in the control group compared to the control group ($P < 0.001$). Comparison of the mean fluorescence values and lesion area between the de- and remineralization cycles for the control and control groups (between-group comparison) showed a statistically significant difference ($P < 0.001$). Conclusions: Only cerium chloride reduces demineralization and improves remineralization of artificial caries lesions in human enamel during pH cycling in vitro.

Muller-Bolla, M., Joseph, C., Pisapia, M. (2017) [120] in their work evaluate the validity and reliability of the newest light-fluorescence device Soprolife® (Sopro-Acteon group) in the detection of occlusal caries in children and adolescents and compare its diagnostic performance with DIAGNOPen® (Kavo). Methods: A multicenter validation study of Soprolife® was conducted in 103 children aged 5 to 15 years on 310 primary and 433 permanent posterior teeth. Sensitivity (SE), specificity (SP) and area under the receiver operating characteristic (ROC) curve (AUC) were assessed using the visual International Caries Detection and Assessment System (ICDAS) and radiographic studies as gold standards. The performance of Soprolife® was compared with the performance of DIAGNOPen® on the same teeth. Reproducibility was assessed using the weighted kappa coefficient. Results: When considering all carious lesions using ICD 1-6, the SE, SP, and AUC for Soprolife® were 88.50, 70.73, and 0.84, respectively. Validity was significantly higher for primary teeth (AUC = 0.90) than for permanent teeth (0.80); the validity of Soprolife® (0.84) was significantly higher than that of DIAGNOPen® (0.80). The

inter- and intra-examiner kappa coefficients were 0.87 and 0.85, respectively. Thus, the authors conclude that Soprolife® was a valid instrument providing reproducible results, especially for primary teeth.

Minimally invasive therapy is becoming increasingly important in dentistry. In minimally invasive dentistry, only infected dentin is removed, while the diseased dentin is left in preparation for cavity restoration. Healthy enamel and dentin have special fluorescent properties compared to demineralized dental tissues, which absorb less light and thus have a lower level of fluorescence. This helps clinicians detect caries and apply the most appropriate treatment strategy during oral cavity preparation. A study by Erol, S., Kamak, H., Erten, H. (2014) [73] examined the effectiveness of the SoproLife camera system, which is a new light-induced fluorescence camera system.

The modern concept of minimally invasive dentistry includes the early detection and treatment of incipient carious lesions. Due to the low sensitivity of visual inspection and radiography in detecting occlusal carious lesions hidden beneath a macroscopically sonic surface, several devices have been developed to improve detection accuracy. DIAGNOdent is one instrument used for this purpose, and VistaProof is a new device recently introduced to the market. Both use light-based fluorescence to detect incipient carious lesions. The diagnosis is based on the fact that carious lesions exhibit a higher level of fluorescence than sonic tissue when excited by light at a specific wavelength. Vistaproof is based on the same principle, but it uses a different excitation wavelength than DIAGNOdent and a video camera to detect fluorescence. The aim of the authors of the article from the Nippon Dental University Society was to compare these two devices and present their clinical application (Betrisey, E., Rizcalla, N., Krejci, I., Ardu, S.2014) [58]

### 1.3. Assessment of the occlusal surface of teeth according to the QLF assessment system

A digital fiber-optic transillumination method for detecting caries (DiagnoCam, KaVo) enables visualization of initial carious lesions, secondary caries, approximal caries, and cracks in the tooth enamel surface on a monitor screen in real time. Software displays the results on a computer monitor, allowing the patient to clearly see the location, area, and severity of the carious lesion. However, the image is captured in black and white and cannot detect subgingival caries. The light emission method, represented by a quantitative light-induced fluorescence (QLF) device, utilizes the natural fluorescence of dental hard tissues, which decreases with demineralization. The device allows for the early diagnosis of carious lesions by detecting fluorescence loss in areas of demineralization and identifying the location, area, depth, and severity of the carious process, as well as the presence of plaque. The method produces a color image displayed in real time on a monitor, clearly demonstrating the patient's oral health. Furthermore, the software calculates the lesion area, degree of demineralization, and depth, allowing for a visual assessment of the success of remineralization over time.

Fluorescence is a result of a process that occurs under certain conditions in molecules known as fluorophores, fluorochromes, or fluorescent dyes when they absorb light. The molecule is excited to a higher energy state and emits fluorescent light. The emission wavelength is always higher than the excitation wavelength. Optical diagnoses using fluorescence can be used in medicine and dentistry. It is tissue-safe and noninvasive, and it can add value to clinical treatments. The aim of this study was to use an optical fluorescence system for wide-field imaging and visual monitoring of plaque and calculus before and after periodontal scaling to improve the diagnosis and monitoring of patients with periodontal disease. The results indicate

that the fluorescence system can detect residual plaque and calculus that are difficult to detect with the naked eye during oral examination. Thus, the optical method has the potential to improve periodontal screening efforts, especially in patients undergoing periodontal care (Sivieri-Araujo, G., Fontana, CR, Costa, MM 2014) [134]

In their study, Ukrainian scientists analyze literature data on dental caries diagnostic criteria and the use of individual indices and systems. Clinical observations indicate that the ICDAS and SIC indices are designed to identify caries risk groups and evaluate oral hygiene. Pitts NB and Eksrand K. [72] proposed taking into account the depth of enamel and dentin damage during clinical visual assessment of a carious defect. The ICDAS II index makes it possible to determine the stage and depth of the carious process, from initial carious changes in enamel (in the form of spots) to an obvious cavity in the dentin of the teeth. To assess the epidemiological situation, monitor and evaluate the effectiveness of preventive measures, it is advisable to use the ICDAS II and SIC indices together with the ICDAS index. (Smolyar N.I. Smolyar, Chukhrai N.L. 2016) [39].

Scientists at the Indiana University School of Dentistry (Kim, B.-R., Kang, S.-M., De Josselin De Jong. 2019) [90] present an in vitro study to examine the utility of comparing red fluorescence between active and inactive caries lesions, and whether changes in red fluorescence and fluorescence loss influence lesion activity after remineralization. Sixty-two non-cavitated smooth surface caries lesions on extracted human teeth were classified as active or inactive lesions using the Nyvad system prior to a 12-day pH cycling procedure. Quantitative light-induced fluorescence digital images were used to measure fluorescence parameters before and after pH cycling. At baseline, the intensity (DR) and area (ADR) of red fluorescence were 1.5 and 2.2 times higher in active lesions than in inactive lesions (p 0.05). The ratio of ADR to lesion area was associated with the classification of active lesions (odds ratio = 1.031;

95% confidence interval = 1.005-1.058). After pH cycling, active lesions showed approximately 2- and 8-fold greater decreases in median ADR values and fluorescence loss related to lesion volume (DQ) compared with inactive lesions (P 0.05). Thus, red fluorescence varies according to lesion activity, and red fluorescence area and lesion volume change after remineralization. These results suggest that red fluorescence measurement may be a useful way to objectively assess lesion activity in smooth superficial lesions.

### 1.4. Efficiency of different light-based fluorescence systems for predicting dental caries

Mortensen Diana, Hessing-Olsen Ilse. (2018) [119] present a study that evaluates the clinical performance of impedance spectroscopy, laser fluorescence and radiographs in detecting occlusal caries and compares them using a scoring system.

A total of 62 patients were recruited for the study, and one occlusal surface was selected by two examiners using the ICDAS visual scoring system, CarieScan PRO (ACIS), DIAGNOdent pen (LF-pen), and radiographs. The procedures were repeated over 1-4 weeks. Diagnostic performance was expressed as sensitivity, specificity, predictive values, accuracy, and diagnostic odds ratio (DOR) using the ICD as the gold standard. Intra- and inter-examiner reproducibility was assessed using intraclass correlation coefficients (ICC) for numerical results and kappa values for categorical data. Five patients withdrew from the study. A total of 54% of the teeth had early or absent lesions (ICD 0 to 2), while 46% had moderate or extensive lesions (ICD 3 to 5). The Spearman correlation coefficients were 0.65, 0.60, and 0.71 for the ICDAS versus ACIS, ACIP-pen, and bitewing radiographs, respectively. ACIS demonstrated high specificity and positive predictive values but low sensitivity, while the LF-pen had moderate sensitivity and high specificity. Accuracy and Dor were highest for radiographs. ICC values ranged between 0.65 and 0.88 for ACIS and 0.89 and 0.94

for the LF-pen. Weighted kappa values ranged from 0.81 to 0.91 for ICDAS and 0.90-0.92 for radiographs. The researchers concluded that all three methods were useful for detecting occlusal caries, but radiography performed better than visual scoring. ACIS demonstrated the highest specificity and positive predictive value, but sensitivity was low, and clinical management was less convenient. Therefore, further clinical studies are needed to evaluate the long-term impact of early caries detection on dental health.

(Luczaj-Cepowicz Elzbieta, Marczuk-Kolada Grazyna 2019) [109] The aim of the present study is to evaluate the extent of early carious lesions using the (ICDAS) II system and DIAGNOdent pen in comparison with microsurgical examination. Forty-eight molars and premolars were qualified for the study. Visual and diagnostic examinations of the pen device were performed by two experts. The actual extent of the lesions was determined using a micro-CT examination. The optimal value of the cut-off criterion was determined using the Youden index. Inter- and intra-experimental reproducibility was calculated for the two methods using the intraclass correlation coefficient. Sensitivity, specificity, and accuracy of these methods were compared using the McNemar mid-P test. The significance level was set at $P < 0.05$. For the enamel threshold, the ICDAS II scale showed slightly higher average assessed parameters compared to the DIAGNOdent pen. For the dentin threshold, all assessed parameters had higher average values on the ICDAS II scale compared to the DIAGNOdent pen. The optimal cutoff points for the enamel and dentin thresholds are lower than those suggested by the manufacturer. The ICDAS II and the DIAGNOdent pen demonstrated high inter- and intraobservatory reproducibility of test results. To improve the diagnostic efficiency of the DIAGNOdent pen, consideration should be given to modifying the cutoff values recommended by the manufacturers. After modifying the cutoff values, the combination of the ICDAS II and DIAGNOdent pen device will be the best choice for detecting caries on occlusal surfaces.

A new study by Marczuk-Kolada G, Luczaj-Cepowicz E, Obidzinska M, Rozycki J. (2020) [111] presents the results of an ex vivo comparative performance study of the ICDAS II visual scale and two fluorescence methods (DIAGNOdent Pen and VistaCam iX) in detecting occlusal carious lesions in permanent teeth using cone beam computed tomography (CBT) as a reference test. One hundred and sixty molars and premolars were selected for the study. Visual diagnostic examinations of the Pen and VistaCam iX were performed by two experts. The actual extent of the lesion was determined using CBT. Inter- and intra-experimental reproducibility was calculated for the three methods using the intraclass correlation coefficient. The sensitivity, specificity, and accuracy of these methods were compared using the McNemar mid-P test. The significance level was set at $P < 0.05$. The study showed that the intraclass correlation coefficients (ICC) for intra- and inter-rater reproducibility were high for all data. For the enamel threshold, sensitivity and accuracy were significantly higher for VistaCam iX and ICDAS II compared to DIAGNOdent Pen ($P < 0.05$). The results obtained with the DIAGNOdent pen showed significantly higher specificity values for the enamel threshold ($P < 0.05$). The results obtained with VistaCam iX showed the lowest sensitivity, but significantly higher specificity and accuracy for the dentin threshold ($P < 0.05$). ICDAS II is an effective method for detecting early carious lesions, characterized by higher sensitivity compared to devices using fluorescence. To improve the diagnostic efficiency of the evaluated devices, the possibility of changing the cutoff values recommended by the manufacturers should be considered.

Zandoná A Ferreira, Ando M, Gomez G F. (2013) [150] show that previous caries treatment experience correlates with future caries risk; thus, early detection of lesions is important for risk assessment and management. In their study, the authors aimed to determine whether quantitative parameters of light-induced fluorescence (QLF)—area (A [mm(2)], fluorescence loss (F [% ]), and Q [% × mm(2)]—obtained

using image analysis could predict lesion progression. The researchers obtained consent from 565 children (aged 5 to 13 years) and their parents/guardians and examined them at baseline and at regular intervals for 48 months according to the International Caries Detection Scoring System (ICDAS), annual radiographs, and QLF. QLF images from surfaces with ICDAS 0/1/2/3/4 at baseline that progressed (N = 2,191) to cavitation (ICDAS 5/6) or fillings and surfaces that did not progress to cavitation/fillings (N = 4,141) were analyzed Independently for A, F, and Q. Linear mixed-effects models were used to compare means and slopes (changes over time) between surfaces that progressed and those that did not. QLF A, F, and Q increased more rapidly for surfaces that progressed than for surfaces that did not progress ($p = .0001$), regardless of the type of surface or baseline ICDAS score. The AUC for ICDAS ranged from 0.65 to 0.80, but adding information on QLF improved the AUC (0.82–0.87, $p < .0005$). The researchers concluded that more rapid changes in QLF variables may indicate lesion progression toward cavitation and be more clinically significant than actual QLF values.

Barbería Elena, Maroto Myriam (2008) [57] conducted an in vivo study to compare a laser fluorescence system with a visual system for the diagnosis of occlusal caries in children with primary and permanent molars. The authors selected 320 untreated, non-cavated primary and permanent molars from healthy children aged 6 to 14 years for evaluation. Two authors performed the laser fluorescence evaluation. Another author completed the clinical evaluation. The kappa value was 0.68. The authors compared the sensitivity, specificity, predictive values, odds ratio, and receiver operating characteristic (ROC) curves for the laser fluorescence system. For the entire sample, the sensitivity and specificity of the laser fluorescence system were 0.79 and 0.87, respectively. The positive to negative odds ratio for the entire sample was 6.33 and 0.23. The positive and negative predictive values for the entire sample were 33.9% and 98.1%, respectively. The area under the receiver operating

characteristic (ROC) curve (AUC) was 0.92 for the entire sample. The laser fluorescence system was more accurate than visual assessment in identifying non-cavity lesions and healthy surfaces in primary and permanent molars. Clinical implications: In daily practice, dentists can consider the laser fluorescence system as an additional tool for visually examining the occlusal surfaces of primary and permanent molars. Using the latest diagnostic equipment will allow practitioners to fundamentally change their approach to caries treatment without preparation and filling, preserving the natural hard tissue of the tooth.

**Conclusion of the literature review**

Thus, this literature review presents data from scientists worldwide assessing the effectiveness of quantitative light fluorescence technologies for predicting the risk of dental caries. Light fluorescence significantly improves diagnostic quality and allows for a more precise definition of the boundaries of non-invasive therapy. Quantitative light fluorescence is a modern method for diagnosing dental caries. This method can be considered minimally invasive and complements previously proposed methods.

# CHAPTER 2. RESEARCH MATERIAL AND METHODS

## 2.1. Clinical characteristics of the examined patients

The data for this clinical study were collected at the Tashkent State Dental Institute, Uzbekistan. Potential participants are patients who visited the Department of Dental Diseases Prevention of the Tashkent State Dental Institute from September 2020 to May 2021. All patients were given an explanation of the objectives and procedures of this clinical study. The study included those who subsequently gave written consent to participate and were in good general health.

The study examined 305 patients aged 15-35 years who visited the Department of Prevention of Dental Diseases of the Tashkent State Dental Institute. Patients with systemic diseases, patients undergoing orthodontic treatment, suffering from VNCHD disorder, severe periodontitis, symptoms of bleeding on the oral mucosa and pregnant women were excluded.

Restored teeth that included a sealant or filling in the occlusal surface, teeth with hypoplasia or fluorosis and teeth with other characteristics that could affect the results of the study were excluded on the basis of visual inspection. To conduct this study, the occlusal surface of the selected molars will be divided into 3 sections: distal, central, mesial. The distal section includes the distal pit, the central section includes the central pit, and the mesial section includes the mesial pit. Each section is evaluated separately according to different evaluation systems.

## 2.2. Research methods

### 2.2.1. Evaluation and analysis of biofilm from QLF images from the occlusive surface of the tooth.

Quantitative light fluorescence (QLF) technology is an additional method that can detect the smallest changes in teeth based on tooth autofluorescence that occurs when irradiated with visible blue light. These technologies allow dentists to identify the plade and assess its degree of cariogenicity. In this method, the tooth is irradiated with a pulsed stream of harmless blue light, the wavelength of which is 405±7 nm. On these rays of blue light, dental plaques show red fluorescence [53,84]. This optical phenomenon can be explained by endogenous fluorescent porphyrin, such as protoporphyrin IX as the main component, produced by some microorganisms of the oral cavity, which have a strong fluorescence in the red region of the spectrum when excited by violet light in the range of 400 to 420 nm [73,104]. Quantitative light-induced fluorescence (QLF) technology based on this optical

phenomenon is used to detect and quantify bacterial deposits and lesions associated with bacteria using blue and white LEDs and a modified filter set [57].

For the study, you can choose the QrayPen device from the QLF series. (Fig.2.1). Before the examination, QLF images of the occlusive surface of the molars were made using a QrayPen device in a darkened room under the same lighting conditions to maximize the quality of the obtained QLF images. Normal white-light images and successive fluorescence images were obtained to analyze the plaque.

Before shooting, the occlusal surfaces were sufficiently dried (5 seconds) with an air flow. W-blocks (Aio Bio, South Korea) were used to maintain the same angle of the images.Q-Ray version 1.45 was used to analyze the occlusal plaque. (Inspektor Research Systems BV, The Netherlands).

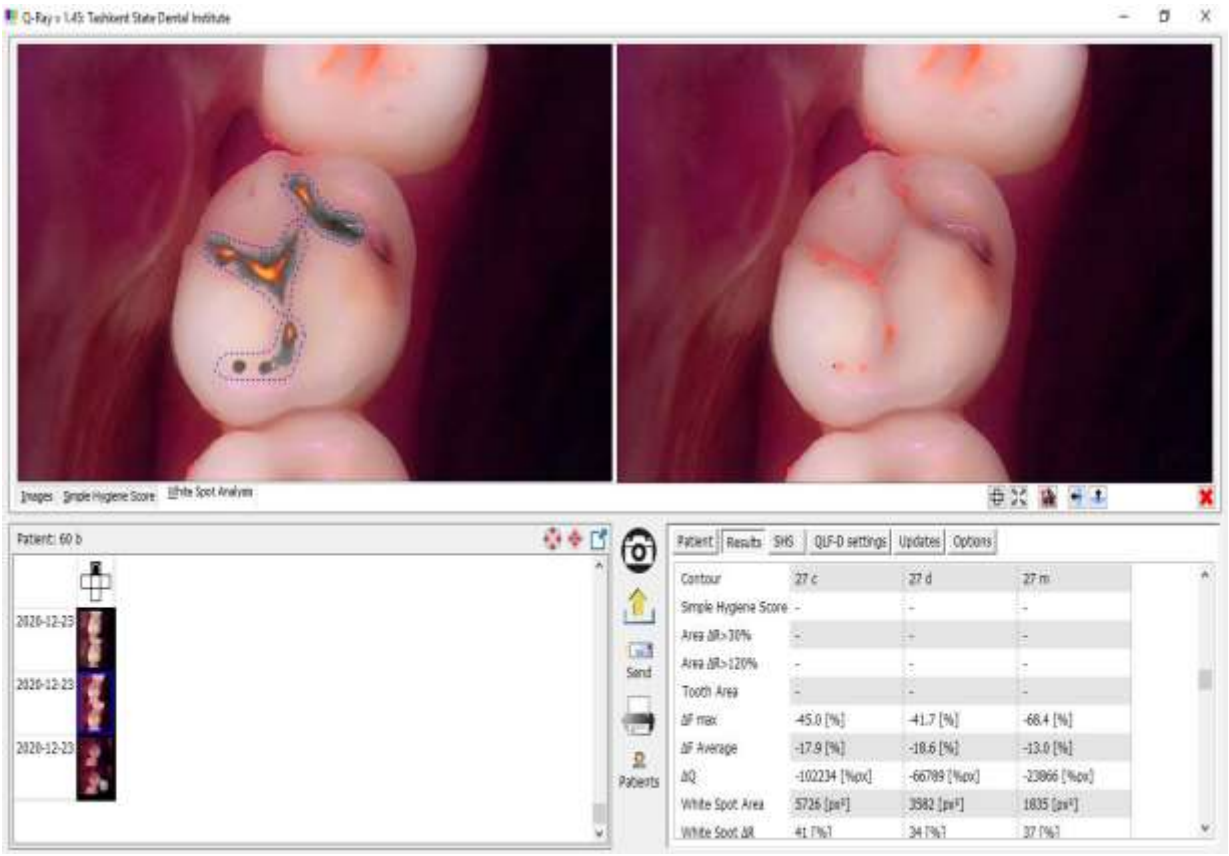



Fig. 2.2. Analysis of occlusal plaque with Q-Ray version 1.45.

According to QLF images, each pit was evaluated before and after cleaning the occlusal plaque. The result was determined by combing from the images before and after the removal of the ΔR plaque of the indicator that shows bacterial activity in the change in red fluorescence. (Figure 2.2)

### 2.2.2. Evaluation of the occlusive surface of teeth according to the International Caries Detection and Assessment System (ICDAS 2- International Caries Detection and Assessment System)

The scores obtained were classified according to three levels of risk groups according to the following arbitrary criteria: low risk, score 0-40 ($5.4 < pH \leq 7.0$); medium risk, 41-70 points (4. $4 < pH \leq 5.4$); and high risk, 71-100 points ($3.0 \leq pH \leq 4.4$). (Fig. 2.8)

In this system, the occlusal surface of chewing teeth is estimated using codes.

Codes and criteria for assessing the classification of carious status based on the ICDAS-2 system.

Healthy tooth surface: Code 0

There should be no signs of caries (no or doubtful change in the transparency of the enamel after prolonged air drying (recommended drying time is 5 s). Surfaces with developmental defects such as enamel hypoplasia, fluorosis, tooth abrasion (abrasion, abrasion and erosion) and external or internal stains will be registered as healthy. The researcher should also evaluate as a healthy surface with multiple colored cracks, if such a condition is observed in other pits and fissures, a condition that is consistent with non-carious habits (for example, frequent tea drinking).

The first visual change of enamel: Code 1

Code 1: Pits and fissures

When examined in a wet state, there are no signs of any color change associated with carious activity, but after prolonged air drying (for adequate dehydration of carious

enamel damage, about 5 s is offered) carious turbidity or discoloration (white or brown lesion) is visible. which is not consistent with the clinical manifestations of healthy enamel or when there is a color change due to caries, which does not correspond to the clinical appearance of healthy enamel and is limited to the limits of the pit and fissure area (wet or dry). The appearance of these carious areas does not correspond to the colored pits and cracks, as defined in code 0.

Code 1: Smooth tooth surfaces

When examined in the wet state, there are no signs of any color change associated with carious activity, but after prolonged drying, carious clouding (white or brown lesion) is visible in the air, which does not correspond to the clinical appearance of healthy enamel. This will be visible from the cheek or lingual surface.

Distinct visual change of enamel: Code 2

Зуб должен выглядеть влажным. Во влажном состоянии наблюдается кариозное помутнение (белое пятно) или коричневое кариозное изменение цвета, которое шире, чем естественная фиссура/ямка, что не соответствует клиническому виду здоровой эмали (Примечание: поражение должно все еще будет видно, когда высохнет) Distinct visual change of enamel: Code 2

The tooth should look wet. In the wet state, there is a carious clouding (white spot) or a brown carious discoloration that is wider than the natural fissure/pit, which does not correspond to the clinical type of healthy enamel (Note: the lesion should still be visible when it dries)

Local destruction of enamel due to caries without visible dentin or underlying shadow: code 3

A tooth visible wet may have a clear carious opacity (white spot) or a brown carious discoloration that is wider than a natural fissure/pit, which does not correspond to the clinical appearance of healthy enamel. After drying for about 5 s, carious loss of tooth tissues is observed at the entrance or inside the pit or fissure/pit. Visually, this will be visible as evidence of demineralization (opaque white, brown or dark brown walls).

Dark shadow from dentin with or without destruction of enamel: code 4

The shadow should clearly reflect the caries that began on the surface of the assessed tooth. If, according to the researcher, the carious lesion began on the adjacent surface and there are no signs of caries on the assessed surface, the surface should be encoded "0".

Distinct cavity with visible dentin: Code 5

Cavitation in an opaque or discolored enamel, exposing the dentin under it. A tooth visible wet may have a darkening of the dentin, visible through the enamel. After drying for 5 s, there are visual signs of loss of tooth structure at the entrance or inside the pit or fissure - clear cavitation. There are visual signs of demineralization (opaque white, brown or dark brown walls) at the entrance to the pit or fissure or inside them, and, according to the expert, the dentin is exposed.

Extensive distinct cavity with visible dentin: Code 6

Clear loss of tooth structure, the cavity is both deep and wide, dentin is clearly visible on the walls and at the base. A vast cavity occupies at least half of the tooth surface or possibly reaches the pulp.

The state of teeth (teeth) or surfaces (surfaces) is recorded with t/s codes.

Evaluation of all tooth surfaces with code 0 (ICDAS = 0) corresponds to an intact tooth. Codes 1,2,3 characterize carious damage to the teeth of the surfaces within the enamel. Codes 4,5,6 characterize carious damage to the teeth of the surfaces within the enamel and dentin, which is expressed by the index 4-6.

### 2.2.3. Evaluation of the occlusal surface of teeth according to the QLF evaluation system (QLF Scoring- QS- occlusal)

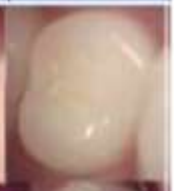
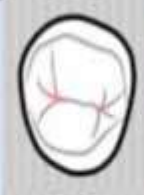
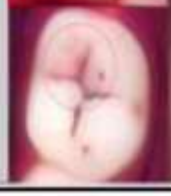
The QS-occlusal assessment system is based on an intuitive classification that uses two fluorescence parameters (fluorescence loss and red fluorescence) to assess the severity of caries. To assess the occlusal surface of the teeth according to the QLF evaluation system, you will need one of the devices based on quantitative light fluorescence (QLF). To determine the status of caries in budget clinics or institutions, you can use the QrayView device. (Fig. 2.9). And for scientific research, you can use other devices from the QLF range such as QrayPen, QrayCam or QrayCamPro, which allow you to take QLF images for further study of the clinical situation.

**Fig 2.9. QrayView device from the QLF series. (Aio Bio, South Korea)**

In this method, the studied tooth is irradiated with a harmless stream of blue light with a wavelength of 407 nm. And the tissues of the tooth in response are fluorescated in accordance with the severity of the lesion. During visual inspection with the help of special glasses, the fluorescence included in the kit in the foci of demineralization or intra-tissue bacterial activity decreases and looks red light. In healthy areas, the light of the tissue does not change.

Table 2.2.

Codes and criteria of the QS-occlusal evaluation system

| Код | Описание | Определения | Схема | Флюоресценция | Обычный свет |
|---|---|---|---|---|---|
| 0 | Здоровый зуб | Нет потери флюоросценции и нет усиления красной флуоресценции в ямках и/или фиссурах |  |  |  |
| 1 | Подозреваемый или начальный кариес | потеря флуоресценции и красная флуоресценция в виде линий или пятен в ямках и/или фиссурах |  |  |  |
| 2 | Кариес эмали | потеря флуоресценции и красное флуоресцентное свечение, распространяющееся вокруг ямок и фиссур |  |  |  |
| 3 | Кариес дентина | красное флуоресцентное свечение, распространяющееся вокруг ямок и фиссур и наличие темной тени от дентина |  |  |  |

As shown in Table 2.2, due to the severity of the lesion, QS-occlusal codes increase QS- = 1, the lesion spread to the outer half of the enamel along the pit or fissure and spread from side to side along the direction of progression of occlusal caries, which simultaneously spread to the inner half of the enamel for QS = 2. for which QS =3 progressed to dentin. The advantage of this method is the determination of caries activity to choose the appropriate treatment protocol and a simpler and more convenient assessment scale.

### 2.2.4. Evaluation and analysis of carious lesions from QLF images from the occlusal surface of the tooth.

Newly developed technologies based on quantitative light-induced fluorescence (QLF) create high-resolution images using a digital SLR camera. On QLF images, healthy teeth look the same as in the original images obtained using a double filter. And in the foci of demineralization or intra-tissue bacterial activity, fluorescence decreases and looks red. This is more useful for detecting lesions, since the change in fluorescence is more pronounced in the presence of demineralization of teeth or caries of surfaces [9,10]. In addition, it is possible to obtain an image in white light simultaneously with a fluorescent image, which eliminates problems associated with anatomical structures when assessing occlusal caries using only fluorescent images. In particular, the QLF image can be used to assess the severity of dental caries by detecting the red fluorescence of porphyrin, which is produced by oral bacteria and penetrates the tooth surface, as well as the structures of oral bacteria, such as plaque and tartar. [11–13]. Moreover, carious lesions can be easily detected in the QLF image, representing not only the loss of fluorescence, which is associated with changes in the usual mineral content [14], but also the metabolic activity of bacteria based on the increase in red fluorescence [15].

In addition, it is possible to objectively quantify the condition of the lesion using various QLF quantitative parameters calculated using the included software to track the smallest changes to ensure that the preventive measures used correspond to the

status of the lesion and the treatment methods are effective. [16–18]. (Fig. 2.10)

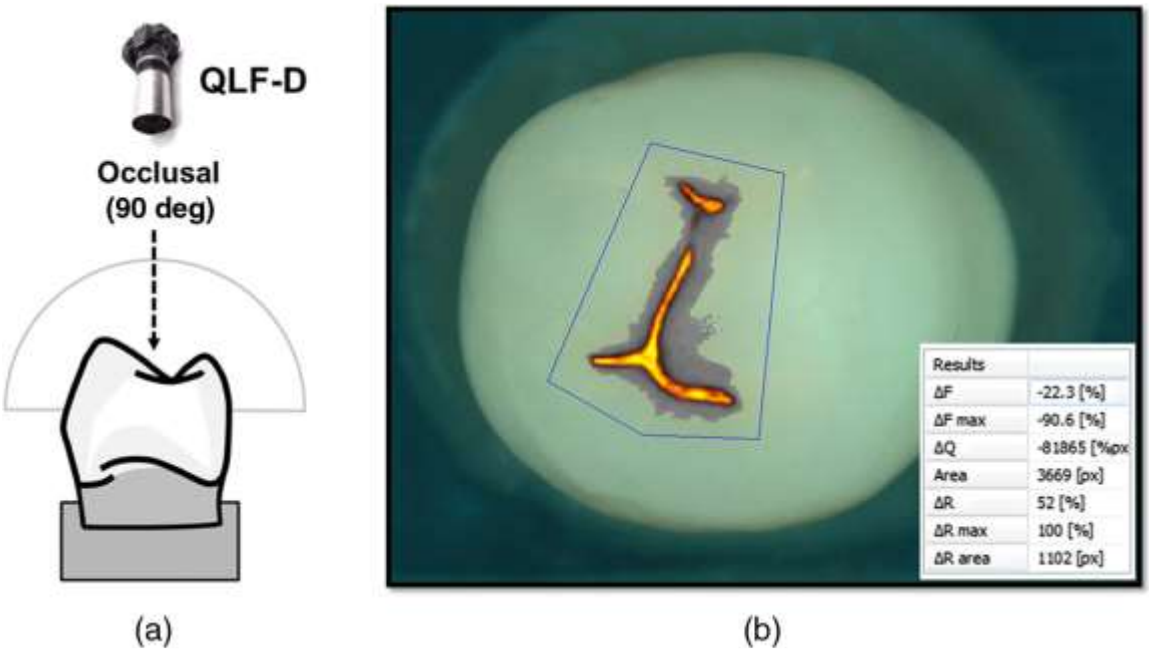



**Figure 2.10. a) Schematic view of image removal, b) QLF image with parameters**

**Significant differences in the parameters of red fluorescence are clearly useful for distinguishing processes in dental tissues with high reliability in relation to occlusal caries.**

Quantitative parameters of QLF images:

ΔF-average loss of fluorescence,

ΔFmax-maximum loss of fluorescence

ΔQ-volume of the lesion,

ΔR-change in the ratio of red and green fluorescence,

ΔRmax - the maximum change in the ratio of red and green fluorescence

ΔRarea- area change in the ratio of red and green fluorescence.

### 2.2.5. . Evaluation of bite radiography Bitewing

After obtaining QLF images, bite X-rays of the same tooth were taken. Standard bite X-rays were taken using the MINIX-S dental X-ray portable model system (DIGIMED Co., Ltd. South Korea) and intra-ord digital sensor DVS-200 (DIGIMED Co., Ltd. South Korea) (Fig. 2.11). The digital intraoral sensor on the lingual side of the tooth and the X-ray machine worked at 60 kV and 2 mA with an average exposure time of 0.63 seconds. Images were simultaneously viewed on the monitor using the appropriate image software (rainbow TM Image Viewer Twain, Dentium Co., Ltd. South Korea.). As previously reported, the assessment was calculated on the basis of the following criteria [24,25,124]. The X-ray score was calculated on the basis of bite images.

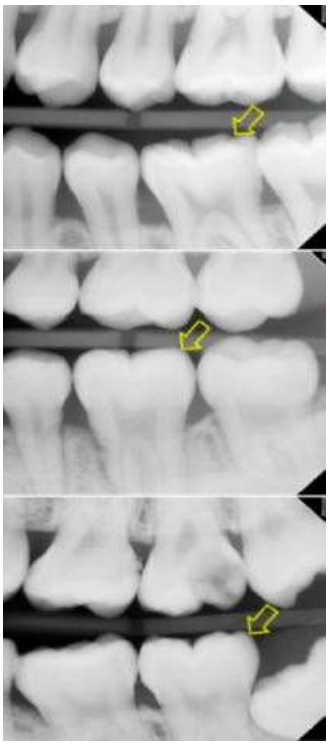



**Figure 2.2.5 Taking an image of Bitewing bite radiography (left) and sample images (right).**

Evaluation of bite images and QLF was carried out by one specialist. To prevent QLF and bite images from afflicting the assessment, each evaluation sheet was prepared separately, and bite and QLF images of the same patient on the same day were not evaluated simultaneously. The criteria were applied conservatively, as lower scores were applied to lesions that were difficult to distinguish (Table 2.2.5).

**Table 2.2.5.**

**Bitewing bite radiography definitions**

| Degree | Criterion |
|---|---|
| **0** | X-ray transparency is not visible |
| **1** | Initial X-ray transparency is visible in the enamel |
| **2** | X-ray transparency in dentin, but limited to the outer 1/3 of the dentin |
| **3** | Expansion of X-ray transparency to the middle of 1/3 of dentin |

## 2.3 Statistical processing of the obtained data

The results of the study were processed using IBM SPSS 20 statistical analysis software. Determined the frequency of signs (%), the arithmetic mean number (M), the mean square deviation and the mean arithmetic error (m). The reliability of the differences in the studied data was assessed using the Student criterion (t) and variance analysis (ANOVA), as well as the correlation coefficient. The differences were considered significant at $p<0.05$.

Occlusive biofilm was first studied as the only determinant of the outcome of caries in two-dimensional analysis. At the level of the anatomical region, the assessment of occlusal plaque and the outcomes of caries were determined on the same site of each molar. Risk factors (RR) and 95% confidence interval (CI) were estimated that anatomical areas without plaques or with thin plaques are more likely to be healthy than areas with thick or heavy plaques. RR and CI were also calculated, according to which anatomical areas without plaques or with thin plaques were more likely to be inactive lesions than areas with thick and heavy plaques. These estimates were not adjusted at the level of teeth and adolescents. Filled, sealed or missing surfaces were not included in the analysis.

## CHAPTER 3. RESULTS OF THE RESEARCH

### 3.1. Results of participants' indicators

The study included 305 patients (153 women and 152 men) aged 15-35 years who visited the Department of Dental Disease Prevention at the Tashkent State Dental Institute. Restored teeth that included sealants or fillings on the occlusal surface, teeth with hypoplasia or fluorosis, and teeth with other characteristics that could affect the study results were excluded based on visual inspection. Patients with systemic diseases, patients undergoing orthodontic treatment, TMJ disorder, severe periodontitis, symptoms of mucosal bleeding, and pregnant women were also excluded. This procedure resulted in a final inclusion of 60 patients with one or more visually detected occlusal caries. 34 of these patients included in the study were female patients with a mean age of 21.3 ± 5.2 years and 26 of them were male patients with a mean age of 20.8 ± 5.7 years.

**Table 3.1.**

**Participants' characteristics in the study**

| Floor | Number of participants | Middle age | Number of teeth | Number of pits |
|---|---|---|---|---|
| **Men** | **26** | **20.8 ± 5.7** | **172** | **516** |
| **Women** | **34** | **21.3 ± 5.2** | **217** | **651** |
| **Total:** | **60** | **21.1 ± 5.3** | **389** | **1167** |

The occlusal surfaces of the selected molars were then divided into three sections: distal, central, and mesial. The distal section includes the distal fossa, the central section includes the central fossa, and the mesial section includes the mesial fossa. Each section was separately assessed and recorded. A total of 1,167 fossae from 389 permanent molars of the maxillary and mandibular jaws suitable for this study were examined. (Table 3.1.)

### 3.2. Results of biofilm cariogenicity level indicators from QLF images of the occlusal surface of the tooth.

To determine the cariogenicity level of biofilm from QLF images of the occlusal surface of teeth, a digital microvideo camera with a filter system and Qray computer analysis software were used. Accumulated pathogenic microflora (plaque), which autofluoresces red on the occlusal surface of chewing teeth, was analyzed.

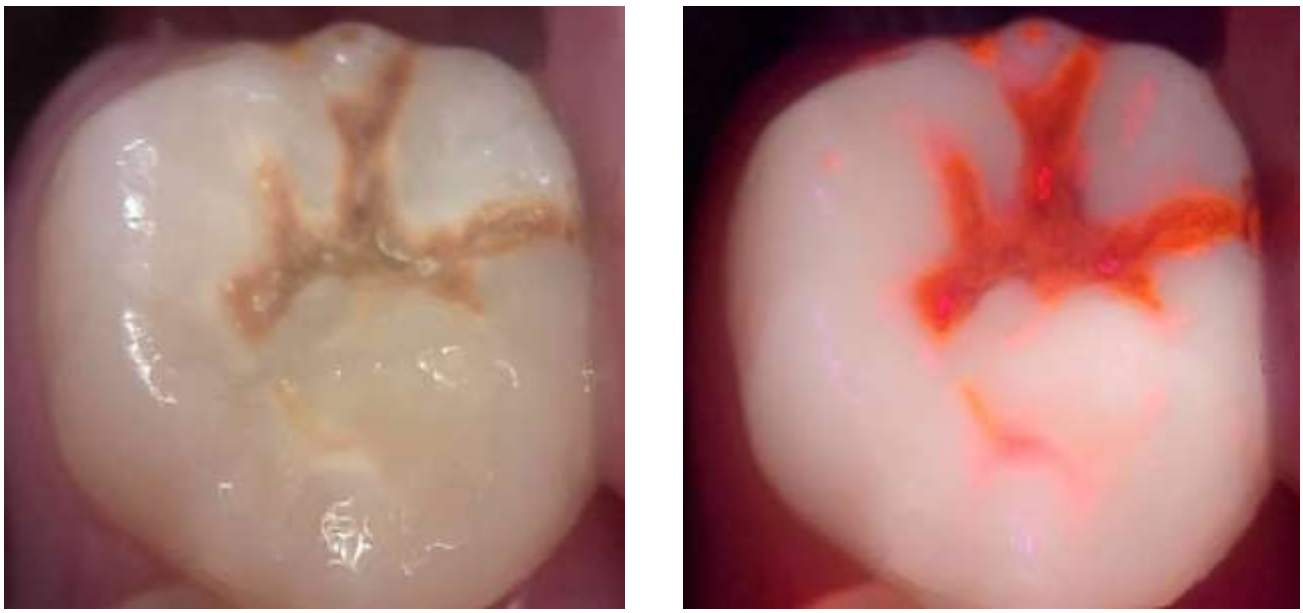


**Fig. 3.2. View of the occlusal surface of a tooth with excessive plaque accumulation with conventional illumination (left) and using quantitative light fluorescence technology (right)**

To analyze the fluorescent properties of plaque, we calculated the red fluorescence intensity from fluorescence images of each tooth. A region of interest (ROI) was drawn around the boundaries of the selected teeth whose fluorescence images showed plaque. The red and green values of each pixel within the plaque region were then obtained using image analysis software (Q-Ray version 1.45, Inspektor Research Systems). The average red-to-green ratio, indicating the relative red intensity of each pit, was calculated. Using QLF images, each pit was assessed before and after occlusal plaque removal. The result was determined by calculating the ΔR index, which reflects bacterial activity and changes in red fluorescence, from the images before and after plaque removal.

**Table 3.6**

**Average occlusal plaque values ΔR in different groups of upper and lower jaw molars using the Q-ray program.**

| Localization | 1st molar | | | 2nd molar | | | 3rd molar | | |
|---|---|---|---|---|---|---|---|---|---|
| Mesial fossa | 2.2±3.5 | IN | 2.1±4.3 | 15.5±5.6 | IN | 14.3±9.4 | 11±6.7 | IN | 13.8±10.9 |
| | | N | 2.4±5.6 | | N | 16.4±10.1 | | N | 10.4±9.4 |
| Central fossa | 2.4±5.6 | IN | 2.3±5.5 | 16.8±6.8 | IN | 18.1±8.6 | 353.4±9.5 | IN | 403.9±73.3 |
| | | N | 2.6±6.8 | | N | 15.74±10.6 | | N | 319.6±91.7 |
| Distal fossa | 6.8±4.4 | I | 6.4±4.8 | 6.7±6.7 | IN | 8.3±7. | 115.6±7 | I | 114.3 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | N | | | | 1 | .8 | N | ±82.5 |
| | | N | 7.2±5.8 | | N | 5.9±5.4 | | N | 121.2 ±76.6 |

### 3.3. Results of the occlusal surface indicators of teeth according to the International Caries Detection and Assessment System (ICDAS - International Caries Detection and Assessment System-2)

Before assessing caries status according to the International Caries Detection and Assessment System (ICDAS 2), the chewing surfaces of the teeth were cleaned with a low-speed angle brush and then rinsed with water. If necessary, the teeth were dried with air. Each pit was individually assessed using the ICDAS 2 scoring system. The resulting scores on the permanent molars were plotted and recorded (no cavities or cavities).

**Table 3.7**

**The obtained results of ICDAS 2 determination in different groups of molars of the upper and lower jaws**

| Codes ICDAS 2 | Number of pits | Jaw | 1st molar | | | 2nd molar | | | 3rd molar | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | M | C | D | M | C | D | M | C | D |
| **0** | 209 | Upper | 37 | 13 | 4 | 66 | 10 | 21 | 29 | 10 | 19 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 122 | Lower | 19 | 3 | 5 | 30 | 8 | 22 | 17 | 7 | 11 |
| **1** | 52 | Upper | 2 | 1 | 0 | 6 | 5 | 4 | 13 | 10 | 11 |
| | 27 | Lower | 5 | 0 | 1 | 7 | 3 | 3 | 1 | 4 | 3 |
| **2** | 353 | Upper | 35 | 55 | 62 | 28 | 61 | 63 | 9 | 22 | 18 |
| | 265 | Lower | 27 | 39 | 42 | 36 | 38 | 46 | 13 | 9 | 15 |
| **3** | 49 | Upper | 0 | 4 | 4 | 1 | 19 | 9 | 2 | 8 | 2 |
| | 39 | Lower | 3 | 9 | 4 | 1 | 14 | 2 | 0 | 5 | 1 |
| **4** | 19 | Upper | 0 | 1 | 4 | 0 | 6 | 4 | 0 | 1 | 3 |
| | 21 | Lower | 0 | 1 | 2 | 1 | 9 | 1 | 0 | 6 | 1 |
| **5** | 1 | Upper | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 6 | Lower | 0 | 2 | 0 | 0 | 3 | 1 | 0 | 0 | 0 |
| **6** | 1 | Upper | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 3 | Lower | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |

As can be seen in Figure 3.4. Of the 1167 pits examined, 331 pits (28.3%) were defined as code 0-Healthy tooth surface, 79 pits (6.8%) were defined as code 1-First visual change in enamel, 618 pits (53%) were defined as code 2-Distinct visual change in enamel, 88 pits (7.5%) were defined as code 3-Localized destruction of enamel due to caries without visible dentin or underlying shadow, 40 pits (3.4%) were defined as code 4-Underlying dark shadow from dentin with or without localized destruction of enamel, 7 pits (0.6%) were defined as code 5-Distinct cavity with visible dentin, 4 pits (0.4%) were defined as code 6-Extensive distinct cavity with visible dentin.

**Fig. 3.3. Quantitative indicators of certain ICDAS 2 codes in different groups of molars of the upper and lower jaws**

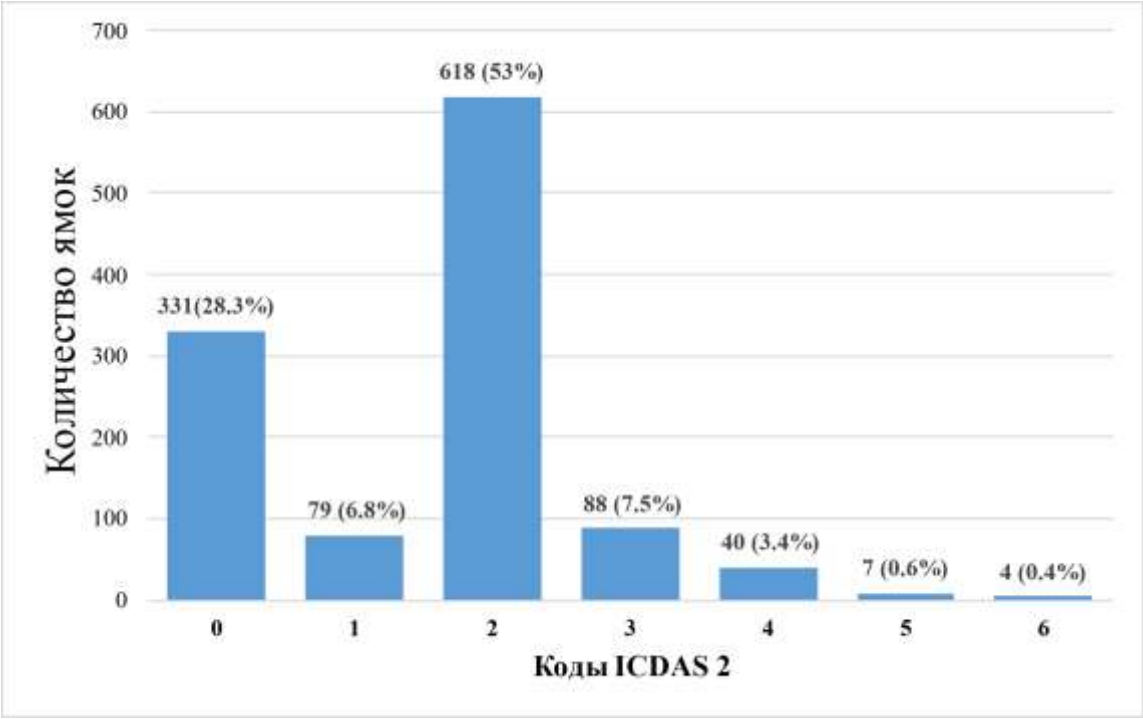


**Fig. 3.3. Results of ICDAS 2 indicators between groups of chewing teeth of the upper and lower jaw.**

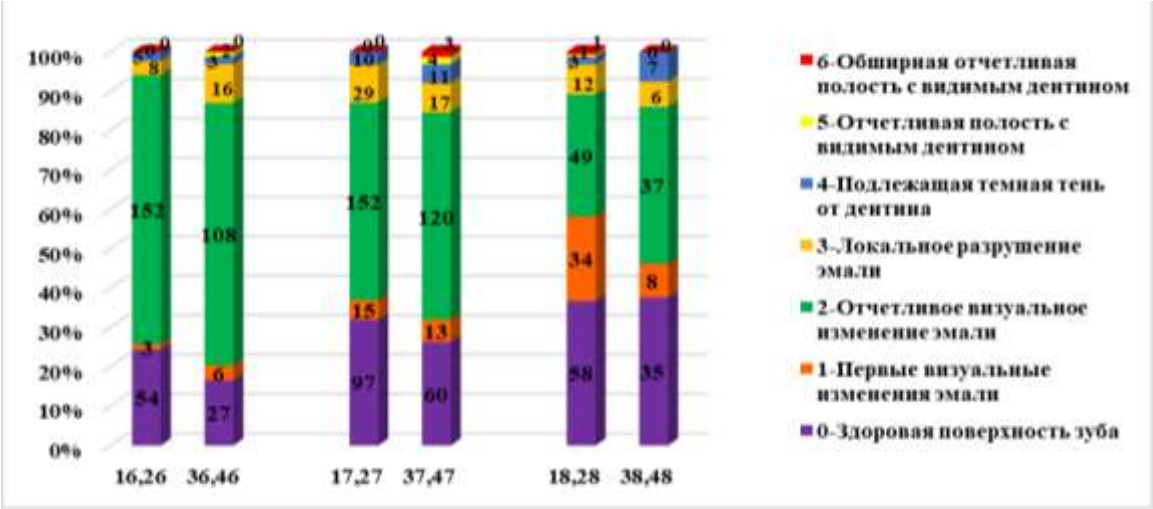



**Fig. 3.3. Results of ICDAS 2 indicators between groups of chewing teeth of the upper and lower jaw.**

**Table 3.8.**

**The obtained results of ICDAS 2 determination in different groups of molars of the upper and lower jaws**

| Localization | 1st molar | | | 2nd molar | | | 3rd molar | | |
|---|---|---|---|---|---|---|---|---|---|
| Mesial fossa | 1.09±0.91 | IN | 0.37±0.91 | 0.88±0.99 | IN | 0.29±0.87 | 0.76±0.65 | IN | 0. |
| | | N | 0.39±0.92 | | N | 0.47±1.09 | | N | 0. |

When studying the obtained data, the highest ICDAS 2 scores among the groups of chewing teeth were found on the occlusal surface of the first molars 1.67±1.09, for the second molars this score was 1.56±1.24 and the lowest scores were found for the third molars 1.28±0.94. By localization, the highest ICDAS 2 scores were determined on the central fossa 2.02±1.29, consequently on the distal 1.67±1.12 and the lowest scores were determined on the mesial fossa 0.92±0.88. (Table 3.8.)

### 3.4. Results of the occlusal surface indicators of teeth according to the QLF scoring system (QLF Scoring- QS- occlusal)

Before assessing the occlusal surface of the teeth using the QLF occlusal scoring system, all artificial and natural light in the room was excluded. The assessment was conducted using only the QrayView device and special goggles. When necessary, the teeth were dried with an air stream. Each pit was individually assessed using the QS-occlusal scoring system. The resulting scores on the permanent molars were mapped and recorded at individual anatomical sites of the sulcal pit system and at surface level. The outcomes were the presence of healthy areas/surfaces and areas/surfaces with active or inactive caries lesions (without cavities or cavities).

**Table 3.9.**

**The obtained results of determining -QS-occlusal in different groups of molars of the upper and lower jaws**

| QS-occlusal | Description | Number of pits | Jaw | 1st molar | | | 2nd molar | | | 3rd molar | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | M | C | D | M | C | D | M | C | D |
| 0 | Healthy tooth | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 382 | IN | 48 | 57 | 51 | 68 | 59 | 46 | 24 | 9 | 20 | |
| 1 | Reversible or initial caries | 270 | N | 37 | 30 | 29 | 49 | 42 | 46 | 16 | 12 | 9 |
| | | 189 | IN | 23 | 16 | 15 | 30 | 32 | 37 | 18 | 9 | 9 |
| 2 | Enamel caries | 126 | N | 16 | 15 | 18 | 17 | 16 | 18 | 12 | 6 | 8 |
| | | 97 | IN | 0 | 1 | 8 | 3 | 8 | 14 | 11 | 29 | 23 |
| 3 | Dentin caries | 66 | N | 0 | 7 | 4 | 8 | 10 | 10 | 3 | 10 | 14 |
| | | 16 | IN | 3 | 0 | 0 | 0 | 2 | 4 | 0 | 6 | 1 |

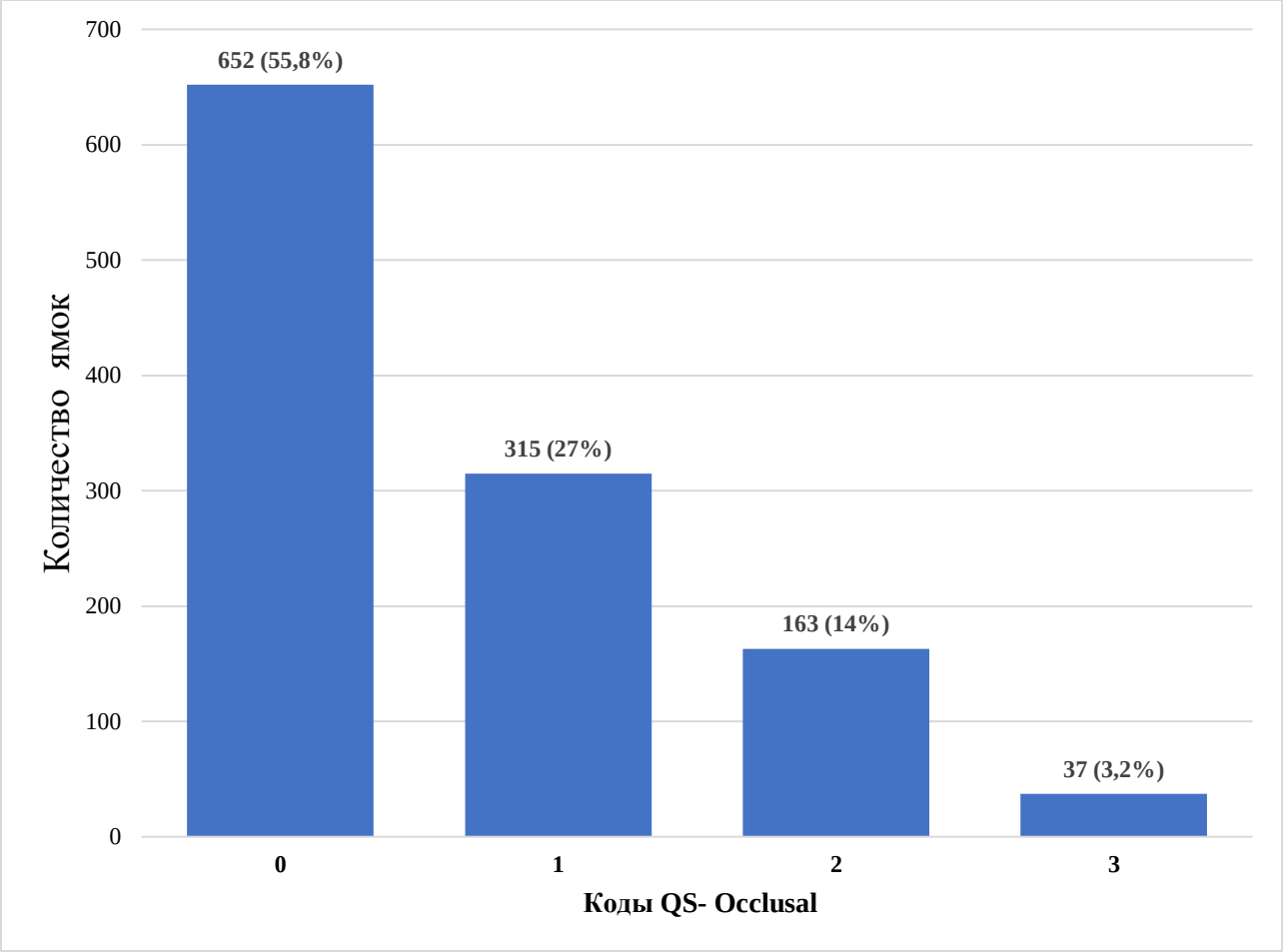



**Fig. 3.4 Quantitative indicators of certain QS-occlusal codes in different groups of molars of the upper and lower jaws**

As can be seen in Figure 3.6, out of the 1167 pits examined, 652 pits (55.8%) were identified as code 0-Healthy, 315 pits (27%) were identified as code 1-Suspected or initial caries, 163 pits (14%) were identified as code 2-Enamel caries, 37 pits (3.2%) were identified as code 3-Dentin caries.

**Table 3.10.**

**The obtained results of QS-occlusal determination in different groups of molars of the upper and lower jaws**

| Localization | 1st molar | | | 2nd molar | | | 3rd molar | | |
|---|---|---|---|---|---|---|---|---|---|
| Mesial fossa | 0.39±0.51 | IN | 0.43±0.59 | 0.42±0.59 | IN | 0.35±0.51 | 0.69±0.54 | IN | 0.75±0.63 |
| | | N | 0.35±0.42 | | N | 0.51±0.67 | | N | 0.58±0.42 |
| Central fossa | 0.41±0.53 | IN | 0.24±0.38 | 0.64±0.80 | IN | 0.53±0.69 | 1.42±0.89 | IN | 1.60±0.99 |
| | | N | 0.64±0.65 | | N | 0.78±0.90 | | N | 1.12±0.72 |
| Distal fossa | 0.51±0.61 | IN | 0.41±0.57 | 0.68±0.77 | IN | 0.76±0.81 | 1.11±0.75 | IN | 1.09±0.82 |
| | | N | 0.68±0.65 | | N | 0.57±0.70 | | N | 1.16±0.66 |

When studying the obtained data, the highest QS-occlusal values among the groups of chewing teeth were found on the occlusal surface of the third molars 1.07±0.75, for the second molars this value was 0.58±0.73 and the lowest points were found in the first molars 0.44±0.55. By localization, the highest QS-occlusal points were determined on the central fossa 0.73±0.77, then on the distal 0.72±0.72 and the lowest points were

determined on the mesial fossa 0.47±0.55.

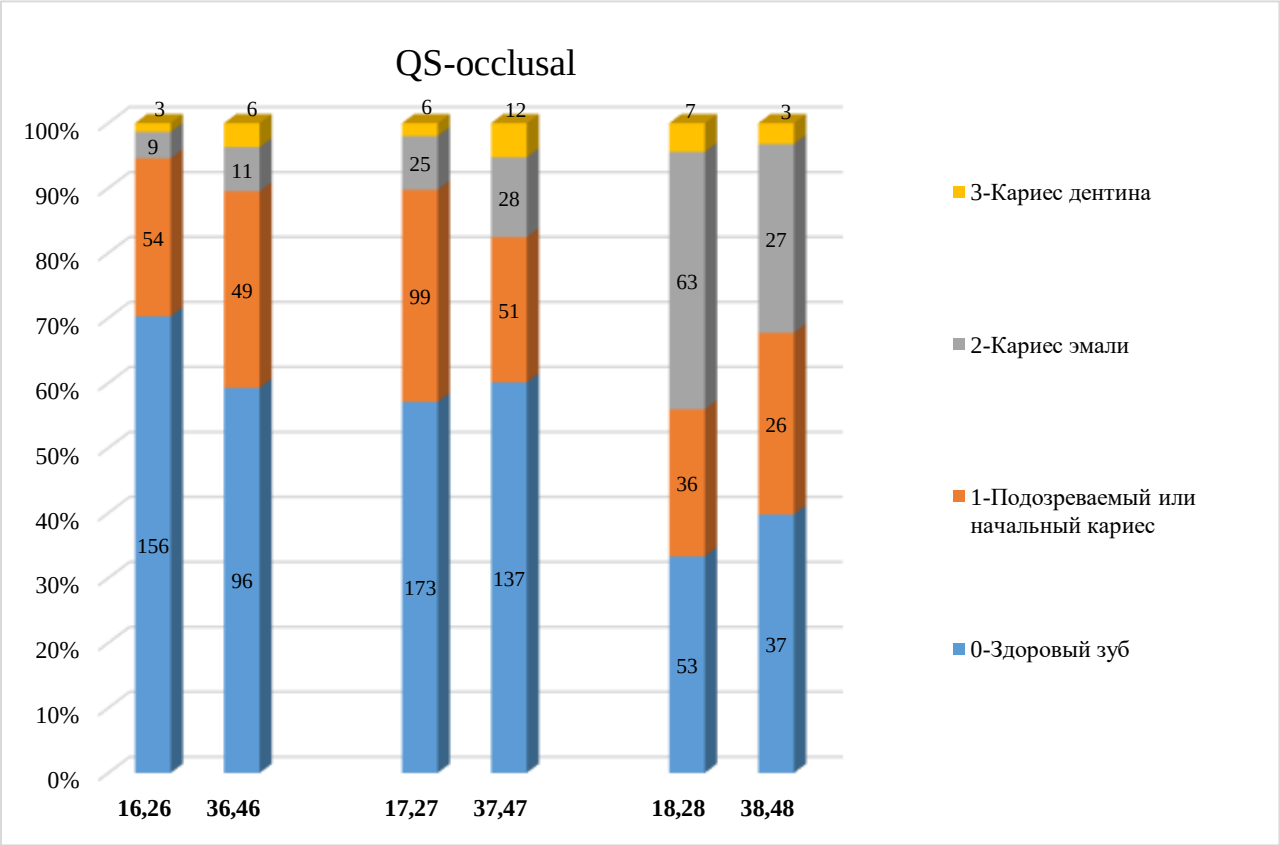



**Fig. 3.4. Results of QS-occlusal indices between groups of chewing teeth of the upper and lower jaw.**

### 3.5. Results of carious lesion indices from QLF imagesfrom the occlusal surface of the tooth.

Carious lesions were assessed and analyzed using QLF images of the occlusal surfaces of the teeth. W-blocks were used to maintain a consistent angle when capturing QLF images. Each pit was assessed using QLF images after cleaning the occlusal plaque. A zone of interest was drawn around the boundary of the selected pit. The ΔF was then determined using image analysis software (Q-Ray version 1.45, Inspektor Research Systems BV, Amsterdam, the Netherlands).

**Table 3.11**

**Average occlusal caries values ΔF in different groups of molars from QLF images using the Q-ray program.**

| Localization | 1st molar | | | 2nd molar | | | 3rd molar | | |
|---|---|---|---|---|---|---|---|---|---|
| Mesial fossa | 30±3.5 | IN | 35.4±5.9 | 38.8±5.2 | IN | 35.6±5.1 | 32.2±6.1 | IN | 37.5±6.3 |
| | | N | 26.5±4.2 | | N | 41.3±6.7 | | N | 30.5±4.2 |
| Central fossa | 32.2±5.6 | IN | 24.3±8.2 | 51.5±6.8 | IN | 49.3±6.9 | 112.2±9.5 | IN | 116.9±9.5 |
| | | N | 46.6±6.5 | | N | 57.8±9.2 | | N | 109.1±7.2 |
| Distal fossa | 37.8±4.4 | IN | 41.3±7.8 | 37.1±6.6 | IN | 40.6±8.1 | 155.4±7.8 | IN | 150.9±10.8 |
| | | N | 68.7±9.5 | | N | 35.7±7.7 | | N | 161.7±12.6 |

When studying the obtained data, the highest ΔF values among the groups of chewing teeth were found on the occlusal surface of the third molars 99.9±8.0, for the second molars this value was 45.2±6.3 and the lowest points were found in the first

molars 33.3±4.6. By localization, the highest ΔF points were determined in the distal fossa 72.1±6.5, then in the central 63.7±7.6 and the lowest points were determined in the mesial fossa 34.2±5.0.

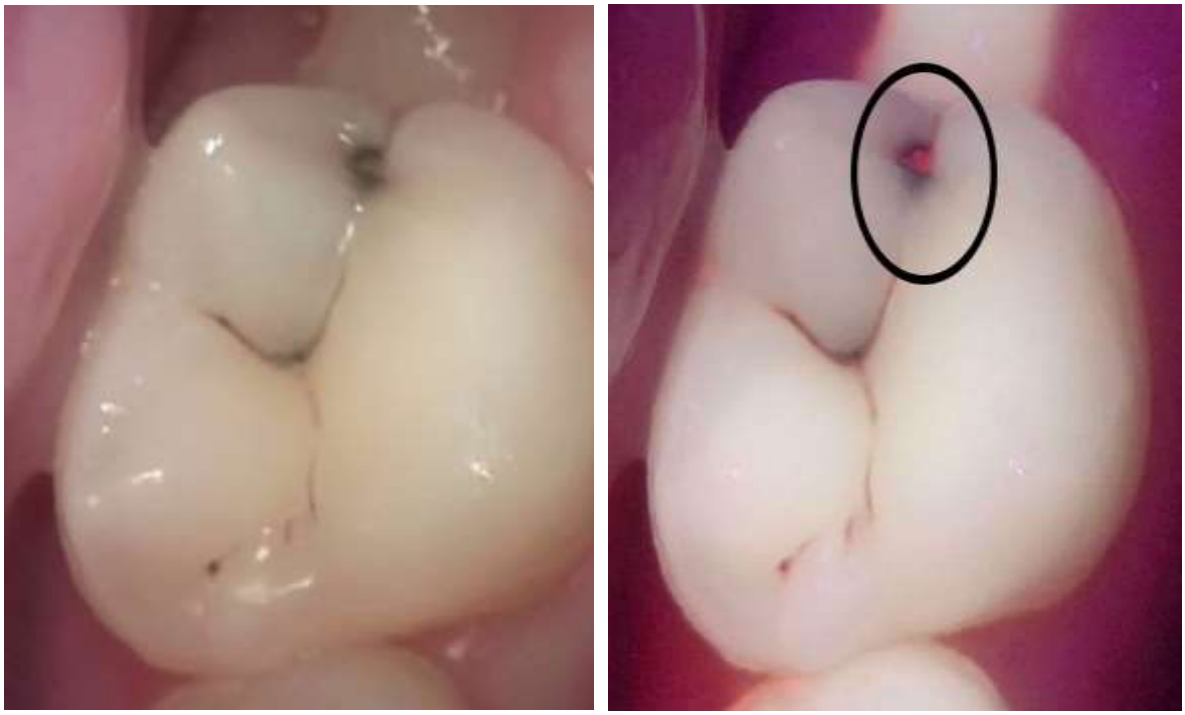


**Fig. 3.5. View of active caries on the occlusal surface with conventional illumination (left) and using quantitative light fluorescence technology (right)**

### 3.6. Bitewing bitewing radiography evaluation results

When studying the obtained data, the highest Bitewing radiography indicators among the groups of chewing teeth were found on the occlusal surface of the third molars 0.97 ± 0.55, for the second molars this indicator was 0.48 ± 0.53 and the lowest scores were found in the first molars 0.34 ± 0.25. By localization, the highest QS-occlusal scores were determined at the central fossa 0.66 ± 0.57, consequently, at the distal 0.62 ± 0.62 and the lowest scores were determined at the mesial fossa 0.39 ± 0.45.

**Table 3.12.**

**Results of bitewing radiography in different groups of upper and lower jaw molars**

| Localization | 1st molar | | | 2nd molar | | | 3rd molar | | |
|---|---|---|---|---|---|---|---|---|---|
| Mesial fossa | 0.07±0.04 | IN | 0.08±0.09 | 0.08±0.05 | IN | 0.07±0.01 | 0.11±0.04 | IN | 0.13±0.06 |
| | | N | 0.06±0.02 | | N | 0.11±0.07 | | N | 0.09±0.04 |
| Central fossa | 0.09±0.03 | IN | 0.07±0.08 | 0.26±0.06 | IN | 0.23±0.09 | 0.67±0.06 | IN | 0.69±0.09 |
| | | N | 0.11±0.05 | | N | 0.28±0.08 | | N | 0.62±0.07 |
| Distal fossa | 0.11±0.03 | IN | 0.11±0.07 | 0.15±0.03 | IN | 0.16±0.08 | 0.34±0.08 | IN | 0.31±0.02 |
| | | N | 0.12±0.05 | | N | 0.14±0.07 | | N | 0.36±0.06 |

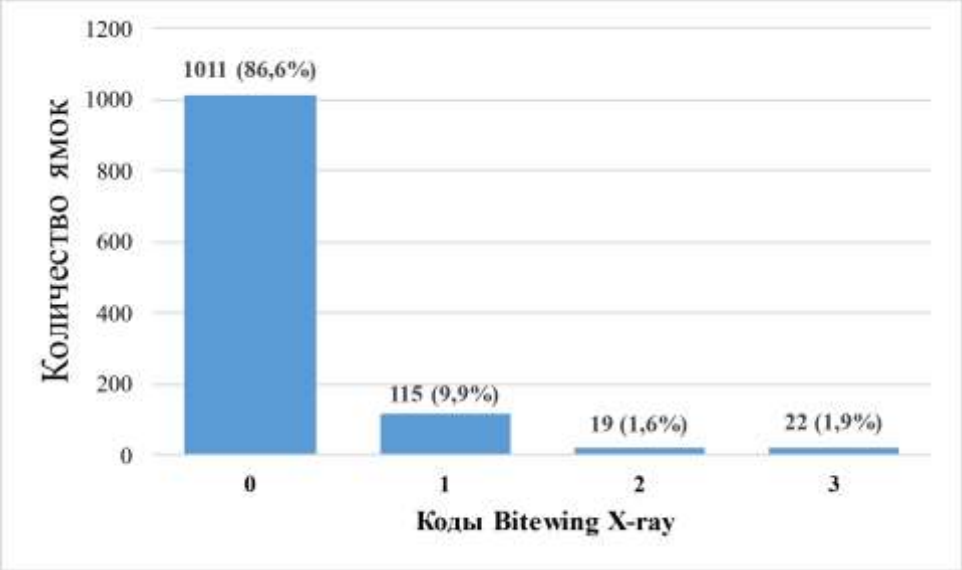



**Fig. 3.6. Quantitative indicators of bitewing radiography in different groups of molars of the upper and lower jaws**

### 3.7. Results of determination of caries activity of the occlusal surface of permanent molars using new technologies

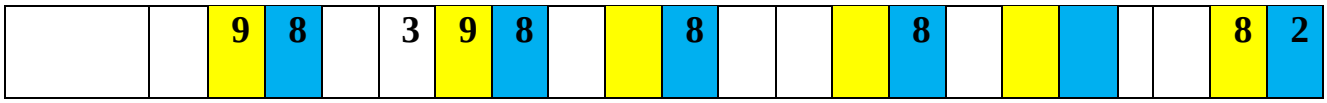
To determine the caries activity of the occlusal surface of permanent molars after visual assessment of ISDAS-2, the QrayView device with the Qs-occlusal assessment system was used.

**Table 3.15.**

**Percentage ratio of caries activity between ICDAS-2 and QS occlusal readings in different groups of maxillary and mandibular molars**

| Pit | 1st molar | | | | | | | 2nd molar | | | | | | | 3rd molar | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Meuse.** | 39 | 28 | 33 | B | 44, | 28, | 26, | 46,2 | 18, | 35, | B | 56,8 | 16 | 27, | 42, | 39,4 | 18,2 | B | 41,5 | 41, | 17, |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 8 | 3 | 9 | | 6 | 2 | | | | 2 | 4 | | | | 5 | 1 |
| | | | | H | 31,4 | 27,4 | 41,2 | | | | H | 32,8 | 21,9 | 45,3 | | | | H | 44 | 36 | 20 |
| Price. | 9,4 | 32 | 58,6 | B | 15,3 | 20,8 | 63,9 | 4,22 | 39,2 | 56,6 | B | 5,21 | 38,5 | 56,3 | 6,85 | 71,2 | 21,9 | B | 4,444 | 80 | 15,6 |
| | | | | H | 1,8 | 44,5 | 53,7 | | | | H | 2,86 | 40 | 57,1 | | | | H | 10,7 | 57,1 | 32,1 |
| Dis. | 4,8 | 35,5 | 59,7 | B | 5,5 | 31 | 63,5 | 16,3 | 42,5 | 41,3 | B | 11,1 | 48,9 | 40 | 21,7 | 58 | 20,3 | B | 22,7 | 54,5 | 22,7 |
| | | | | H | 4 | 42 | 54 | | | | H | 22,9 | 34,3 | 42,9 | | | | H | 20 | 64 | 16 |
| **M** | **17,3** | **31,** | **50,** | | **17,** | **31,** | **50,** | **21,2** | **34** | **44,** | | **21,2** | **34** | **44,** | **23** | **56,8** | **20,2** | | **23** | **56,** | **20,** |




| | |
|---|---|
| | Healthy pit |
| | Active caries |
| | Arrested caries |

**Table 3.16.**

**Cross-tabulation of caries activity between ICDAS 2 and QS occlusal values in different groups of maxillary and mandibular molars**

| Qs-occlusal / ISDAS 2 | 0-Healthy tooth | 1-Suspected or initial caries | 2-Enamel caries | 3-Cariesdentin | Total |
|---|---|---|---|---|---|
| 0-Healthy tooth surface | 211 | 94 | 24 | 2 | 331 |
| 1-The first visual changes in enamel | 19 | 25 | 35 | 0 | 79 |
| 2-Distinct visual change in enamel | 356 | 173 | 79 | 10 | 618 |

| | | | | | |
|---|---|---|---|---|---|
| 3-Local destruction of enamel | 49 | 17 | 21 | 1 | 88 |
| 4-Underlying dark shadow from dentin | 17 | 6 | 4 | 13 | 40 |
| 5-Distinct cavity with visible dentin | 0 | 0 | 0 | 7 | 7 |
| 6-Large, distinct cavity with visible dentin | 0 | 0 | 0 | 4 | 4 |
| Total | 652 | 315 | 163 | 37 | 1167 |

| | |
|---|---|
| 211(18%) | Healthy pit |
| 515(44,2%) | Active caries |
| 441(37,8%) | Arrested caries |

As can be seen in Table 3.15, the caries activity of the 1st molars was 31.9% and the arrested caries rate was 50.8%. On the 2nd molars, the caries activity was 34% and the arrested caries rate was 44.8%. And on the 3rd molars, the caries activity was 56.8% and the arrested caries rate was 20.2%. And individually, the highest caries activity was observed at the central fossa of the upper 3rd molar and amounted to

80%, and the lowest caries activity was observed at the mesial fossa of the upper 2nd molar and amounted to 18.6%. The highest rate of arrested caries was observed at the central fossa of the upper first molar, at 63.9%, and the lowest rate of arrested caries was observed at the central fossa of the upper third molar, at 18.6%. An increase in caries activity can be observed with distal tooth positioning in the jaw and a greater ratio of arrested caries with mesial tooth positioning in the jaw.

Table 3.16 shows that of the 1,167 pits examined, 211 (18%) were healthy, and 956 (82%) pits showed caries during visual inspection. When examined with the QrayView device, red fluorescence was detected in 515 (44.2%) pits, and no red fluorescence was detected in 441 (37.8%) of these. The absence of red fluorescence indicates that there is no bacterial activity in these pits.

### 3.8.Results of statistical processing of the obtained data

Results of comparative analysis of correlations between ICDAS-2 and QS-occlusal

To assess the relationship between the ICDAS-2 score and the QS occlusion scale, the Pearson correlation coefficient was calculated. There was a positive correlation between the two variables, $r = 0.209$; $n = 1167$; $p = 0.001$.

Fig. 3.8. Scatter plot (dot diagram) to understand the direction of the relationship between ICDAS-2 and QS-occlusal

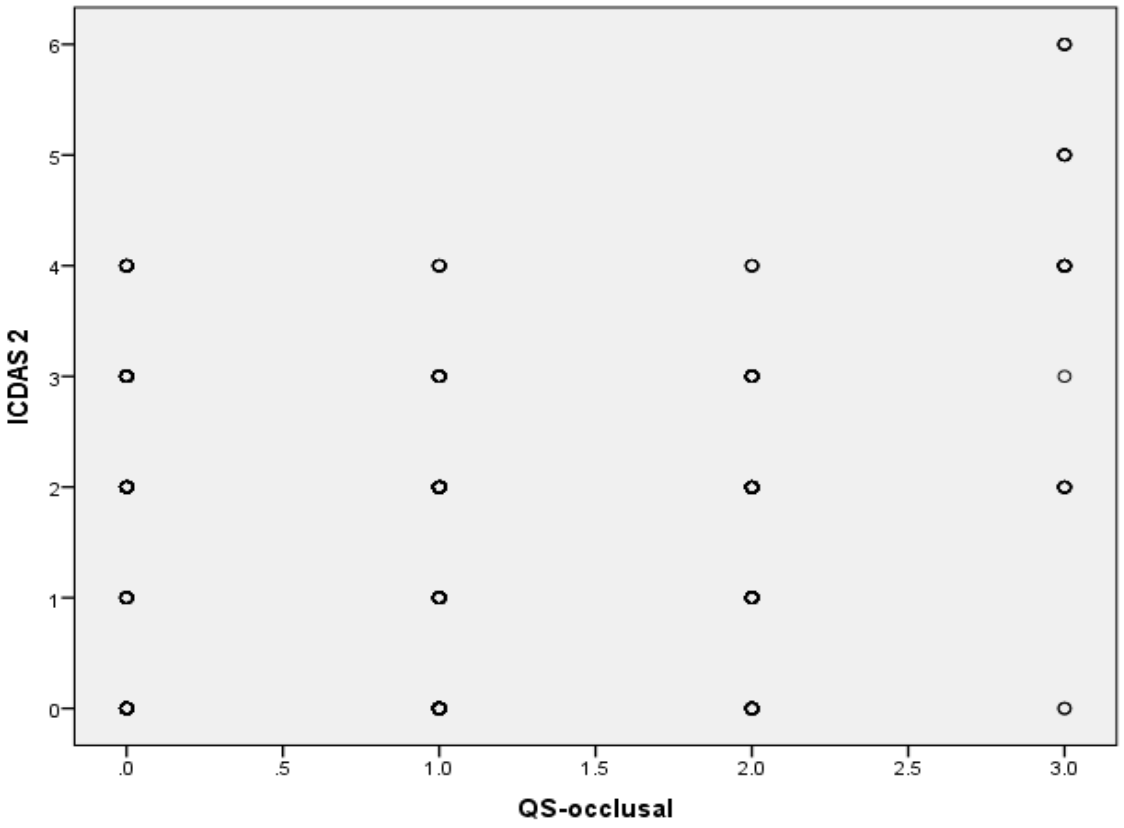
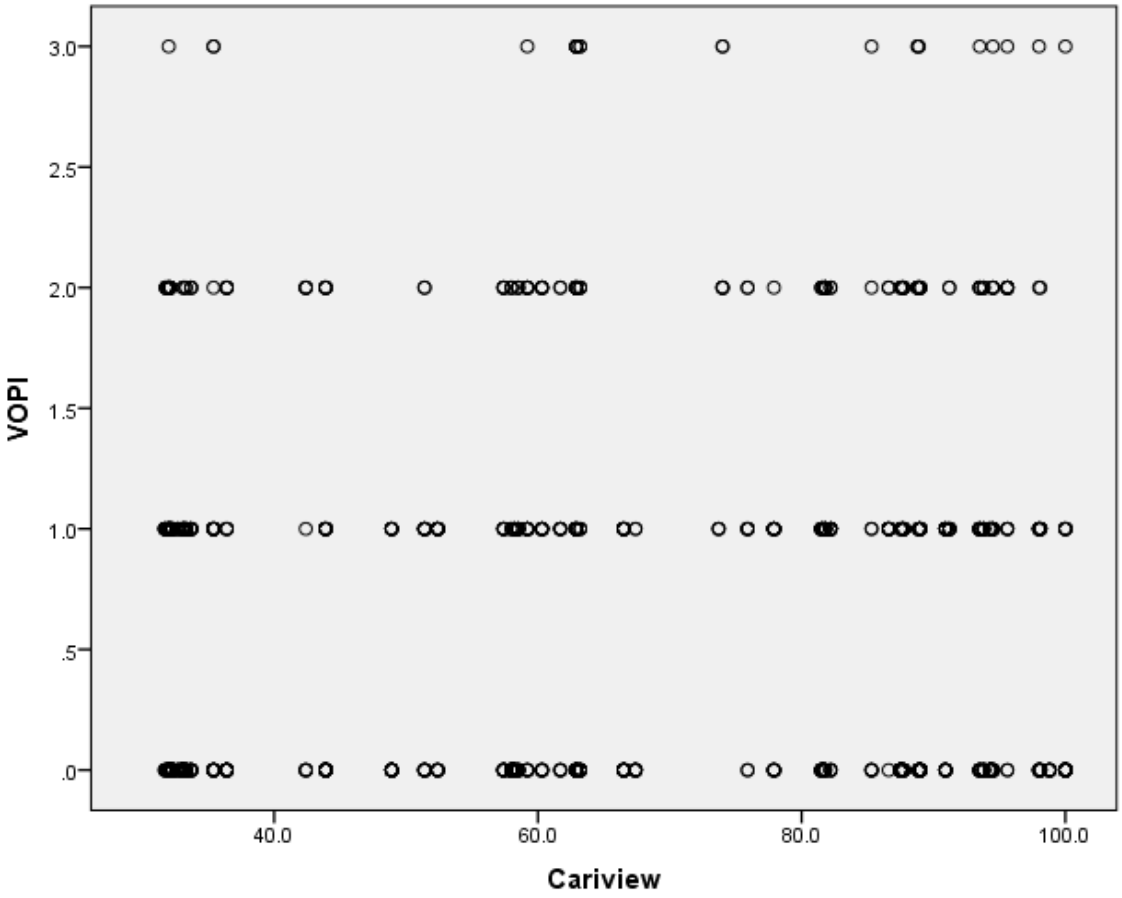



**Fig. 3.8. Scatter plot (dot diagram) to understand the direction of the relationship between ICDAS-2 and QS-occlusal**

The scatterplot summarizes the results (Fig. 3.11). Overall, a strong positive correlation was observed between the ICDAS-2 level and the QS occlusion score. Increasing ICDAS-2 levels correlated with increasing QS occlusion scores.

**Results of the analysis of correlations between VOPI and plaque cariogenicity level (CARIVIEW)**

To assess the relationship between the VOPI level and the CARIVIEW scale, the Pearson correlation coefficient was calculated. There was no relationship between the two variables, $r = 0.025$, $n = 1167$, $p = 0.390$.




3.8.Results of statistical processing of the obtained data

Results of comparative analysis of correlations between ICDAS-2 and QS-occlusal

To assess the relationship between the ICDAS-2 score and the QS occlusion scale, the Pearson correlation coefficient was calculated. There was a positive correlation

between the two variables, r = 0.209; n = 1167; p = 0.001.

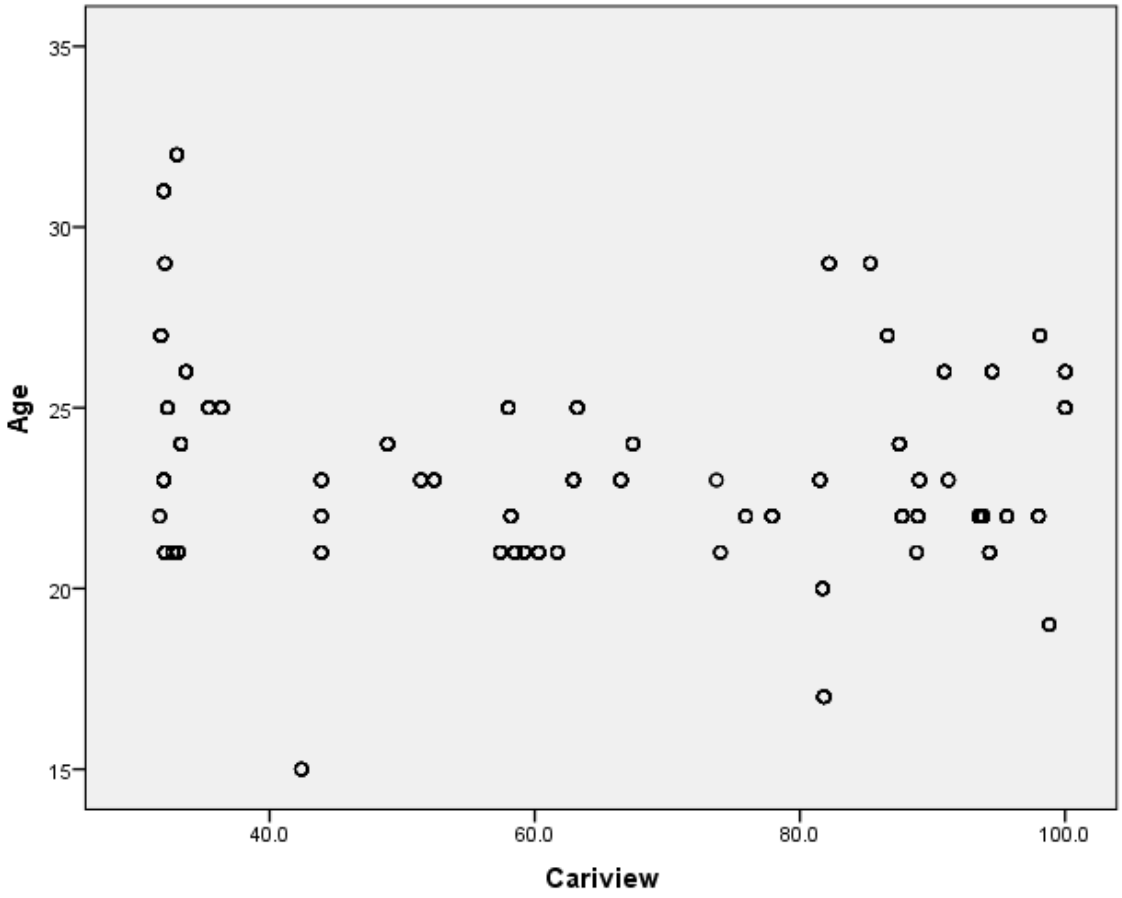



**Fig. 3.9. Scatterplot**

The scatterplot summarizes the results (Fig. 3.13). Overall, a weak negative correlation was observed between patient age and the CARIVIEW score. Increasing age correlated with a decreasing CARIVIEW score. In other words, aging was negatively correlated with plaque cariogenicity.

**Results of the analysis of variance (ANOVA)**

Where there are two groups of independent samples, a t-test should be used. If there are more than two groups, the most appropriate statistical test is a one-way analysis of variance (ANOVA).

A one-way between-subjects ANOVA was performed to compare the ICDAS-2 scores for high, medium, and low plaque cariogenicity. A significant effect of plaque cariogenicity level according to the ICDAS-2 scales was observed at the $p<0.001$ level for the three conditions [$F(2, 1164) = 26.30$; $p<0.001$]. Post-hoc comparisons using the Tukey HSD test showed that the mean score of high plaque cariogenicity level ($M = 1.26$, $SD = 1.12$) was significantly different from the low plaque cariogenicity level ($M = 1.63$; $SD = 1.13$) and the medium plaque cariogenicity level. However, the medium plaque cariogenicity level ($M = 1.80$; $SD = 1.12$) did not differ significantly from the low plaque cariogenicity level. Taken together, these results suggest that high plaque cariogenicity levels do influence ICDAS-2 scores. Specifically, our results suggest that teeth with high plaque cariogenicity levels may have a higher ICDAS-2 score. Moderate plaque cariogenicity levels do not significantly increase ICDAS-2 scores.

A one-way between-subjects ANOVA was conducted to compare VOPI scores for high, moderate, and low plaque cariogenicity levels. There was no significant effect of plaque cariogenicity level on VOPI scores at the $p < 0.05$ level across the three conditions [$F(2, 1164) = 0.43$; $p = 0.65$]. Taken together, these results suggest that plaque cariogenicity levels do not influence VOPI scores.

A one-way between-subjects ANOVA was conducted to compare QS occlusion scores for high, moderate, and low plaque cariogenicity levels. There was no significant effect of plaque cariogenicity level on QS occlusion scores at the $p < 0.05$ level across the three conditions [$F(2, 1164) = 0.84$; $p = 0.43$]. Taken together, these results suggest that plaque cariogenicity levels do not influence QS occlusion scores.

# CHAPTER 4. DISCUSSION

According to WHO data, since the late 1990s most countries have observed a marked increase in noncavitated carious lesions, which makes the early diagnosis and prevention of dental caries highly relevant [13,98,128].

Previous studies using QLF technology have shown that red fluorescence is characteristic of mature dental plaque, enabling its detection without an additional disclosing step [86,89]. Moreover, the red fluorescence of dental plaque correlates significantly with caries and gingivitis and may indicate pathogenic potential [59,110].

Because red fluorescence is associated with biofilm maturity in the oral cavity, the present study used a two-tone plaque disclosing agent (Mira-2-Ton solution, Hager & Werken, Duisburg, Germany). Its composition includes water, sodium benzoate, potassium sorbate, Acid Red 92 (CI 45410), and Acid Blue 9 (CI 42090). According to the manufacturer, it differentiates “new” plaque (stained pink) from “old” plaque (stained blue). Continuous in-vitro rinsing can completely wash out the blue dye, in contrast to the pink dye [141].

Participants in the present sample were asked to refrain from oral hygiene procedures on the day of the appointment, which falls in the mid-range of protocols used in comparable studies [18,28]. Assuming thorough plaque removal the previous evening, this approach was expected to yield predominantly young plaque (pink staining) at the time of examination.

With respect to the Cariview test for plaque cariogenicity, Caufield et al. described a “window of infectivity” from 19 to 31 months of age as a critical period for acquisition of cariogenic bacteria; most children become infected during this interval [27].

For clinical assessment of carious lesions, the International Caries Detection and Assessment System (ICDAS) was selected—an ambitious but essential step. The first task in understanding any chronic infectious disease is to determine how it can be detected clinically. Although dentists have studied dental caries for more than a century, the lack of consensus on how to define and measure this condition is difficult to accept. This echoes the call made by G. V. Black in 1910. Therefore, the findings of the present study may be used to develop objective decision criteria for optimal caries prevention and treatment by calculating ΔF values for lesions classified according to QS-Occlusal.

Several investigations have examined how the characteristics of red fluorescence vary with caries severity. Although some prior studies reported that red-fluorescence intensity changes with lesion depth, it has been difficult to detect subtle differences in fluorescence properties in noncavitated lesions because cavitated lesions were often assessed retrospectively [129]. In contrast, the present study used extracted teeth and evaluated their fluorescence images using the QS-Occlusal scheme as follows: presence/absence of fluorescence expression (QS-Occlusal = 0/1); presence/absence of fluorescence elongation (QS-Occlusal = 1/2); and presence/absence of red fluorescence together with a dark shadow (QS-Occlusal = 2/3).

Changes in red-fluorescence properties with increasing lesion severity mirrored previous retrospective findings: both the intensity and the area of red fluorescence increased with lesion activity relative to baseline red fluorescence [112]. Red fluorescence is produced by bacterial metabolites such as porphyrins and increases with cariogenicity [115].

Since the intensity of red fluorescence increases with the cariogenicity of the biofilm [131], red fluorescence depends on lesion severity, which is determined by the composition of the intra-lesional bacterial community and its metabolic activity

during caries progression. Although it was difficult in this study to establish a direct correlation between caries activity and the presence of red fluorescence, confirmation of such an association in future research would allow clinicians to assess caries status and select appropriate treatment by evaluating the level of red fluorescence within lesions.

Finally, intra- and inter-examiner reliability was evaluated to determine whether the proposed QS-Occlusal system is clinically useful. The results demonstrated high reproducibility, with ICC values of 0.94 (95% CI: 0.93–0.95) for intra-examiner reliability and 0.86 (95% CI: 0.84–0.88) for inter-examiner reliability.

Although the presence or absence of red fluorescence (RF) was initially regarded as a confounding factor in studies of early carious lesions [129,137,139], it now appears to be a useful indicator of overall oral health and helps in interpreting a patient's clinical status [142]. RF can be observed throughout the oral cavity but is detected more frequently on carious surfaces than on sound surfaces within the same individual [136]. Conversely, the absence of RF is used as an indicator of cavity cleanliness after preparation.

Among posterior teeth, the greatest plaque accumulation was noted on the occlusal surfaces of third molars ($1.32 \pm 0.80$), followed by second molars ($0.59 \pm 0.63$), whereas the lowest accumulation was recorded on first molars ($0.38 \pm 0.46$). A positive association between plaque quantity and its cariogenicity was also identified.

Traditional visual examination of carious lesions showed only 39.2% agreement with radiographic assessment. When relying solely on visual inspection without considering caries activity, there was a 54.9% likelihood of overdiagnosis, which may adversely affect subsequent treatment protocols.

For assessing and analyzing the cariogenicity of dental biofilm, the QrayPen intraoral camera can be employed. This device does not require plaque staining, streamlines the examination process, and may serve as a reliable instrument for precise quantitative evaluation of dental plaque in the future.

This technology is also educational and motivating for patients, as it enables visual and quantitative monitoring of improvements in oral health over time. The camera helps demonstrate caries activity and the presence of microbial plaque, facilitating informed decision-making about treatment.

Conclusion. This section provides a concise, structured version of the original scientific material while preserving key findings. The format has been adapted for clarity and remains consistent with academic writing standards.

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