APPLICATION OF QUANTITATIVE LIGHT-INDUCED FLUORESCENCE TECHNIQUE TO DETERMINE INDIVIDUAL ORAL HYGIENE LEVELS

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Indices that reflect individual oral hygiene levels are widely used to determine microbial plaque of the tooth surface. When teaching patients how to take care about the oral cavity, dentists use visual demonstration of the dental plaque localization. The quantitative light-induced fluorescence (QLF) technique represents a modern method to diagnose individual oral hygiene, in which even minimal microbial plaque buildup shows up as red fluorescence. The study aimed to assess the oral hygiene status using the quantitative light-induced fluorescence technique. Dental deposits were detected using QLF; the Quigley Hein, Green-Vermillion, DMF indices were detected clinically. The findings show that Simple Hygiene Scores do not exceed 2, when the caries intensity is very low or low ($p < 0.05$). In these groups, the Green-Vermillion and Quigley Hein index values reach 0.5 ± 0.23 and 0.2 ± 0.14, respectively. When the caries intensity is medium, Simple Hygiene Scores vary between 1–5 points. Very high caries intensity is characterized by the Simple Hygiene Score between 3 and 5 points (maximum Green-Vermillion and Quigley Hein index values reach 2.3 ± 0.43 and 2.1 ± 0.35) ($p < 0.05$). Thus, the quantitative light-induced fluorescence technique can be used in clinical trials for objective oral hygiene assessment, visual demonstration of dental plaque buildup to patients, and assessment of the dynamic changes in these indicators.

Keywords: dental plaque, oral hygiene, quantitative light-induced fluorescence

Author contribution: Pobozhieva LV — research procedure, data analysis, manuscript writing; Kopetskiy IS — manuscript editing; Kopetskaya AI — data analysis, manuscript writing.

Compliance with ethical standards: the study was approved by the Ethics Committee of the Pirogov Russian National Research Medical University (protocol No. 238 dated 19 March 2024). All the subjects submitted the informed consent to participation in the study.

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ПРИМЕНЕНИЕ МЕТОДА КОЛИЧЕСТВЕННОЙ СВЕТОИНДУЦИРОВАННОЙ ФЛУОРЕСЦЕНЦИИ В ОПРЕДЕЛЕНИИ УРОВНЯ ИНДИВИДУАЛЬНОЙ ГИГИЕНЫ ПОЛОСТИ РТА

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Для определения микробного налета на поверхности зубов широко применяют индексы, которые отражают уровень гигиены полости рта. При обучении пациентов уходу за ротовой полостью врачи-стоматологи используют визуальную демонстрацию локализации зубного налета. Метод количественной светоиндуцированной флуоресценции (QLF) является современным методом диагностики индивидуальной гигиены полости рта, при использовании которого даже минимальное скопление микробного налета проявляется в виде красной флуоресценции. Целью исследования было изучить гигиеническое состояние полости рта с применением метода количественной светоиндуцированной флуоресценции. Выявление зубных отложений проводили с использованием QLF, клинически определяли индексы Quigley и Hein, Green-Vermillion, КПУ. Результаты исследования показали, что при очень низком и низком уровнях интенсивности кариозного процесса показатели Simple Hygiene Score не превышают 2 балла ($p < 0,05$). В данных группах значения индексов Green-Vermillion и Quigley, Hein достигали значений 0,5 ± 0,23 и 0,2 ± 0,14 соответственно. При среднем уровне интенсивности кариозного процесса показатели Simple Hygiene Score варьируют от 1 до 5 баллов. Очень высокий уровень кариозного процесса характеризуется значениями Simple Hygiene Score от 3 до 5 баллов (максимальные показатели индексов Green-Vermillion и Quigley, Hein достигали 2,3 ± 0,43 и 2,1 ± 0,35) ($p < 0,05$). Таким образом, метод количественной светоиндуцированной флуоресценции может быть использован в клинических исследованиях для объективной оценки гигиены полости рта, наглядной демонстрации скопления зубного налета пациентам и изучения данных показателей в динамике.

Ключевые слова: зубной налет, гигиена полости рта, количественная светоиндуцированная флуоресценция

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Microbial plaque forms biofilms on the tooth surface, which represents a major etiological factor of dental caries and inflammatory periodontal diseases [1–3].

A number of studies have proven that it is possible to use the quantitative light-induced fluorescence (QLF) technique as a new method to detect biofilms in the oral cavity [4, 5].

Biofilm removal from the tooth surface is an effective method to prevent the main dental diseases. It seems extremely important to teach patients methods of individual oral hygiene and encourage them to perform oral hygiene regularly on a daily basis. Dentists use visual demonstration of dental plaque localization in clinical practice to teach patients how to take care about the oral cavity [6, 7].

Hygienic indices are widely used to quantify microbial plaque on the tooth surface. To detect microbial plaque, the dental deposits are stained with dyes and assessed through visual control, which does not preclude incorrect interpretation and takes time for accurate calculation and measurement [8, 9].

The advanced noninvasive quantitative light-induced fluorescence (QLF) technique involving the use of the oral camera equipped with software allows one not only to quantify dental plaque, but also measure the area of the microbial plaque buildup and calculate the Simple Hygiene Score (SHS). It should also be noted that software can analyze such parameters, as the lesion area/white spot area (area % px 2), fluorescence loss/average enamel mineral loss (ΔF, %), lesion depth (ΔFmax, %), lesion volume/maximum mineral loss (ΔQ, % px), area showing bacterial activity/extent of bacterial activity in the lesions (ΔR, %), maximum bacterial activity (ΔRmax, %), area of bacterial activity (ΔR Area, %) [10, 11].

Even minimal microbial plaque buildup shows up as red fluorescence [11]. The microbial biofilm produces porphyrin, which is manifested by the color change in vivo [12]. The QLF-D method can be used as an alternative to the existing clinical index methods, regardless of the assessed tooth regions [13, 14]. Microbial plaque detection is accomplished without using dyes [15]. The QLF-D method can be used to teach patients individual oral hygiene [16].

Thus, the use of QLF is of great clinical interest in terms of assessing the oral hygiene status.

The study aimed to assess the oral hygiene status using the quantitative light-induced fluorescence technique.

METHODS

The study involved 204 individuals (132 females and 72 males). Inclusion criteria: females and males seeking care or routine examination; age 18–44 years; no dental arch defects in the frontal section (in individuals with physiological or abnormal bite). Exclusion criteria: patients undergoing orthodontics treatment; prosthetic constructions in the frontal section; age below 18 and over 44 year; acute oral inflammatory disease; decompensated somatic disorder; refusal to participate in the study.

The clinical phase consisted of collecting complaints and history taking, oral cavity examination. Disorders of dental hard tissues and periodontal tissues were diagnosed based on ICD-10.

The DMF index (decayed, missing, and filled index) was determined in all subjects in order to assess the intensity of caries lesions. According to the WHO assessment criteria, five caries intensity levels are distinguished in the age group 33–44 years: very low (0.2–1.5), low (1.6–6.2), medium (6.3–12.7), high (12.8–16.2), very high (16.3 and above).

Oral hygiene status was assessed by the quantitative light-induced fluorescence method. The Q-ray dental software, Qraycam Pro camera (AIOBIO, Republic of Korea), and Inspektor Research Systems detector (Netherlands) were used for QLF. The following indicators were determined to detect microbial plaque buildup and oral hygiene status assessment: Simple Hygiene Score with the range of 0–5; area of bacterial activity (ΔR Area, %).

Clinically, oral hygiene status was determined based on the Green-Vermillion (OHI-S) index. Oral hygiene was assessed as good (values within the range of 0–0.6), satisfactory (0.7–1.6), unsatisfactory (1.7–2.5), or poor (over 2.6). Buccal surface of the teeth 16 and 26, labial surface of the teeth 11 and 31, and lingual surface of the teeth 36 and 46 were examined to determine OHI-S.

Furthermore, the Quigley Hein dental plaque index was determined on the vestibular surface of 12 frontal maxillary and mandibular teeth using the dental plaque indicator (Plaque Test, PRESIDENT). Six index values are distinguished: no plaque, isolated flecks of plaque, band of plaque at the gingival margin, up to 1/3 of the tooth surface covered with plaque, plaque from 1/3 to 2/3 of the surface, plaque on more than 2/3 of the surface.

Statistical processing of the study results was performed using Microsoft Office Excel 2017 (Microsoft Corporation) and the Statistica 12.0 (StatSoft) software package. Relative values were calculated; descriptive statistical methods were applied involving calculation of the mean, average error, and standard deviation.

RESULTS

The gender and age distribution of surveyed individuals is provided in Table 1. The average age of surveyed females was 27.73 (± 1.9) years, and that of surveyed males was 31.54 (± 2.3) years.

Based on the study results, very low caries intensity was revealed in 5.9% of surveyed individuals with the DMF value of 1.5 ± 0.34. Low caries intensity was determined in 13.7% of surveyed individuals with the DMF value of 5.6 ± 0.43. Medium caries intensity was revealed in 35.3% of cases with the average DMF value of 11.3 ± 1.2, high intensity — in 37.3% of cases with the DMF value of 14.6 ± 1.3, very high intensity — in 7.8% of cases with the DMF value of 17.2 ± 0.8 (Fig. 1).

The analysis of the Green-Vermillion index values has shown that the patients' oral hygiene corresponds to good, when the caries intensity is very low or low, to satisfactory, when the caries intensity is moderate-to-high, and to unsatisfactory, when the caries intensity is very high.

Oral hygiene indices (Green-Vermillion and Quigley Hein) are provided in Table 2.

Table 1. Gender and age distribution of subjects

Total number of surveyed individuals, *n*	*n* = 204	
Average age of surveyed individuals, years	29.3 (± 2.4) (min 18 ÷ max 44)	
Gender distribution of surveyed individuals, *n*	Males *n* = 72	Females *n* = 132
Average age of surveyed individuals depending on gender, years	31.54 (± 2.3) (min 18 ÷ max 44)	27.73 (± 1.9) (min 18 ÷ max 42)

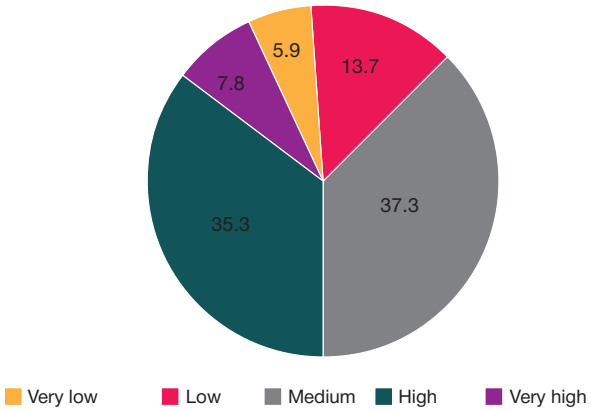

Fig. 1. Distribution of subjects by caries intensity, %

The analysis of the Quigley Hein index values has shown that patients with medium, high, and very high caries intensity need individual oral hygiene improvement (index values above 1) (Fig. 3).

Thus, the results of data interpretation based on the Green-Vermillion and Quigley Hein indices of the surveyed individuals were similar, despite the differences in determination of indices.

Assessment of both indices suggests that oral hygiene of patients with very low or low caries intensity corresponds to good and does not require adjustment, in contrast to the overwhelming majority of individuals with the medium, high, and very high DMF values.

In our study, microbial plaque buildup and oral hygiene estimates based on the Simple Hygiene Score were determined in the region of the maxillary and mandibular incisors and canines. The QLF-D diagnosis allows one to detect even slight dental plaque buildup in red fluorescence, as shown as blue pseudo-stain (Fig. 4).

The quantitative light-induced fluorescence (QLF) method enabled the noninvasive, quick, objective determination of the patients' oral hygiene status (Fig. 5).

Quantitative and qualitative assessment of dental plaque in surveyed individuals is provided in points (range 0–5 points) (Table 3).

Based on the Simple Hygiene Score it was determined that the values were 0–2 points, when the caries intensity was very low or low. When the caries intensity was medium, the Simple Hygiene Score varied between 1 and 5 points, when it was high — 2–5 points, when it was very high — between 3 and 5 points (Fig. 6).

DISCUSSION

In the study we determined hygienic indices in patients with different caries intensity using conventional methods and the quantitative light-induced fluorescence technique. According to the data obtained, when the caries intensity was very low, the Simple Hygiene Score corresponded to 0 and 1

Fig. 2. Patient A., 22 years. Photo protocol of oral hygiene status assessment. DMF — 3, Green-Vermillion index — 0.5, Quigley Hein index — 0.92

(Green-Vermillion — 0.4 ± 0.12, Quigley Hein — 0.2 ± 0.07) ($p < 0.05$). SHS values of 1 and 2 points corresponded to low caries intensity (Green-Vermillion — 0.5 ± 0.23, Quigley Hein — 0.2 ± 0.14) ($p < 0.05$). In these groups, the clinical index values suggest good individual oral hygiene. When the caries intensity is medium, the Simple Hygiene Score varies between 1 and 5 points (Green-Vermillion — 1.2 ± 0.27, Quigley Hein — 1.4 ± 0.32). High caries intensity is characterized by the SHS 2–5 points (Green-Vermillion — 1.5 ± 0.31, Quigley Hein — 1.5 ± 0.28). Very high caries intensity is characterized by the Simple Hygiene Score 3–5 points (Green-Vermillion — 2.3 ± 0.43, Quigley Hein — 2.1 ± 0.35) ($p < 0.05$).

According to the data provided by a number of authors, SHS 0 indicates good oral hygiene status, while SHS 5 indicates poor status [17]. Our study has shown that SHS values of 0, 1, and 2 corresponded to good oral hygiene status. However, the dental plaque distribution and production within the dental arch can vary considerably, as reflected by the Simple Hygiene Score values.

There is a report of the QLF-D limitation when used to assess general oral status. This is due to the fact that QLF reflects well the diagnosis in the region of frontal maxillary and mandibular teeth. Thus, measurement in the region of maxillary molars, as well as on the palatal and lingual tooth surface, it limited due to complexity of taking images of these regions [18]. Our findings have shown that SHS determination in the region of the frontal group of teeth enables quick and reliable detection of microbial plaque buildup. It should be noted that for a number of indices it is necessary to determine dental plaque on the lingual/palatal tooth surface, which is more convenient to do using a probe.

No need to stain dental deposits should be considered an advantage of the method [19].

CONCLUSIONS

It is reasonable to use the QLF method for screening aimed to estimate the patients' individual oral hygiene.

Table 2. Oral hygiene status indices, M ± sd

Caries intensity	Green-Vermillion index	Quigley Hein index
Very low	0.4 ± 0.12	0.2 ± 0.07
Low	0.5 ± 0.23	0.2 ± 0.14
Medium	1.2 ± 0.27	1.4 ± 0.31
High	1.5 ± 0.31	1.5 ± 0.28
Very high	2.3 ± 0.43	2.1 ± 0.35

Fig. 3. Patient K., 27 years. Clinical assessment of hygienic indices. DMF — 8, Green-Vermillion index — 1.7, Quigley Hein index — 3.3

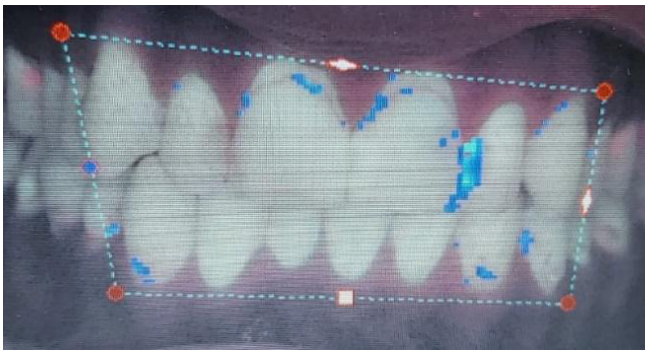

Fig. 5. Patient M., 25 years. The areas covered with dental plaque are analyzed using the software tool. DMF — 13. SHS — 2, area of bacterial activity (Area ΔR) — 30% — 4[%]

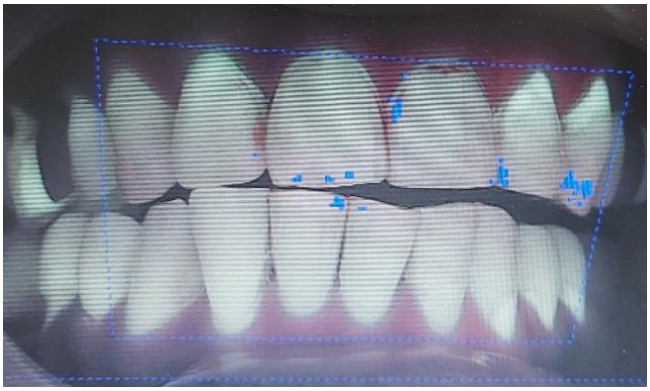

Fig. 4. Patient N., 32 years. Results of the oral hygiene status QLF diagnosis. DMF — 10. SHS — 1, area of bacterial activity (Area ΔR) — 30% — 1[%]

Fig. 6. Patient A., 21 years. Dental plaque assessment involving the use of QLF diagnosis. DMF — 7. SHS — 5, area of bacterial activity (Area ΔR) — 30% — 34[%].

Table 3. Simple Hygiene Score (SHS) in surveyed individuals

Caries intensity	Number of surveyed individuals	Simple Hygiene Score (SHS)
Very low	3	0
	9	1
Low	13	1
	15	2
Medium	2	1
	13	2
	23	3
	22	4
	12	5
High	1	2
	23	3
	25	4
	27	5
Very high	2	3
	5	4
	9	5
Total	204	

The quantitative light-induced fluorescence objectively and transparently reflects the dental plaque buildup and allows one to assess the dynamic changes in SHS. However, the issue of the clinical significance of determining the area of bacterial activity on dental restorations is still poorly understood.

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