



Application of QLF technology for assessing the oral hygiene status of children living in residential care institutions

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Abstract

INTRODUCTION. Modern approaches to the prevention of dental diseases in children require the use of objective methods for assessing oral hygiene, particularly in socially vulnerable groups.

AIM. The aim of this study was to evaluate the effectiveness of quantitative light-induced fluorescence (QLF) technology in assessing oral hygiene status in children living in residential care institutions.

MATERIALS AND METHODS. The study included 207 students of boarding schools in the Yaroslavl and Moscow regions and 197 children living in families (control group). The observation period lasted 24 months. Examination was carried out before and after the implementation of a comprehensive preventive program, which included instruction in proper oral hygiene techniques, motivational sessions, and supervision of individual oral care. The Qscan (QLF) system, the IGR-U oral hygiene index (modified Green–Vermillion index), and clinical assessment of periodontal tissues (PMA index) were used.

RESULTS. A statistically significant reduction in the area and intensity of fluorescent dental plaque was observed in children from residential care institutions after the program ($p < 0.05$), accompanied by improvement in hygiene indicators. In the control group, positive changes were present but less pronounced.

CONCLUSIONS. QLF technology enabled early detection of hygiene deficiencies and provided more precise monitoring of individual preventive measures compared with visual methods. The findings support the inclusion of QLF in clinical monitoring protocols for oral health in children living in residential care institutions.

Key words: QLF diagnostics, oral hygiene, institutionalized children, caries prevention, Qscan, residential care facilities, hygiene index, pediatric dentistry

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Применение технологии QLF в оценке гигиенического статуса детей, проживающих в учреждениях интернатного типа

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Резюме

ВВЕДЕНИЕ. Современные подходы к профилактике стоматологических заболеваний у детей требуют применения объективных методов контроля гигиенического состояния полости рта, особенно в группах социального риска.

ЦЕЛЬ РАБОТЫ. Изучение эффективности технологии количественной световой люминесценции (QLF) при оценке уровня гигиены полости рта у детей, проживающих в учреждениях интернатного типа.

МАТЕРИАЛЫ И МЕТОДЫ. В исследование включены 207 воспитанников школ-интернатов Ярославской и Московской областей и 197 школьников, проживающих в семьях (контрольная группа). Период наблюдения составил 24 месяца. Оценка проводилась до и после комплексной программы профилактики, включавшей обучение навыкам рациональной гигиены, мотивационные занятия и контроль индивидуального ухода. Использовались аппарат Qscan (QLF), индекс ИГР-У и клиническая оценка состояния тканей пародонта (индекс РМА).

РЕЗУЛЬТАТЫ. Наблюдения продемонстрировали достоверное уменьшение площади и интенсивности флюоресцирующего налета у детей из интернатных учреждений после внедрения программы

($p < 0,05$), что сопровождалось улучшением гигиенических показателей. В контрольной группе положительная динамика была выражена менее значительно.

ВЫВОДЫ. Применение QLF позволило выявлять ранние нарушения гигиены и оценивать качество индивидуальных профилактических мероприятий более точно, чем визуальные методы. Полученные данные подтверждают целесообразность включения QLF-технологии в программу клинического мониторинга стоматологического здоровья воспитанников интернатных учреждений.

Ключевые слова: QLF-диагностика, гигиена полости рта, дети-сироты, профилактика кариеса, Qscan, интернатные учреждения, индекс ИГР-У, детская стоматология

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INTRODUCTION

The preservation of children's oral health remains a critical objective of both clinical and social dentistry, as the prevalence of dental caries and inflammatory periodontal diseases in the pediatric population continues to be high [1–3]. Particular attention is directed toward children living in residential care institutions, where lifestyle characteristics, limited opportunities for individual supervision, and insufficient motivation for oral hygiene contribute to an increased risk of developing dental pathology [4–6].

Traditional methods for assessing oral hygiene status, primarily based on clinical indices, are widely used in practice and have demonstrated their effectiveness. However, their diagnostic value may be reduced due to subjectivity in interpretation and dependence on the clinician's experience, which becomes especially significant during long-term monitoring of large organized groups [7; 8]. In recent years, objective digital technologies have gained increasing importance, enabling improved diagnostic accuracy and standardization of follow-up assessments [9; 10].

One such method is Quantitative Light-Induced Fluorescence (QLF), which is based on the detection of changes in the optical properties of dental hard tissues and bacterial biofilm. This technology allows the identification of early signs of demineralization, quantification of plaque area and density, and monitoring of preventive interventions over time [11; 12]. An additional advantage lies in its visual nature, which facilitates the development of children's conscious attitude toward oral hygiene – an important consideration when working with socially vulnerable populations [13; 14].

The QLF technique is grounded in the ability of dental hard tissues to emit a fluorescent signal when exposed to light of a specific wavelength. When the tooth surface is illuminated with blue light (approximately 405 nm), sound enamel exhibits a uniform greenish-yellow fluorescence, whereas demineralized areas demonstrate reduced fluorescence intensity due to mineral loss [15; 16].

Dental plaque and biofilm containing endogenous porphyrins emit a characteristic reddish-orange fluorescence, allowing both visual and quantitative differen-

tiation between plaque-accumulated areas and healthy tooth surfaces [5]. This optical contrast enables early detection of enamel changes and objective evaluation of oral hygiene quality.

Modern QLF systems, including the Qscan device, are equipped with software that automatically calculates the area and intensity of fluorescence and generates digital reports for longitudinal monitoring. Owing to its high sensitivity, non-invasive nature, and documentation capabilities, the method has become widely adopted in preventive and pediatric dentistry [9; 10; 17].

Another important advantage of QLF is its demonstrative character: visualization of plaque accumulation and demineralization areas enhances children's motivation to maintain proper oral hygiene, which is particularly relevant in residential care settings where individual supervision is limited [2; 18].

Despite the proven clinical utility of QLF, relatively few studies have investigated its application for systematic oral hygiene monitoring among children living in residential institutions [3; 19]. This underscores the need to further explore the role of QLF technology in evaluating the outcomes of comprehensive preventive programs aimed at improving the oral health status of children residing in institutional care settings.

AIM

Aim of the study – to determine the diagnostic value and practical effectiveness of Quantitative Light-Induced Fluorescence (QLF) technology in assessing the oral hygiene status of children living in residential care institutions during the implementation of a comprehensive preventive dental program.

OBJECTIVES OF THE STUDY

1. To conduct a comparative assessment of the baseline oral hygiene status in children residing in residential care institutions and their peers raised in family environments.

2. To evaluate changes in oral hygiene status among children in residential institutions during the implementation of a comprehensive preventive program.

3. To analyze the potential of QLF technology in detecting early signs of impaired oral hygiene and initial alterations in dental hard tissues.

4. To compare QLF diagnostic findings with traditional clinical indicators of oral hygiene status (OHI-S, PMA index).

5. To assess the role of QLF as a motivational tool for improving children's adherence to individual oral hygiene practices.

6. To determine the practical significance of QLF technology for monitoring the effectiveness of preventive interventions in residential child care institutions.

MATERIALS AND METHODS

The clinical component of the study was conducted between 2022 and 2024 at the Department of Therapeutic Dentistry, Institute of Dentistry, Pirogov Russian National Research Medical University, as well as during outreach preventive examinations in residential child care institutions of the Yaroslavl Region (Pereslavl-Zalessky, Solba settlement) and the Moscow Region (Dmitrov). A total of 404 children aged 6–12 years participated in the study.

Participants were divided into two main groups. The observation group consisted of children residing in social care institutions: the shelter at the Nikolo-Solbinsky Convent ($n = 73$), the Pereslavl-Zalessky Sanatorium Children's Home ($n = 69$), and the Dmitrov Residential Care Institution for Children with Physical Disabilities ($n = 65$). The control group included 197 schoolchildren from School No. 1206 (Moscow).

Children in both groups were further stratified into two age subgroups in accordance with World Health Organization recommendations: Subgroup A – children aged 6–9 years; Subgroup B – children aged 10–12 years. Group allocation was performed using random sampling among children who met the inclusion criteria.

Follow-up dental examinations were performed at baseline and during the implementation of the preventive program at 6, 12, and 24 months. Participation of children from residential institutions was based on official authorization from institutional administrations and voluntary assent of the child. In the family-based control group, written informed consent was obtained from parents or legal guardians.

Inclusion criteria:

- age 6–12 years;
- mixed or permanent dentition (fully primary dentition was excluded);
- consent of the child and legal representatives/institutional administration.

Exclusion criteria:

- refusal of participation by the child or legal guardians;
- age below 6 or above 12 years;
- acute diseases or exacerbation of chronic conditions.

During the observation period, children in residential institutions participated in a comprehensive preventive program that included:

- theoretical instruction on individual oral hygiene practices;
- practical training in toothbrushing techniques with supervised performance;

- regular motivational sessions;

- monitoring of the use of personal oral hygiene products (toothbrush, toothpaste, and additional aids).

Children living in family settings did not receive additional preventive interventions beyond routine school-based dental examinations.

Oral hygiene status was assessed using Quantitative Light-Induced Fluorescence (QLF) with the Qscan device. Examinations were performed under standardized clinical conditions in accordance with the manufacturer's recommendations. The area and intensity of plaque fluorescence were analyzed on the vestibular surfaces of the maxillary anterior teeth and premolars.

The following clinical indices were used for comparative assessment:

- the Simplified Oral Hygiene Index (OHI-S; Green-Vermillion modification);
- the PMA index for evaluation of periodontal tissue status.

Each examination required no more than 15 minutes. All data were recorded using a unified protocol, and photographic materials were archived. Statistical analysis was performed using standard methods of variation statistics. Differences were considered statistically significant at $p < 0.05$.

RESULTS

During the 24-month follow-up period, data were obtained reflecting changes in oral hygiene status among children living in residential care institutions and those residing in family settings.

At baseline, children from residential institutions demonstrated significantly higher values of the Simplified Oral Hygiene Index (OHI-S), averaging 2.06 ± 0.22 , compared with 1.22 ± 0.09 in the control group of schoolchildren. The PMA index also indicated more pronounced inflammatory changes of the marginal periodontium in institutionalized children ($31.4 \pm 2.0\%$) versus $12.5 \pm 1.2\%$ in the control group ($p < 0.05$).

Assessment of oral hygiene using the OHI-S at baseline revealed that children from two residential institutions (the shelter at the Nikolo-Solbinsky Convent and the Pereslavl-Zalessky Sanatorium Children's Home) had a mean OHI-S score of 1.81 ± 0.12 , corresponding to a fair level of oral hygiene. In contrast, children from the Dmitrov Residential Care Institution demonstrated significantly higher values (2.55 ± 0.27), indicating poor oral hygiene at the start of the study.

After 24 months, marked positive dynamics were observed in the first two institutions within the observation group: the OHI-S decreased to 0.75 ± 0.10 , corresponding to a good level of hygiene. In the Dmitrov institution, the OHI-S decreased to 1.77 ± 0.09 ; although this reflected improvement, the hygiene level remained unsatisfactory.

Analysis of periodontal tissue status using the PMA index demonstrated a high prevalence of gingival inflammation among children deprived of parental care. At baseline, the mean PMA value was $31.4 \pm 2.0\%$, decreasing to $19.7 \pm 5.2\%$ after 24 months, indicating a substantial reduction in inflammatory signs and

improvement in oral hygiene skills among institutionalized children.

In the control group, positive dynamics were also observed, though less pronounced. In Subgroup A, the OHI-S decreased from 1.31 ± 0.52 to 1.25 ± 0.19 , and the PMA index decreased from $11.31 \pm 0.28\%$ to $9.92 \pm 0.78\%$. In Subgroup B, the OHI-S decreased from 1.12 ± 0.32 to 1.07 ± 0.02 , while the PMA index decreased from $13.65 \pm 0.02\%$ to $12.28 \pm 0.66\%$ (Tables 1, 2).

QLF visualization (Qscan device) initially revealed pronounced fluorescent zones in the cervical regions of anterior teeth in 100% of children from residential institutions, confirming a low level of oral hygiene and the presence of early enamel demineralization areas (Fig. 1).

After 24 months, fluorescence intensity in the same regions was substantially reduced, visually confirming a decrease in bacterial plaque accumulation and enamel stabilization. However, abundant soft dental plaque was still detected in 22% of institutionalized children (Fig. 2).

The longitudinal observation demonstrated that the application of QLF technology allows not only objective monitoring of changes in oral hygiene status but also effective use of visualization for educational purposes. Children who participated in motivational sessions involving demonstration of their individual QLF images showed greater engagement and adherence to oral hygiene practices.

Table 1. Simplified oral hygiene index (OHI-S) values of the study participants

Таблица 1. Показатели индекса гигиены ИГР-У участников исследования

Institution	Subgroup	Baseline	6 months	12 months	24 months
Shelter at the Nikolo-Solbinsky Convent	A	1.72 ± 0.90	0.83 ± 0.10	0.56 ± 0.02	0.52 ± 0.12
	B	1.70 ± 0.10	0.74 ± 0.12	0.48 ± 0.02	0.39 ± 0.14
Pereslavl-Zalessky Sanatorium Children's Home, Yaroslavl Region	A	1.98 ± 0.09	1.38 ± 0.14	1.12 ± 0.09	1.14 ± 0.03
	B	1.84 ± 0.14	0.94 ± 0.03	0.92 ± 0.08	0.94 ± 0.03
Dmitrov Residential Care Institution for Children with Physical Disabilities, Moscow Region	A	2.17 ± 0.02	2.12 ± 0.15	1.85 ± 0.90	1.67 ± 0.03
	B	2.93 ± 0.02	2.57 ± 0.15	2.33 ± 0.09	1.87 ± 0.15
School No. 1206, Moscow	A	1.31 ± 0.52	1.29 ± 0.52	1.23 ± 0.31	1.25 ± 0.19
	B	1.12 ± 0.32	1.14 ± 0.62	0.94 ± 0.57	1.07 ± 0.02

Table 2. Assessment of periodontal tissue status (PMA index) in study participants

Таблица 2. Оценка состояния тканей пародонта (PMA) участников исследования

Institution	Subgroup	Baseline	6 months	12 months	24 months
Shelter at the Nikolo-Solbinsky Convent	A	28.10 ± 0.36	16.92 ± 0.72	13.28 ± 0.78	11.52 ± 0.03
	B	24.70 ± 0.92	11.49 ± 0.63	7.08 ± 0.94	6.81 ± 0.51
Pereslavl-Zalessky Sanatorium Children's Home, Yaroslavl Region	A	31.56 ± 0.67	19.14 ± 0.74	17.7 ± 0.29	16.13 ± 0.11
	B	28.90 ± 0.19	17.61 ± 0.66	13.94 ± 0.61	12.64 ± 0.38
Dmitrov Residential Care Institution for Children with Physical Disabilities, Moscow Region	A	38.20 ± 0.47	33.8 ± 0.28	34.10 ± 0.19	34.8 ± 0.35
	B	36.92 ± 0.82	35.08 ± 0.71	35.16 ± 0.45	36.42 ± 0.38
School No. 1206, Moscow	A	11.31 ± 0.28	10.61 ± 0.08	10.08 ± 0.03	9.92 ± 0.78
	B	13.65 ± 0.02	12.28 ± 0.94	11.61 ± 0.67	12.28 ± 0.66



Fig. 1. Identification of dental plaque at baseline using the Qscan device

Рис. 1. Идентификация зубного налета в начале исследования при помощи аппарата Qscan



Fig. 2. Identification of dental plaque after 24 months of follow-up using the Qscan deviceю

Рис. 2. Идентификация зубного налета спустя 24 месяца исследования при помощи аппарата Qscan

The obtained results are consistent with both international and domestic studies confirming the high sensitivity of the QLF method in monitoring the condition of dental hard tissues and the quality of oral hygiene. Unlike subjective indices, QLF technology enables detection of minimal changes in biofilm structure, which supports its integration into preventive programs in organized child populations.

DISCUSSION

The comprehensive study conducted among children residing in residential care institutions and schoolchildren living in family settings demonstrated statistically significant differences in baseline dental status between the groups. Institutionalized children exhibited higher values of the Simplified Oral Hygiene Index (OHI-S) and the PMA index, as well as a greater area of fluorescent plaque according to QLF assessment, reflecting insufficient individual oral hygiene and more pronounced inflammatory changes in periodontal tissues.

Implementation of a comprehensive preventive program, including oral hygiene education, regular motivational supervision, and monitoring using QLF technology, resulted in a significant improvement in the oral hygiene status of children from residential institutions. After 24 months of follow-up, a statistically significant reduction in OHI-S and PMA values was recorded ($p < 0.05$), along with a 78% decrease in plaque fluores-

cence intensity, indicating the high effectiveness of the proposed intervention.

Application of Quantitative Light-Induced Fluorescence (QLF) provided an objective assessment of oral hygiene status and enabled detection of even minimal changes in the structure of the bacterial biofilm. Visualization of plaque accumulation and demineralization areas enhanced the educational impact of preventive measures and strengthened children's motivation to adhere to individual oral hygiene practices.

The findings confirm the high sensitivity and reproducibility of the QLF method for longitudinal monitoring of oral health status. Integration of this technology with conventional index-based assessments expands the diagnostic capabilities of the clinician and improves the accuracy of clinical interpretation at early stages of pathological development.

CONCLUSION

QLF technology may be regarded as a promising tool for integration into routine preventive dental examinations of children residing in residential care institutions, as it combines high diagnostic value, safety, visual clarity, and educational potential.

Incorporation of this method into pediatric preventive dentistry practice can enhance the quality of clinical monitoring and improve the effectiveness of oral hygiene education programs, particularly within socially vulnerable populations.

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