ORIGINAL ARTICLE

https://doi.org/10.5125/jkaoms.2024.50.6.333
pISSN 2234-7550 · eISSN 2234-5930

Assessment of oral health status in intensive care unit patients using quantitative light-induced fluorescence: a multicenter cross-sectional study

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Abstract (J Korean Assoc Oral Maxillofac Surg 2024;50:333-342)

Objectives: The aim of this study was to evaluate oral hygiene using quantitative light-induced fluorescence (QLF) and to compare its results with those of oral examination to determine the applicability of QLF technology for assessing oral health status and oral hygiene in intensive care unit (ICU) patients.

Materials and Methods: We analyzed oral health status, oral examination findings, oral hygiene evaluations using QLF technology, and dry mouth in a sample of 70 hospitalized ICU patients. The relationship between oral hygiene assessments using QLF technology and oral examinations was analyzed using Pearson correlation coefficients.

Results: The average participant age was 62.16 years, and the average ICU hospitalization period was 144.94 days. Oral hygiene assessments based on QLF and examination showed a significant positive correlation with the red fluorescence intensity of oral biofilm and number of teeth requiring extraction.

Conclusion: Oral hygiene evaluations of hospitalized ICU patients using QLF technology were confirmed and classified based on the red fluorescence intensity of oral biofilm. Increases in red fluorescence intensity and distribution area were correlated with the number of teeth requiring extraction.

Key words: Intensive care units, Oral care, Oral health, Oral hygiene assessment, Quantitative light-induced fluorescence technology

[paper submitted 2024. 6. 26 / revised 2024. 8. 18 / accepted 2024. 8. 26]

I. Introduction

The incidence and prevalence of healthcare-associated infections are increasing as medical technology advances[1-3]. The most common and deadly infections involve the respiratory tract, and these have the most significant impact on patients admitted to intensive care units (ICUs)[2,4,5]. Inadequate oral care can lead to an imbalance in the oral microbiome and promote the formation of dental plaque and pathogenic bacterial colonies, turning dental tissues into reservoirs for pathogen dissemination[6]. This can increase the likelihood of disease reaching the lungs and other organs, and impair overall systemic conditions[7,8]. The oral hygiene status of patients in ICUs is reportedly closely associated with aspiration pneumonia and ventilator-associated pneumonia (VAP)[9-11].

The most common cause of nosocomial infection in the ICU environment and the second most common hospital-acquired infection, VAP is often caused by bacteria that colonize the mouth and dental plaque, increasing the duration of mechanical ventilation and hospital stays, and leading to high mortality rates. It is a serious medical condition that carried a 33%-50% risk of death[12]. Several studies have reported that improving oral hygiene through active interventions can reduce the risk of VAP[11]. A systematic review and meta-analysis published in 2020 found that professional dental care can also reduce the risk of non-VAP pneumonias[13]. Most oral-health assessment criteria traditionally follow the oral assessment guide proposed by Eilers et al.[14], recommending consultation with an oral healthcare specialist in cases of pain, tooth mobility, bleeding

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during brushing, gingival swelling, dental calculus, discoloration of the teeth or tongue, and improper dental prosthesis[15]. However, it may be difficult for nurses to make such assessments while performing their duties in the challenging environment of the ICU. Easily applicable and effective methods for assessing the oral health of hospitalized patients are therefore needed. Quantitative light-induced fluorescence (QLF) visualizes dental caries, tooth fractures, and dental plaque by detecting porphyrins, the metabolic products of cariogenic bacteria, using visible light at 450 nm[16-19]. Because it operates on the principle of a camera in a non-invasive manner from outside the body, QLF can be used by nurses to visually display bacterial lesions in the mouths of hospitalized patients[20,21]. The aim of this study was to evaluate oral hygiene using QLF and analyze any correlation between such evaluations and oral examination, in an effort to confirm the applicability of QLF technology to the assessment of oral health and hygiene in hospitalized patients in ICUs.

II. Materials and Methods

1. Study design

This study was a multicenter cross-sectional evaluation of the oral health of patients hospitalized in the ICU. This observational study involved four research institutions and 70 participating patients from June 15 to October 31, 2021.

2. Participants and data collection procedures

Adult patients (aged 19 years or older) hospitalized in the ICU who gave consent to participate in the study after the purpose and process of the study was explained to them or their guardians were selected as research subjects if they had at least one untreated tooth remaining in the mouth and required oral care (mouth breathing, gingivitis, or periodontitis). Patients were excluded if they had congenital malformations of the oral and maxillofacial region; were hospitalized in an ICU by a dental attending physician; or had medical conditions (uncontrolled general condition, uncontrollable involuntary facial muscle stiffness or movement) that precluded an oral examination.

3. Measurements

1) Medical record data collection

General characteristics related to ICU hospitalization, such as the patients' hospitalization period, ICU type, state of consciousness, and tracheal intubation type, were collected from electronic medical records.

2) Evaluation of oral health using visual inspection

A workshop was conducted to evaluate the oral health of the participants using visual inspection, and judgment criteria were applied by the dentist in charge of each institution before the oral examination. The oral examination evaluated decayed and missing teeth. Teeth affected by periodontitis were operationally evaluated based on tooth mobility and bleeding on probing and were classified and recorded as periodontitis teeth. Finally, participants requiring dental treatment were classified by calculating the number of decayed, missing, and periodontitis permanent teeth (DMPT) index, which counts the number of teeth affected by dental caries and fractures, tooth loss, and periodontitis. Oral candidiasis and dry mouth were also evaluated. The need for extraction was based on observation of moderate to severe periodontitis and mobility, root caries, or fractures extending to the root.

3) Optical oral hygiene evaluation using QLF technology

Oral hygiene evaluations of the tongue and tooth surface were performed by QLF using a Qraypen C oral camera (AIOBIO), and images were taken and analyzed by a trained examiner (M.K.J.). The QLF device operates in a manner similar to that of a camera. For accurate assessments, it is essential to create an environment in which only the QLF light source is accessible, without interference from other light sources. The imaging area should be dry and free of any liquids, such as saliva. To evaluate the tongue coating, the dorsal anterior third of the tongue's surface was photographed and classified into one of three groups using a QLF tongue coating score of 0-2 according to the presence and intensity of red fluorescence on the resulting image.(Fig. 1) Next, to evaluate oral biofilms, representative teeth in the quadrant were photographed based on the buccal surface of the tooth in the rearmost part of the intra oral. They were classified into four groups according to the presence and distribution area of red fluorescence.(Fig. 2)

4) Dry mouth evaluation using an oral moisture-measuring device

Mucus (approval number: 22200BZX00640000; Life) was used to evaluate the dryness of the tongue and oral mucosa. (Fig. 3) To evaluate the participant's dry mouth pattern, the average of three measurements was calculated following

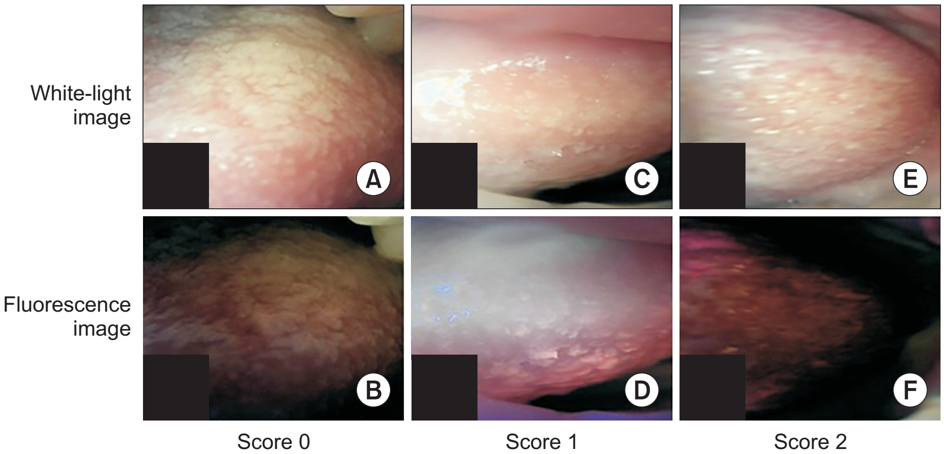

Fig. 1. Representative images of quantitative light-induced fluorescence (QLF) scoring system for tongue coating. A, B. QLF tongue coating score 0 (no red fluorescence visible). C, D. QLF tongue coating score 1 (red fluorescence slight glow extending around dorsal surface of tongue). E, F. Tongue coating score 2 (red fluorescence strong glow extending around dorsal surface of tongue). A, C, E. White-light image of QLF. B, D, F. Fluorescence image of QLF.
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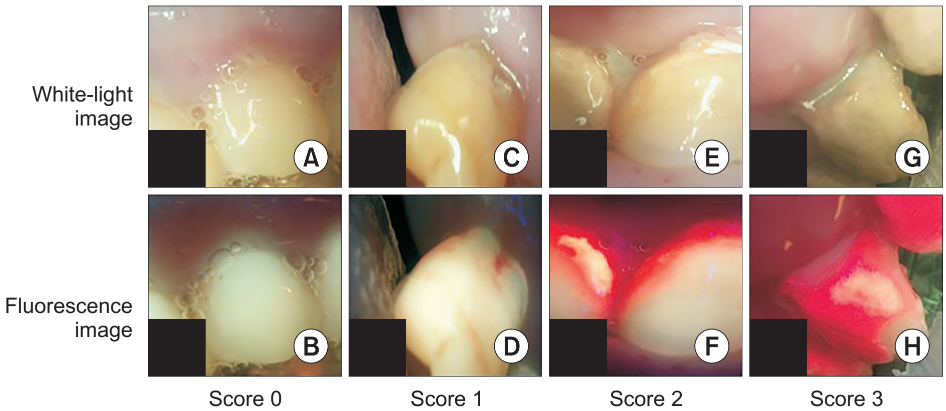

Fig. 2. Representative images of quantitative light-induced fluorescence (QLF) scoring system for oral biofilm used for buccal tooth surface. A, B. QLF oral biofilm score 0 (no red fluorescence visible). C, D. QLF oral biofilm score 1 (red fluorescence liner glow extending around surface of tooth). E, F. Oral biofilm score 2 (red fluorescence within 1/3 of the coronal portion glow extending around surface of tooth). G, H. Oral biofilm score 3 (red fluorescence over 1/3 of the coronal portion glow extending around surface of tooth). A ,C, E, G. White-light image of QLF. B, D, F, H. Fluorescence image of QLF.
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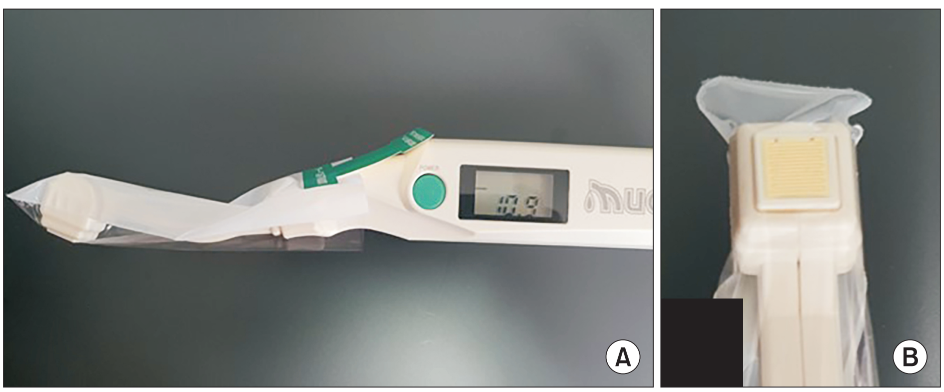

Fig. 3. Oral moisture measuring device. A. Oral moisture measuring device body (Mucus, approval number: 22200BZX00640000; Life). B. Oral mucosa and tongue contact sensors.
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the manufacturer's instructions. Then, the sensor was gently placed in contact with the dorsal surface of the tongue and the buccal mucosa to measure dryness. The dryness level was displayed as a numerical value on the Mucos device, with lower numbers indicating greater dryness. A measurement value of 27.0 or higher was classified as normal, and a value of 0-26.9 was classified as dry mouth.

4. Statistical analysis

Statistical analysis of the collected data was performed using SPSS software (IBM SPSS Statistics ver. 25.0 for Windows, IBM). The general characteristics of patients hospitalized in the ICU, visual inspection, and oral-health evaluation using QLF technology were analyzed using frequency analysis and descriptive statistics. A chi-square test and a one-way analysis of variance were performed to determine the differences in oral health status evaluation results according to the ICU hospitalization period. Post hoc tests were analyzed using the Duncan tool. The correlation between ICU variables and oral examination variables was analyzed using a Pearson correlation coefficient.

5. Ethical considerations

Ethical approval for the study was obtained from the Institutional Ethics Review Committee of Ajou University Hospital (approval number: AJIRB-MED-OBS-21-244). All participants or their guardians supplied consent before participating in the study. Information on research subjects obtained through oral examinations was not used for any purpose other than this research, and anonymity and confidentiality were assured. This study was reported in accordance with the Strengthening Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Table 1. General characteristics of ICU patients (n=70)

Variable	Mean±SD	n (%)
Age (yr)	62.16±18.63	
Sex		
Male		51 (72.9)
Female		19 (27.1)
Level of consciousness		
Unconscious		40 (57.1)
Conscious		30 (42.9)
ICU length of stay (day)	144.94±519.72	
Type of ICU		
Medical		45 (64.3)
Surgical		25 (35.7)
Duration of intubation (day)	155.21±497.25	
Types of intubations		
Doesn't exist		24 (34.3)
Oral		33 (47.1)
Tracheal		8 (11.4)
Nasal		5 (7.2)
Type of nutrition supply		
Fast		8 (11.4)
Oral		19 (27.1)
Vein		16 (22.9)
L-tube		27 (38.6)

(ICU: intensive care unit, SD: standard deviation)

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III. Results

1. General characteristics of the participants

The average age of the 70 participants was 62.16 years. Males accounted for 72.9% of the study group and females 27.1%. Patient level of consciousness was 'unconscious' in 57.1% and 'conscious' in 42.9%. ICU type was 64.3% medical and 35.7% surgical, and the average ICU hospitalization period was 144.94 days.(Table 1)

2. Oral examinations using visual inspection

In oral examinations using visual inspections, the average number of missing teeth per person was 7.06 and the number of teeth affected by periodontitis was 5.23. One or more dental treatments were required by 81.4% of participants, with 57.1% needing scaling and 5.7% reporting oral candidiasis.(Table 2)

3. Assessment of oral hygiene using QLF

The presence of red fluorescence on the dorsal surface of the tongue was observed in 58.6% of participants in fluorescence imaging. When classified according to fluorescence

Table 2. Oral examination using visual inspection of ICU patients (n=70)

Variable	Mean±SD	n (%)
Oral examination		
No. of remaining teeth	20.40±9.17	
No. of caries teeth	0.63±1.37	
No. of missing teeth	7.06±8.73	
No. of teeth requiring extraction	1.00±2.31	
No. of teeth associated with periodontitis symptoms	5.23±7.15	
Need for dental treatment		
None		13 (18.6)
Present		57 (81.4)
Need for caries treatment		
None		54 (77.1)
Present		16 (22.9)
Need for extraction treatment		
None		53 (75.7)
Present		17 (24.3)
Need for scaling treatment		
None		30 (42.9)
Present		40 (57.1)
Need for periodontal flap surgery treatment		
None		60 (85.7)
Present		10 (14.3)
Need for oral candidiasis treatment		
None		66 (94.3)
Present		4 (5.7)

(ICU: intensive care unit, SD: standard deviation)

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Table 3. Assessment of oral hygiene using QLF technology (n=70)

Variable	n (%)
Tongue coating	
No red fluorescence	22 (31.4)
Red fluorescence exists	41 (58.6)
Not measurable	7 (10.0)
Classification according to red fluorescence intensity of tongue coating	
Score 0 (no red fluorescence)	22 (34.9)
Score 1 (slight red fluorescence)	25 (39.7)
Score 2 (strong red fluorescence)	16 (25.4)
Oral biofilm	
No red fluorescence	4 (5.7)
Red fluorescence exists	57 (81.4)
Not measurable	9 (12.9)
Classification according to red fluorescence intensity of oral biofilm	
Score 0 (no red fluorescence)	4 (6.6)
Score 1 (linear red fluorescence)	34 (55.7)
Score 2 (red fluorescence within 1/3 of the coronal portion)	17 (27.9)
Score 3 (red fluorescence over 1/3 of the coronal portion)	6 (9.8)

(QLF: quantitative light-induced fluorescence)

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intensity, “strong red fluorescence” was observed in 25.4% of patients. Red fluorescence originating from an oral biofilm on the buccal surface of the teeth was used to evaluate oral hygiene, with red fluorescence evident in 81.4% of cases. When classified according to intensity, “linear red fluorescence” was observed in 55.7% of participants, “red fluorescence within 1/3 of the coronal portion” was observed in 27.9%, and “red fluorescence over 1/3 of the coronal portion” was observed in 9.8%.(Table 3)

4. Assessment of dry mouth using an oral moisture-checking device

In assessment of dry mouth, the average measurement value of the dorsal surface of tongue was 23.40 and the average measurement value of the buccal mucosa was 28.95. In assessment of dry mouth based on the cut-off value for diagnosing dry mouth, dryness of the tongue was found to be 51.4% and dryness of the buccal mucosa was 20.0%. We found that 55.7% of the participants were experiencing dry mouth, as assessed based on the presence of dryness in at least one area of the tongue or buccal mucosa.(Table 4)

5. Differences in oral examination and oral hygiene assessment according to ICU hospitalization period

A statistically significant difference in the assessment of oral health status was evident in visual inspections according to ICU hospitalization in the “number of teeth associated with periodontitis symptoms,” and 10.6 teeth were affected for “more than 14 days.” As for the difference in need for dental treatment, the “14 days or more” group showed the highest frequency in “need for scaling treatment,” at a statistically significant level.(Table 5)

Table 4. Assessment of dry mouth using an oral moisture-checking device (n=70)

Variable	Mean±SD	n (%)
Dryness of the tongue	23.40±9.88	
Classification of tongue dryness		
Normal		34 (48.6)
Dryness		36 (51.4)
Dryness of buccal mucosa	28.95±3.31	
Classification of dryness of buccal mucosa		
Normal		56 (80.0)
Dryness		14 (20.0)
Diagnosis of dry mouth		
Normal		31 (44.3)
Dry mouth		39 (55.7)

(SD: standard deviation)

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An assessment of oral hygiene using QLF according to the ICU hospitalization period revealed a higher frequency of red fluorescence on the tongue and tooth surface in the “more than 14 days” group, but the difference was not statistically significant.(Table 5)

6. Correlation between ICU hospitalization variables, oral hygiene using QLF technology, dry mouth, and oral examination

As a result of identifying the correlation between the ICU hospitalization period, tracheal intubation period, and oral examination variables, the “number of teeth associated with periodontitis symptoms” showed a significant positive correlation (r=0.636, $P<0.01$; r=0.603, $P<0.01$).

As a result of identifying the correlation between oral hygiene assessment based on QLF and oral examination variables, the red fluorescence intensity of oral biofilm and the total red fluorescence intensity in intra oral showed a significant positive correlation with the “number of teeth requiring extraction.”(Table 6)

IV. Discussion

In this study, we assessed the oral health status of ICU patients using QLF and oral-dryness detectors. A pathological oral biofilm was identified in 81.4% of patients via QLF, which aligns with the proportion of patients considered by

Table 5. Differences in oral examination and oral hygiene assessment according to ICU hospitalization period (n=70)

Variable	1-6 days (n=33)	7-13 days (n=14)	14 days or more (n=23)	*P*-value
Oral examination				
No. of remaining teeth	21.0±8.4	17.1±10.7	21.5±9.3	0.953
No. of caries teeth	0.6±1.4	0.6±1.3	0.7±1.4	0.978
No. of missing teeth	7.0±8.4	8.9±9.8	6.1±8.8	0.766
No. of teeth requiring extraction	0.8±2.1	1.3±1.9	1.0±2.9	0.728
No. of teeth related periodontitis	2.6±2.9[1]	2.6±4.5[1]	10.6±9.6[2]	<0.001
Need for dental treatment				
None	8 (24.2)	4 (28.6)	1 (4.3)	0.095
Present	25 (75.8)	10 (71.4)	22 (95.7)	
Need for caries treatment				
None	25 (75.8)	11 (78.6)	18 (78.3)	0.966
Present	8 (24.2)	3 (21.4)	5 (21.7)	
Need for extraction treatment				
None	27 (81.8)	7 (50.0)	19 (82.6)	0.043
Present	6 (18.2)	7 (50.0)	4 (17.4)	
Need for scaling treatment				
None	16 (48.5)	9 (64.3)	5 (21.7)	0.027
Present	17 (51.5)	5 (35.7)	18 (78.3)	
Need for periodontal flap surgery treatment				
None	28 (84.8)	13 (92.9)	19 (82.6)	0.657
Present	5 (15.2)	1 (7.1)	4 (17.4)	
Need for oral candidiasis treatment				
None	33 (100.0)	11 (78.6)	22 (95.7)	0.014
Present	0 (0.0)	3 (21.4)	1 (4.3)	
Tongue coating				
No red fluorescence	9 (40.9)	8 (36.4)	5 (22.7)	0.277
Slight red fluorescence	11 (44.0)	3 (12.0)	11 (44.0)	
Strong red fluorescence	6 (37.5)	3 (18.8)	7 (43.8)	
Oral biofilm				
No red fluorescence	2 (25.0)	2 (25.0)	0 (0.0)	0.234
Line-like red fluorescence	17 (20.6)	7 (11.8)	10 (29.4	
Red fluorescence within 1/3 of the coronal portion	4 (11.8)	3 (11.8)	10 (58.8)	
Red fluorescence over 1/3 of the coronal portion	3 (16.7)	1 (16.7)	2 (33.3)	
Classification of tongue dryness				
Normal	19 (57.6)	6 (42.9)	9 (39.1)	0.354
Dryness	14 (42.4)	8 (57.1)	14 (60.9)	
Classification of dryness of buccal mucosa				
Normal	29 (87.9)	10 (71.4)	17 (73.9)	0.293
Dryness	4 (12.1)	4 (28.6)	6 (26.1)	
Diagnosis of dry mouth				
Normal	17 (51.5)	6 (42.9)	8 (34.8)	0.460
Dry mouth	16 (48.5)	8 (57.1)	15 (65.2)	

(ICU: intensive care unit)
[1,2]Different letters within the same column indicate significant differences between groups according to Duncan post hoc analysis at α=0.05.
P-value obtained from a chi-square test and one-way ANOVA.
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Table 6. Correlation between ICU hospitalization variables, oral hygiene using QLF technology, dry mouth, and oral examination variables

Variable	No. of remaining teeth	No. of caries teeth	No. of missing teeth	No. of teeth requiring extraction	No. of teeth associated with periodontitis symptoms	Sum of need for dental treatment
ICU length of stay	0.208	0.119	–0.202	–0.113	0.636**	0.075
Duration of intubation	0.210	0.143	–0.203	–0.114	0.603**	0.086
Tongue coating	–0.155	0.041	0.132	0.133	–0.065	–0.037
Oral biofilm	0.038	0.085	–0.054	0.374**	0.113	0.190
Sum of red fluorescence	–0.031	0.133	0.002	0.320*	0.067	0.112
Dryness of tongue	0.211	0.110	–0.221	–0.001	0.101	0.003
dryness of buccal mucosa	0.148	0.031	–0.102	–0.137	–0.006	–0.190
Dry mouth	–0.112	–0.116	0.062	0.113	–0.056	0.049

(ICU: intensive care unit, QLF: quantitative light-induced fluorescence)
*P<0.05, **P<0.01 by Pearson's correlation analysis.
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oral and maxillofacial surgery specialists to be in need of dental treatment. More than half (57.1%) of these patients exhibited calculus formation, indicating that brushing alone was insufficient to manage the oral biofilm and that dental treatment was necessary. On average, active periodontitis was observed in 5.2 teeth per patient. Additionally, 24.3% of patients required extractions due to the potential presence of periapical abscesses, with an average of one tooth affected per patient. A significant correlation was found between the intensity of red fluorescence detected by QLF and the number of teeth requiring extraction (r=0.374, *P*<0.01), suggesting that QLF can accurately identify teeth at risk due to severe periodontal disease. This is particularly important for patients in an ICU, who often have limited access to oral care. Moreover, the study's data revealed a significant positive correlation between the length of ICU stay and the increase in the number of teeth affected by periodontitis (r=0.636, *P*<0.01). This correlation appears to reflect the impact of prolonged intubation and the subsequent accumulation of an oral biofilm, which can exacerbate periodontal disease. ICU patients, who struggle to maintain oral hygiene, are particularly vulnerable to accelerated progression of periodontal disease due to biofilm buildup. Early detection and continuous monitoring using QLF are therefore essential to effectively manage periodontal health in patients with extended ICU stays. These findings strongly suggest that QLF can play a crucial diagnostic role in the oral health management of ICU patients, particularly in the early detection and prevention of periodontal disease progression. The application of QLF in the ICU setting can not only enhance the quality of patient care but play a vital role in preventing tooth extractions due to severe periodontal disease.

Numerous studies have demonstrated the effectiveness of oral hygiene management, including the application of chlorhexidine (CHX), in preventing respiratory diseases. An analysis of the correlation between microbes collected from patients exposed to various durations of mechanical ventilation and those collected from respiratory samples found that oral microbes are associated with increased amounts of bacteria, including *Enterococcus faecalis, Fusobacterium periodonticum, Gemella morbillorum, Neisseria mucosa, Propionibacterium acnes, Prevotella melaninogenica, Streptococcus oralis, S. sanguinis, Treponema denticola, T. socransckii,* and *Veillonella parvula*, in the respiratory systems of patients who have used mechanical ventilation for long periods (>48 hours)[22]. These bacteria can move rapidly from the oral cavity to the lungs during oral intubation, contributing to the development of VAP[23]. Patients with oral intubation are therefore at higher risk for VAP and require more thorough oral hygiene management[24]. Patients in the ICU on mechanical ventilation, particularly those with poor oral hygiene, are exposed to the risk of VAP due to plaque accumulation[25]. Recent reviews of randomized controlled trials from 2008 to 2018 concluded that preventing VAP and managing oral hygiene in ICU patients are closely related and crucial to reducing patient mortality rates[25].

To effectively manage oral hygiene in ICU patients, various studies on the use of toothbrushes and oral functions have been presented. CHX, which is an oral agent, has demonstrated an antibacterial effectiveness of almost 75%-90% even when applied for only 15 seconds[26]. CHX is relatively easy for nurses to apply in the ICU environment for effective oral hygiene management and VAP prevention. Education on oral care and oral hygiene practices including CHX reportedly reduce the incidence of VAP[8,27,28]. However, oral hygiene management alone cannot effectively remove already pathologically formed biofilm, necessitating dental intervention. In cases of dental caries or moderate to severe periodontitis, even the use of 0.2% CHX is ineffective[29]. Various studies report that 65%-90% of ICU patients require operative interventions, and most require scaling, caries treatment, and extractions, as we found in this study[23,30-34]. Dentists providing aggressive oral care (scaling, periodontal surgery, dental caries treatment, and tooth extraction) to ICU patients have reported considerable success at preventing respiratory tract infections[10,13,35]. The primary diagnostic tool used in this study, QLF, is a non-invasive extracorporeal optical tool that can be easily applied by non-dental professionals and is highly effective with less than 1 minute of filming time per patient. It can also be used to analyze fluorescent patterns, compare oral hygiene methods' effectiveness, and visualize and remove oral biofilm in real-time[19,36]. QLF is an optical technique that utilizes blue visible light with a peak wavelength of 405 nm and coupled with a long-pass filter. This method enables the detection and characterization of dental plaque by identifying the red fluorescence emitted by porphyrins and bacterial metabolites within the biofilm[37]. By using QLF, clinicians can assess plaque presence and quantify the extent of red fluorescence without the need for any staining solutions[38,39]. Consequently, QLF offers a non-invasive approach to plaque detection, allowing for a more objective evaluation of oral hygiene status, particularly in challenging cases such as patients admitted to ICU[40].

In addition to oral biofilm, oral dryness caused by mouth breathing and oral candidiasis should be considered. This study's use of an oral moisture-checking device showed that 55.7% of patients exhibited oral dryness. Hyposalivation exposes teeth directly to acidic challenges from food, beverages, or acidogenic oral bacteria, leading to demineralization, which can result in dental erosion or caries[41,42]. Xerostomia has been indirectly related to gingival disease activity through the accumulation of dental plaque[43]. Dry mouth is also associated with oral candidiasis[44,45]. Although oral dryness is not directly an infectious state, it indicates a need for special oral care in ICU patients. Within the limitations of this study, this suggests that QLF and oral moisture-checking devices can be used for the primary screening of ICU patients who require aggressive dental treatment. Further research is needed on the impact of aggressive dental interventions in ICU patients to improve oral hygiene and prevent respiratory infections.

V. Conclusion

Inspection with QLF technology is an effective tool for evaluating oral hygiene in ICU patients, with the intensity of oral biofilm red fluorescence closely correlated with the need for dental operative interventions.

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Authors' Contributions

Conceptualization: all authors. Methodology: all authors. Software: M.K.J. Validation: Y.K. Formal analysis: Y.K. Investigation: M.K.J. Data curation: M.K.J. Writing—original draft preparation: all authors. Writing—review and editing: M.K.J. All authors have read and agreed to the published version of the manuscript.

Funding

This study was supported by the Armed Forces Capital Hospital (Grant No. 2021MDD0116).

Acknowledgements

We would like to thank all the intensive care unit nurses and the hospital dentistry research team for their cooperation in conducting this study, Prof. Jeong-Kui Ku for his assistance in evaluating the patient's oral and teeth condition, and Prof. Baek IL Kim and Dr. Hong-Chul Yoon for their support in applying the quantitative light-induced fluorescence technology.

Ethics Approval and Consent to Participate

This study was approved by the Institutional Review Board of Ajou University Hospital (approval number: AJIRB-MED-OBS-21-244, 14 June 2021). Informed consent was obtained from all participants involved in the study.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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How to cite this article: Kim Y, Jun MK. Assessment of oral health status in intensive care unit patients using quantitative light-induced fluorescence: a multicenter cross-sectional study. J Korean Assoc Oral Maxillofac Surg 2024;50:333-342. https://doi.org/10.5125/jkaoms.2024.50.6.333