Explaining the Red Fluorescence Evident on the Surface of Failed Dental Implants: Case Reports

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The survival of an implant involves not only the rehabilitation of masticatory function but also the management of the implant. A recent meta-analysis found that the prevalence of periimplantitis was 22% and that periimplant disease is associated with increased risk of implant failure. Several factors underlie implant failure, including the lack of osseointegration, periimplantitis, and overloading. An understanding of the risk factors associated with failure would aid the prevention of future complications and help in clinical decision making.

The incidence of periimplant disease is higher when the oral hygiene is worse. The key component for preventing periimplant disease is self-performed oral hygiene, but a significant proportion of people do not perform appropriate plaque control because they do not consider it necessary. Regular periodontal maintenance may prevent periimplant disease and reduce the implant failure rate.

There are now many quantitative devices used in dentistry for revealing the condition of the oral cavity. One of them is quantitative light-induced fluorescence (QLF) as detected with a digital single-lens reflex (SLR) camera (QLF-D), which involves detecting the red fluorescence emitted by porphyrin metabolized by oral bacteria in a mature biofilm.

**Introduction:** It is important to identify the reasons for implant failure when planning future dental treatment. No studies have distinguished the factors that affect implant failure by evaluating the appearance of failed fixtures.

**Purpose:** This study investigated these factors by evaluating the surface of implant fixtures using quantitative light-induced fluorescence-digital (QLF-D), which involves detecting the red fluorescence emitted by porphyrin metabolized by oral bacteria in a mature biofilm.

**Materials and Methods:** The areas of red fluorescence in QLF-D images obtained from all aspects of the fixture surface were then analyzed using quantitative analysis software.

**Results:** Red fluorescence was evident on the surface of implants that failed after at least 2 years of occlusal loading and exhibited severe bone loss. Implants with no fluorescence exhibited a clean surface in blue-light images, and the bone loss could not be observed radiographically.

**Conclusions:** The cases presented that failed dental implant surfaces caused by periimplantitis can be detected by the red fluorescence evident as QLF-D. (Implant Dent 2016;25:1–5)

**Key Words:** dental implant failure, periimplant disease, dental plaque, fluorescence
The aim of this case study was to assess implant failure through optical technology based on the fluorescence. In addition, we discuss which factors significantly influence dental implant failure and fluorescence on the implant surface.

**CASE REPORTS**

**QLF-D System**

Failed implants were imaged using a QLF-D system (QLF-D Biluminator; Inspektor Research Systems BV, Amsterdam, the Netherlands). All patients verbally agreed to the use of failed implant for research. This QLF-D system consists of an SLR camera and is equipped with light sources for producing white-light and blue-light images. Light-emitting diodes (LEDs) are positioned in a ring around the lens opening and filters. All aspects of the implant structure were captured under darkroom situations in the following QLF-D photography conditions: a shutter speed of 1/30 seconds, aperture value of 11.0, and ISO sensitivity of 1600 for white light; and a shutter speed of 1/45 seconds, aperture value of 3.2, and ISO sensitivity of 1600 for blue light. The failed implant was positioned 10 cm from the LEDs. The implant structures such as the fixture, abutment, and cover screw did not fluoresce under blue light. Fluorescence images obtained for each failed implant were analyzed automatically using the digital plaque patch analysis facility provided in the QLF-D software (QA2 v1.21; Inspektor Research Systems BV). An investigator used the software to manually draw an analysis patch surrounding the implant failure for each case. After drawing the patch, the relative redness of the plaque (ΔR) on the fixture surface was analyzed. The value of ΔR ranged from 30 to 120, and corresponds to the percentage difference in fluorescence between the redness of the plaque and the implant surface. The areas with the lowest redness (ΔR30) and the highest redness (ΔR120) were both determined using analysis software according to the red fluorescence intensity; ΔR120 corresponds to the redness exhibited by mature plaque and old calculus.

**Cases With Red Fluorescence**

**Case 1.** A 51-year-old male in good general health and a nonsmoker presented with a chief concern of periodontal disease (Table 1). Dental implants (Replace Select, 4.3 mm in diameter and 13 mm in length; Nobel Biocare AB, Göteborg, Sweden) were inserted in the maxillary left molar in January 2006. Three-unit cement-retained implant restorations were placed on the implants 5 months later. Eight years after implant placement, the patient noticed implant mobility and reported that he could not chew foods. A radiograph obtained before failure revealed periimplant radiolucency and severe bone resorption (Fig. 1). The probing depths were 6, 6, and 8 mm on the 3 unit bridges of the upper left molar. The implant mobility score was 3. In September 2014, an implant exhibiting extensive mobility was extracted with forceps and imaged using QLF-D under darkroom conditions. The white-light image revealed residue granulation tissue on the fixture (Fig. 2), which the red fluorescence in the blue-light image was present from the abutment margin down to the apex region of the implant body (Fig. 3). In particular, the surface of the failed fixture exhibited red fluorescence in the QLF-D image (Fig. 3), corresponding to where there was no remaining granulation tissue in the white-light image (Fig. 2). The fluorescence image was analyzed using QLF-D software, which revealed that the ΔR30 and ΔR120 areas constituted 70% and 58.6% of the implant surface, respectively.

**Case 2.** A 47-year-old male in good general health visited for placement of a dental implant. The implant (4.0 mm in diameter and 10.0 mm in length; Osstem Implant Co., Seoul, Korea, Table 1) was placed in the maxillary right second molar in August 2012, and a guided bone regeneration procedure was performed. The implant had been in place for 2 years. The probing depth before failure was 9 mm, and the mobility score was 3. A radiograph indicated bone resorption after removing the implant. The mobile implant was removed with forceps and then imaged by QLF-D. The white-light image indicated the presence of a calcified biofilm on the upper two-thirds of the fixture, and the blue-light image contained red fluorescence at that area. The red fluorescence was automatically analyzed using the QA2 software, which revealed that the ΔR30 and ΔR120 areas constituted 56% and 8% of the implant surface, respectively.

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**Fig. 1.** Case 1: radiograph obtained just before the implant fell out. Implants at maxillary left posterior site demonstrating bone loss caused by periimplantitis.

**Fig. 2.** Case 1: White light image of the implant. Removed implant structures revealed granulation tissue on the fixtures.

**Fig. 3.** Case 1: representative example of the QLF-D fluorescence image exhibited red autofluorescence on the periimplant.
Failed implants were categorized according to red autofluorescence. A guided bone regeneration procedure was performed at the site. The final delivery was performed in May 2012. Two years later, the patient visited with a chief concern of swelling gums. The patient was a smoker, and fair oral hygiene was revealed when the dental implant was removed. A radiograph of the implant revealed no bone loss (Fig. 4). The implant failed during an examination in May 2014. It was extracted and its structure was imaged by QLF-D. The fixture surface had virtually no residue and so appeared clean in the white-light image (Fig. 5), and no fluorescence was evident in the blue-light image (Fig. 6). Analysis of the fluorescence image using the QA2 software disclosed that the ΔR30 area constituted 7% of the implant surface. However, no gradient in the redness was revealed.

**Case 3.** A 49-year-old male presented for consultation with a root fracture in the mandibular right second molar in January 2012, and a dental implant (4.8 mm in diameter and 11.5 mm in length; Osstem Implant Co., Table 1) was immediately inserted. A guided bone regeneration procedure was performed at the site. The final delivery was performed in May 2012. Two years later, the patient visited with a chief concern of swelling gums. The patient was a smoker, and fair oral hygiene was revealed when the dental implant was removed. A radiograph of the implant revealed no bone loss (Fig. 4). The implant failed during an examination in May 2014. It was extracted and its structure was imaged by QLF-D. The fixture surface had virtually no residue and so appeared clean in the white-light image (Fig. 5), and no fluorescence was evident in the blue-light image (Fig. 6). Analysis of the fluorescence image using the QA2 software disclosed that the ΔR30 area constituted 7% of the implant surface. However, no gradient in the redness was revealed.

**Case 4.** A 50-year-old male patient with history of chronic periodontal disease and good general health visited with a chief concern of tooth mobility. In March 2013, a dental implant (4.5 mm in diameter and 10.0 mm in length; Osstem Implant Co., Table 1) was inserted in the left mandible in the area of the second premolar. The initial stability was good at implant placement, and a guided bone regeneration procedure was performed. A single implant crown was placed in July 2013. The patient visited for a regular checkup in September 2013 during which the implant was unexpectedly extracted. The patient was a heavy smoker at that time and had bruxism and fair oral hygiene. A radiograph obtained before the failure revealed periimplant radiolucency. The extracted implant was imaged using QLF-D. The fixture surface seemed clean in the white-light image, and no fluorescence was evident in the blue-light image. There was no fluorescence elsewhere on the implant, as for the fluorescence of the original fixture under blue-light.

**DISCUSSION**

This is the first study to have evaluated the surfaces of failed implants using QLF-D, which is able to detect the red fluorescence of bacterial porphyrin in a mature biofilm. The failed implants were classified into 2 categories according to the presence or absence of fluorescence. It was determined that the red fluorescence on failed implants was indicative of bacterial infection. It has previously been reported that illumination at 405 nm reveals accumulated dental plaque and calculus on teeth as red fluorescence. Furthermore, the darker red fluorescence was found to be indicative of more mature plaque. Periimplantitis is characterized by bone loss. If a microbial biofilm is left untreated, it may lead to bone loss around a dental implant. Roccuzzo et al reported that the lack of periodontal maintenance in severe periodontally compromised patients performed by an oral health specialist is associated with a failure rate of higher than 50%. Implants that exhibited red fluorescence had been placed more than 2 years previously. Typical signs and symptoms of periimplantitis are poor oral hygiene and severe bone loss. We found red fluorescence at the abutment that was associated with early biofilm formation and dental plaque accumulation. The fluorescence seems to first appear.

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Cases With Red Fluorescence</th>
<th>Cases With No Fluorescence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yrs/sex</td>
<td>51/male 47/male</td>
<td>49/male 43/male</td>
</tr>
<tr>
<td>Tooth site, no.</td>
<td>26 47</td>
<td>47 17</td>
</tr>
<tr>
<td>Fixture diameter and length, mm</td>
<td>4.3 × 13 4.0 × 10</td>
<td>4.8 × 11.5 6.0 × 8.5</td>
</tr>
<tr>
<td>Functioning time, yrs</td>
<td>8 2</td>
<td>2 1</td>
</tr>
<tr>
<td>Mobility</td>
<td>+++ +++</td>
<td>+++ +++</td>
</tr>
<tr>
<td>Oral hygiene</td>
<td>Very poor Poor</td>
<td>Fair Fair</td>
</tr>
</tbody>
</table>

Failed implants were categorized according to red autofluorescence.
at the implant crown and then moves down to the apex region of the implant body.\textsuperscript{11} It is considered that the accumulation of biofilm mass near the apex of the fixture is responsible for the periimplant bone loss (Figs. 2 and 3). Therefore, the presence of red fluorescence is a major factor indicative of failure because it indicates the bacterial contamination that leads to the development of periimplantitis.

However, Coulthwaite et al.\textsuperscript{15} reported that QLF can detect the red fluorescence on the tooth surface, but not the presence of plaque on denture teeth or other materials. In contrast, the use of QLF-D in this study could detect the distinct red fluorescence of dental plaque and calculus on a titanium implant fixture. The previous version of the QLF technology, which was equipped with a single filter, was insufficient for detecting the red fluorescence of bacterial metabolites, but the upgraded QLF-D that uses a modified filter set is optimized for detecting the red fluorescence of dental plaque. This means that it is now possible to effectively visualize the red fluorescence of a mature biofilm that has accumulated on a restoration.

Incremental dental care is an important factor for the successful outcome of an implant, in particular in guarding against dental implant failure due to periimplantitis. Patient should self-perform oral care and understand about self-management, because dental implant failure resulting from periimplant disease is caused by inadequate care.\textsuperscript{16} The cooperation of a patient in performing self-care can be facilitated by the patient being aware that their implant is in a poor condition and possibly at risk of implant failure. We consider that showing the red fluorescence on a failed implant structure to a patient—as performed in this case report—will encourage them to improve their self-management after reimplantation. This case report is the first to confirm that implant failure resulting from periimplantitis can be visualized as red fluorescence using QLF-D.

Failed dental implants in which no fluorescence manifests can be due to minor bone loss (as detectable by radiography) and fair oral hygiene. Such implants might function for less than 2 years. We attribute this failure to a lack of primary osseointegration,\textsuperscript{17} with smoking possibly also playing a role.\textsuperscript{18} Regarding the fourth case, bruxism among parafunctional habits is regarded as one of the possible causative factors for implant failure. Bruxing habits apply excessive occlusal loads to dental implants, which can even result in their failure.\textsuperscript{19} After considering all the causative factors, we assume that implant failure in cases where no fluorescence is evident on the implant surface are caused by multiple negative factors. We therefore consider that there are limitations in investigating the reasons for the dental implant failure in cases where no fluorescence is identified using QLF-D. Furthermore, clinical studies involving larger samples are needed to elucidate why some implants do not exhibit fluorescence. Also, patients should take special precautions as recommended by dental specialists to prevent implant failure, and dentists should try to diagnose the underlying condition before applying implant treatment.

Additional research is required to assess the relationship between the clinical diagnosis and the red fluorescence plaque on an implant according to the oral hygiene of a patient. Moreover, investigation of fluorescence is needed to confirm the potential of QLF-D as a predictive factor for investigating implant failure.

**CONCLUSIONS**

This case report has described the usefulness of the newly developed QLF-D based on fluorescence detection in investigating the causes of differences between dental implant failures due to periimplantitis or other causative factors. This report is the first on the ability of QLF-D in detecting bacterial red fluorescence on the surface of a failed dental implant.

**DISCLOSURE**

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

**References**


