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Case report

Clinical applications of a quantitative light-induced fluorescent (QLF) device in the detection and management of cracked teeth: A case report

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ABSTRACT

Introduction: The aim of this case report was to discuss the clinical application using a quantitative light-induced fluorescent (QLF) device for the diagnosis and treatment of a cracked tooth as visualizing the tooth's crack.
Case report: A 39-year-old woman visited a dental hospital complaining of throbbing pain on tooth #36. Observation of the tooth with naked eyes showed that tooth had a ceramic restoration with no specific findings. QLF device's images around the restoration, and after removal of the restoration were taken. In the QLF image after removal of the restoration, clear red-fluorescent crack line was shown, indicating that microorganism had penetrated along the crack path. During root canal treatment, the QLF image of the inside of the pulp chamber showed a pattern in which the crack line progressed into the tooth. During the treatment of the cracked tooth, the crack line was removed as much as possible using the fluorescent information obtained by the QLF device, and crack lines of fluorescence images quantitatively analyzed using a QLF's software.
Conclusion: Images acquired with the QLF device can provide useful information for detecting crack lines, recording the treatment process, and restorative management of cracked teeth.

1. Introduction

A cracked tooth is defined as an incomplete fracture initiated from the crown and extending subgingivally [1]. Even in teeth with cracks but no clinical symptoms, there is the possibility of a tooth fracture due to the progress of cracks in the future. In addition, microorganisms in the oral cavity can penetrate deep into the tooth along the crack path, causing pulp diseases. Tooth's crack is sometimes difficult to detect by clinical examinations such as radiographic examination or visual examination, diagnosis of cracked teeth is a challenge for clinicians.

Recently, a QLF device designed to quantify the mineral loss and bacterial deposition in dental hard tissue using the excitation of 405 nm blue visible-light has been introduced to identify the location of tooth's cracks and microbial penetration [2–4]. Red-fluorescent line that show auto-fluorescent responses to specific metabolites produced by microorganisms that have penetrated the crack's path efficiently provide clinicians with positional information about the crack. In this case, Q-ray penC(AIOBIO, Seoul, Korea) was used as a QLF device for the detection and management of cracked teeth, and fluorescent images quantitatively analyzed using CrazeLineWizard01 v1.02 (Inspektor Research Systems B.V., The Netherlands).

2. Case report

A 39-year-old woman visited a dental hospital complaining of severe throbbing pain in left lower teeth during mastication. The dentist performed clinical examinations, including radiographic examinations and pulp vitality tests. Tooth #36 was diagnosed with symptomatic irreversible pulpitis. Observation of the occlusal surface with the naked eye showed that tooth #36 had a ceramic restoration with no specific findings. A visual inspection was performed on tooth #36 using a Q-ray penC, an intraoral capture-type QLF device. A red-fluorescent line was observed on the distal side of the ceramic inlay in the fluorescent image (Fig. 1E), and a tooth crack in tooth #36 was, thereby, suspected. QLF Images were successively acquired while removing the old restoration of tooth #36. In the fluorescent image after removing the restoration (Fig. 1F and G), a clear crack line was observed from the distal marginal ridge of tooth #36. Root canal treatment was performed on tooth #36. Fig. 2E–G showed the fluorescent images obtained by sequentially removing the crack line as much as possible to the gingival margin after

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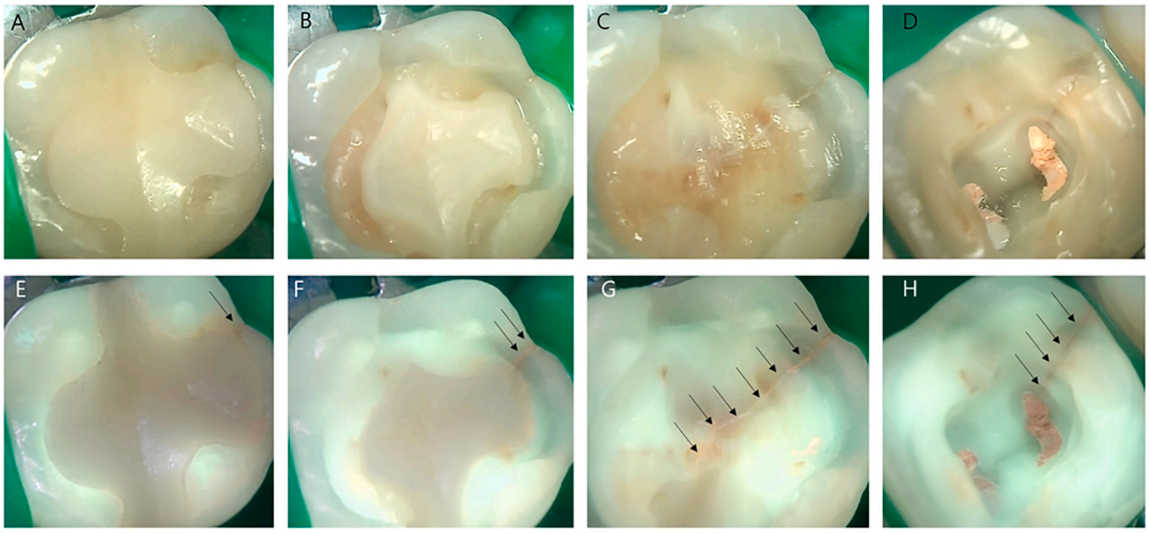

Fig. 1. White-light (upper row) and fluorescent (lower row) images captured by Q-ray penC. Images taken before (A–E) and after (B–F, C–G) of restoration, after canal filling (D–H). Fluorescent image showing distal crack line before (E) and during (F) removing restoration. Fluorescent images clearly showing crack line located inside the pulp cavity after restoration removal (G, H). The arrows indicate tooth crack lines.

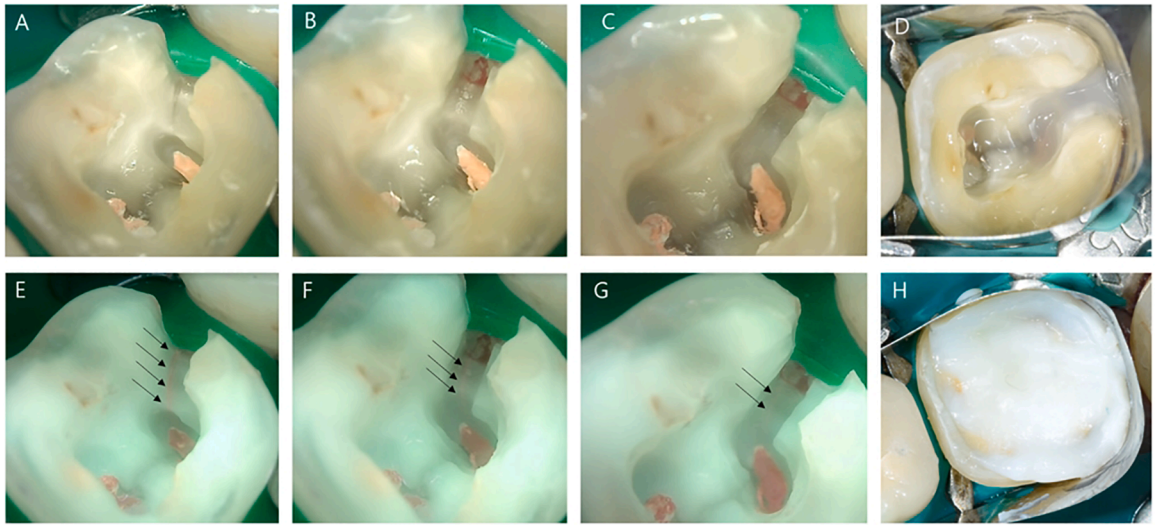

Fig. 2. White-light (upper row, A–C) and fluorescent (lower row, E–G) images captured by Q-ray penC after removing crack line. Images during core build-up (D,H) by capturing DSLR (Digital single-lens reflex camera; Nikon D3400, Tokyo, Japan). E–G fluorescent images showed gradual disappearance of red-fluorescent line indicating the crack line. The arrows indicate the tooth crack lines.

root canal filling. Fig. 2G shows that the red-fluorescent line almost disappeared at the gingival margin. Then, the upper layer of the canal filling material in the distal canal was sufficiently removed below the area where the distal crack line disappeared. Inside cavity space included the previous crack line were filled with adhesive materials (Fig. 2D and H). A full-veneer crown was recommended as the final restoration. Fluorescent images were analyzed using the software after removing the old restoration and at the gingival marginal area after the removal of the crack line. The values of ΔFmax and ΔRmax after removing the old restoration showed −17.5% and 19.9%, respectively, and those of the gingival margin after removing the crack line, showed-11.5% and 7.5%, respectively.

3. Discussion

In this case, the QLF device was used to determine the location and extent of the tooth's crack during the diagnosis and management of a cracked tooth. For a tooth's crack, QLF images appear as a characteristic red-fluorescent line for metabolic by-products such as porphyrins by anaerobic bacteria [2]. The existence of the crack line was not clear in visual inspection with the naked eye for diagnosis, but it was clearly confirmed in the fluorescent image of the QLF device. After removal of the restoration, and during the process of observing the inside of the pulp chamber, QLF's fluorescent images provided useful visual information to identify the direction and progression of the crack's line. Compared to the inspection using dye, visual inspection with QLF images is a more convenient method minimizing multiple steps such as dying, washing, and drying a tooth in crack detection process. In this case, the fluorescent images were captured after removing the old restorations and the point closest to the gingival margin level after the removal of crack lines, and the values of ΔF and △R were quantitatively derived subsequently using the CrazeLineWizard01 v1.02 software. In the fluorescent image of the cracked tooth, the ΔF value represents the loss of fluorescence compared to the normal value for the degree of

reflection and transmission of 405 nm light in the minute gap of the crack [3]. The ΔR value is a value that quantitatively represents the intensity of red-fluorescence expressed for a specific metabolite of microorganisms that has penetrated the tooth's crack [3]. In this case, the values of ΔFmax and ΔRmax at the gingival margin level after removing the crack line decreased compared to those after removing the old restoration. This suggests the possibility of quantitative analysis of the reduction of microscopic gap in the crack line and bacterial activity of contaminated crack line while removing the crack line. For the management of the cracked tooth, it has been reported that an adhesive material on the inside of a cracked tooth is advantageous to stabilize a full-veneer crown restoration of the cracked tooth against occlusal force and to distribute stress [5]. Moreover, when the crack line extends into the root canal, it has been reported that the survival rate of the tooth is increased by removing the upper layer of the canal filling material inside the root canal, where the crack line extends, and then forming an intra-canal barrier with adhesive materials [6]. In this case, the red-fluorescent crack line was removed as much as possible, and the cavity space was sealed with an adhesive resin to stabilize the internal structure of the tooth and improve the sealing of the marginal area. The process of obtaining QLF images step-by-step during the diagnosis and management of cracked teeth was convenient. QLF images were useful as a record-keeping and educational resource for patients.

Although this paper presents a single case, the QLF's fluorescent image provided valuable information about the location and extent of the tooth's crack, which can help to diagnose and to guide treatment decisions of the cracked tooth.

CRediT authorship contribution statement

Sung-Ae Son: Writing – original draft, Visualization, Methodology, Data curation, Conceptualization. **Jae-Hoon Kim:** Visualization, Methodology, Conceptualization. **Jeong-Kil Park:** Supervision, Conceptualization.

Declaration of Competing Interest

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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