Use of an intraoral scanner to evaluate oral health

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Abstract: The purpose of this study was to determine if intraoral scanners (IOS) are useful for dental hygiene instruction. The dental plaque of eight volunteers with healthy dentition was stained with a plaque-disclosing solution, and the O’Leary Plaque Control Record (PCR) was measured by direct observation and by evaluating IOS images. PCR values were higher for IOS images than for direct observation. The difference was greatest for the lingual surface of mandibular anterior teeth. Use of IOS for dental plaque examination might be useful as a novel method for dental hygiene instruction.

Keywords: intraoral scanner, plaque control record, plaque disclosing

Introduction

Dental plaque biofilms are composed of a collection of oral bacteria, some of which can cause dental caries and gingivitis, thus promoting periodontal disease [1]. Plaque first forms on supragingival tissue and crown surfaces. Supragingival plaque progresses into the subgingival region, which causes subgingival plaque formation [2] that is difficult to remove by self-care. Therefore, early plaque removal with daily mechanical plaque control and self-care is important for routine maintenance of oral health [3].

To ensure adequate maintenance by toothbrushing alone, the plaque adhesion state in the intraoral cavity must be carefully evaluated and appropriate oral hygiene instructions provided to patients. Methods to disclose plaque have been used extensively for evaluating dental hygiene, because they allow visualization of oral biofilm, which is mostly colorless [4]. A plaque-disclosing solution is used to stain adhesion plaque, after which each tooth surface is evaluated. This simple protocol enables quantitative evaluation of oral hygiene [5].

Intraoral scanners (IOS) are image-capturing devices used for direct optical impressions in dentistry [6]. Newer IOS devices can record intraoral information as multiple color images [7]. Therefore, an IOS can enable visualization and evaluation of stained dental plaque and might be effective for evaluating plaque control record (PCR). This method is a novel strategy for educating patients on dental hygiene. The present study describes and assesses a novel dental hygiene assessment method that uses an IOS for PCR evaluation.

Materials and Methods

The study was approved by the Independent Ethics Committee of Hiroshima University Hospital (E-2407). All experiments involving humans were conducted in accordance with the principles of the Declaration of Helsinki (http://www.wma.net). All procedures were carried out with the adequate understanding and written consent of the participants.

Eight volunteers participated in this study, which was conducted at Hiroshima University, Japan. Volunteers with no missing teeth, dental caries, or treated teeth on intraoral clinical examination were included in the study.

Evaluation of plaque adhesion state

After photographing the oral cavity with a camera, the plaque adhesion state was evaluated. Plaque adhesion was measured by using the O’Leary PCR. The crown was divided into six surfaces, i.e., the mesial, central, and distal regions of the labial/buccal and lingual/palatal sides, and the presence or absence of stained regions was confirmed. After calculating the PCR, the dentition was scanned with an IOS (TRIOS 3 Basic, 3Shape, Copenhagen, Denmark). The plaque adhesion state was observed on a 3D image, and PCR evaluations were again performed for the screen image. The evaluation time was not specified. These measurements were performed by a single dental hygienist with greater than 15 years of experience in dental hygiene.

Comparison of PCR

PCR values obtained by the direct method and IOS were compared. PCR values were compared for the entire dentition, maxilla total area, maxillary anterior teeth labial/palatal sides, maxillary molars labial/palatal sides, mandibular total area, mandibular incisors buccal/lingual sides, and mandibular molars buccal/lingual sides.

Differences between direct and IOS PCR values were analyzed with the Wilcoxon signed-rank test. The calculations were performed by using BellCurve for Excel (Social Survey Research Information Co., Ltd.), and a P value of less than 0.05 was considered to indicate statistical significance.

Results

Plaque observation

The appearance of intraoral plaque was similar in photographs and 3D images, although colors were lighter in 3D images than in photographs (Fig. 1). Direct observation of the lingual/palatal sides was difficult without a dental mirror; therefore, effective explanation of oral hygiene status to the patient was challenging. Plaque adhesion on the distal-most surface could not be visualized. In contrast, the 3D image directly visualized the labial/buccal surfaces and, by rotating the image, the lingual/palatal surfaces. Moreover, the distal portion of the last molar was easily observed (Fig. 2).

Comparison of PCR

Total PCR score significantly differed between the direct method and IOS. The total PCR average of the eight participants was 57% with the direct method and 64% with the IOS. PCR values tended to be higher with the IOS than with the direct method. Values for the maxilla did not significantly differ between the direct method and IOS (Fig. 3). There was no significant difference for any surface of maxillary teeth (Fig. 4). For mandibular teeth, the PCR score was higher for the IOS than for the direct method (Fig. 3).

PCR scores for the IOS and direct method did not significantly differ for the labial surface of mandibular incisors or the labial or lingual surfaces of mandibular molars. For the lingual surface of mandibular incisors, the PCR score was higher for the IOS than for the direct method (Fig. 4).
Oral self-care by toothbrushing is important in eliminating dental plaque. Despite brushing, however, plaque may remain in the interdental region and near the cervical margin, especially on molars and the distal surface of the last molar. Remnant plaque is calcified by saliva, and calcified bacterial plaque forms supragingival calculus. Further, dental plaque adheres easily to the calculus surface, which complicates its removal [8].

An edible dye changes the color of plaque and is used as a staining solution for plaque visualization. The change in color is caused by an interaction that occurs because of a difference in polarity between plaque components (proteins and polysaccharides) and the staining solution [9].

There are two ways to confirm stained plaque. First, the patient can check the stained plaque with a mirror; however, although it is easy to detect plaque on the labial and buccal surfaces, the lingual surface is difficult to see with a mirror. Second, an operator can photograph the dentition. An intraoral photograph can visualize the occlusal and buccal surfaces, but it is difficult to check the palatal and lingual surfaces, especially the distal surface of the posterior-most molar. In addition, acquisition of oral photographs is time-consuming and distressing to the operator and patient. Moreover, the procedure requires an assistant to apply a cheek retractor and mirror. Therefore, it is difficult to show remnant plaque at such sites to the patient. In contrast, intraoral scanning can be performed quickly with an IOS, which reduces distress for the operator and patient. The obtained image can be rotated by using software and visualized from all directions.

In the present study, stained plaque on the crown surface was imaged with an IOS and detected on a 3D image. Furthermore, plaque could be visualized on the buccal interdental portion of the molar and on the distal surface of the posterior molar. Therefore, the plaque adhesion site could be clearly explained to the patient. This study used an IOS device that could scan different colors. Color 3D images can be used to motivate patients, establish effective communication with
them, and further involve them in treatment and maintenance of oral health. Scanning and image processing require about 90 seconds and 30 seconds, respectively, after which the image must be rotated onscreen when checking stained plaque. Thus, evaluation time is longer for the IOS than for the direct method. However, the operator can magnify and rotate the obtained 3D image to ensure accurate measurements. To prevent infection, the direct method requires two people: an evaluator and a recorder. Because IOS evaluation is indirect, evaluation and recording can be done by one person. Therefore, 3D images are useful for PCR evaluation. In the present study, PCR values were higher for the IOS than for direct measurements of the oral cavity. The difference was greatest for the lingual surface of mandibular anterior teeth. This suggests that direct observation may yield inconsistent results for detection of plaque-disclosing area, because of curvature of the dentition and tongue in the anterior mandibular region.

In this study, a red solution was used for plaque staining, owing to its popularity. However, gingival morphology could be confirmed in images acquired with the IOS. Wei et al. reported that the gingival contour could be evaluated by intraoral digital impressions [10]. It has been proposed that gingival structure and inflammatory symptoms can be confirmed from gingival morphology. In the present PCR scoring method, the obtained data are not absolute values because the evaluation is a grading process that divides teeth into six sections.

A limitation of this study is that the experiment was performed on persons with healthy teeth. The plaque-disclosing solution works well by changing the color of dental plaque, which provides a contrast against the white tooth surface. Future studies should investigate if stained plaque can be distinguished on surfaces of prostheses, such as metal crowns.

In conclusion, 3D images of stained dental plaque acquired with an IOS enabled accurate visualization of plaque on crown surfaces. However, the color was a little lighter for 3D images than for direct observation, and PCR scores tended to be high for anterior teeth of the mandible. Future studies should determine the optimal color for the IOS disclosing solution and compare a greater number of participants. This strategy could prove to be a useful, novel method of dental hygiene instruction for patients. Plaque accumulation on each tooth could be evaluated by binarization of the 3D images, which could lead to development of a new method of evaluating oral hygiene.

Conflict of interest
The authors report no conflicts of interest related to this study.

References