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RESEARCH AND EDUCATION

Digital evaluation of absolute marginal discrepancy: A comparison of ceramic crowns fabricated with conventional and digital techniques

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ABSTRACT

Statement of problem. Marginal discrepancy is key to evaluating the accuracy of fixed dental prostheses. An improved method of evaluating marginal discrepancy is needed.

Purpose. The purpose of this in vitro study was to evaluate the absolute marginal discrepancy of ceramic crowns fabricated using conventional and digital methods with a digital method for the quantitative evaluation of absolute marginal discrepancy. The novel method was based on 3-dimensional scanning, iterative closest point registration techniques, and reverse engineering theory.

Material and methods. Six standard tooth preparations for the right maxillary central incisor, right maxillary second premolar, right maxillary second molar, left mandibular lateral incisor, left mandibular first premolar, and left mandibular first molar were selected. Ten conventional ceramic crowns and 10 CEREC crowns were fabricated for each tooth preparation. A dental cast scanner was used to obtain 3-dimensional data of the preparations and ceramic crowns, and the data were compared with the "virtual seating" iterative closest point technique. Reverse engineering software used edge sharpening and other functional modules to extract the margins of the preparations and crowns. Finally, quantitative evaluation of the absolute marginal discrepancy of the ceramic crowns was obtained from the 2-dimensional cross-sectional straight-line distance between points on the margin of the ceramic crowns and the standard preparations based on the circumferential function module along the long axis.

Results. The absolute marginal discrepancy of the ceramic crowns fabricated using conventional methods was 115 ±15.2 μm, and 110 ±14.3 μm for those fabricated using the digital technique was. ANOVA showed no statistical difference between the 2 methods or among ceramic crowns for different teeth (*P*>.05).

Conclusions. The digital quantitative evaluation method for the absolute marginal discrepancy of ceramic crowns was established. The evaluations determined that the absolute marginal discrepancies were within a clinically acceptable range. This method is acceptable for the digital evaluation of the accuracy of complete crowns. (J Prosthet Dent 2017;■:■-■)

The size of the marginal discrepancy between a restoration and tooth preparation is an important predictor of future ceramic fracture, periodontal health, plaque retention, caries, pulpal pathology, and bone resorption.[1-3] Precise marginal adaptation is essential to ensure long-term prosthetic success.

The quality of the prosthetic fit is usually evaluated in the marginal, axial, and occlusal regions of the prepared teeth.[4] However, no standard has been agreed for the measurement of marginal discrepancy. Holmes et al[5] divided the restoration marginal discrepancy into horizontal marginal discrepancy, vertical marginal discrepancy, and absolute marginal discrepancy. They consider absolute marginal discrepancy to be the most important, as it takes both the horizontal and vertical directions into consideration. It is defined as the linear distance from the finish line of the preparation to the margin of the restoration. This distance can be measured from a cross-sectional view, direct view of the crown on a die, impression replica technique, or clinical examination.[6,7]

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Clinical Implications

A digital method of evaluating marginal discrepancy improves evaluation accuracy and helps dentists evaluate the quality of fixed prostheses objectively and accurately. Digital evaluation methods can also improve communication between dentist and patient. However, the methods used to analyze the restorations are not universally applicable.

Current measurement methods include both in vivo and in vitro techniques. In vivo measurement methods include examination with a dental explorer; however, explorer examination is only qualitative, and examination of the subgingival margin is difficult.[8] Another in vivo method is to seat the crown with a silicone impression material to reproduce the marginal discrepancy and then measure from scanning electron micrographs; however, the silicone material may have defects in the observation area.[9] In vitro measurements may involve sectioning the crown on a die. However, with this method, some locations cannot be observed, and deformation can result during the sectioning process.[10] Another method is to measure images of the margin with a stereoscopic microscope using a computer for processing and measurement.[11]

Dental computer-aided design and computer-aided manufacturing (CAD-CAM) systems are now commonly used in dental offices and are highly sophisticated, allowing marginal discrepancy measurements. Yuan et al[12] used 3-dimensional (3D) scanning and reverse engineering software to digitally design a representation of a complete crown preparation. Lee[13] described a method of visualizing and quantifying the fit discrepancy of fixed dental prostheses by digitizing a misfit space replica and using computer-aided spatial analysis.

With CAD-CAM production of crowns, the cement space is typically set in the software to 50 μm, as 30 to 50 μm has been found to deliver the best marginal fit.[14] However, Beschnidt and Strub[15] demonstrated that the evaluation of the marginal adaptation of restorations depends on factors such as the type of die material used during marginal fit evaluations, whether the specimens were cemented, the effects of aging procedures, the type of microscope, and the location and quantity used for measurements. The factors that have been documented to influence the marginal fit of a dental restoration are the preparation design, location of the preparation finish line (subgingival or supragingival), restorative material, fabrication method, and impression material and technique.[16-20] McLean and von Fraunhofer[6] stated that a restoration is considered clinically successful when the marginal discrepancy and the luting space are less than 120 μm, a range that has been considered clinically acceptable.[20-23]

The purpose of this in vitro study was to use reverse engineering software to investigate a digital quantitative method for evaluating the absolute marginal discrepancy between a ceramic crown restoration and a master preparation, and to use this method to evaluate quantitatively the absolute marginal discrepancy of ceramic crowns fabricated using conventional or digital methods. The null hypotheses were that the absolute marginal discrepancies of ceramic crowns fabricated using conventional or digital methods would not differ and that the absolute marginal discrepancies of different tooth preparations would be similar.

MATERIAL AND METHODS

A typodont (Standard model A50 SET; Nissin) with tooth preparations for the right maxillary central incisor, right maxillary second premolar, right maxillary second molar, left mandibular lateral incisor, left mandibular first premolar, and left mandibular first molar was used for the study. The tooth preparation margins were clearly visible, smooth, and formed a continuous right-angled shoulder. The typodont was placed in a dental simulator (Type 1 Advance; Nissin) mounted on a dental chair. Ten conventional ceramic crowns and 10 CAD-CAM crowns were fabricated for each preparation. The sample size (n=10) was determined from pilot studies with a power analysis to provide statistical significance (α=.05) at 80% power. For the conventional crowns, an elastomeric impression (Impregum Penta Soft; 3M) was made and poured with Type 4 gypsum (Die Stone Peach; Heraeus Kulzer) to produce a cast. The crowns were fabricated by an experienced technician in a feldspathic porcelain (Vita In-Ceramic Alumina; Vita Zahnfabrik). The CAD-CAM crowns were fabricated with the CEREC chairside system. A digital impression (CEREC Omnicam; Dentsply Sirona), was made and the system used to fabricate 10 ceramic crown from feldspathic ceramic blocks (CEREC Blocs S3-O 14; Dentsply Sirona).

A calibrated dental cast scanner (Activity 880; Smartoptics) was used to scan the preparation and the ceramic crown after it has been seated on the preparation. The 3D point clouds of the standard preparation surface and the surface of the ceramic crown after it had been seated on the standard preparation were obtained in standard tessellation language (STL) format. The scan was made twice in the same coordinate system. Subsequently, the 3D scanner was used to scan the ceramic crown, and the 3D data of the intaglio and external surfaces of the ceramic crown were obtained in STL format (Fig. 1).

A registration module (Studio 2013; Geomagic) was used for manual registration. The initial position was

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