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Clinical evaluation comparing the fit of all-ceramic crowns obtained from silicone and digital intraoral impressions based on wavefront sampling technology

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ABSTRACT

Objective: The aim of this study was to compare the fit of ceramic crowns fabricated from conventional silicone impressions with the fit of ceramic crowns fabricated from intraoral digital impressions.

Methods: Twenty-five participants with 30 posterior teeth with a prosthetic demand were selected for the study. Two crowns were made for each preparation. One crown was fabricated from an intraoral digital impression system (IDI group) and the other crown was fabricated from a conventional two-step silicone impression (CI group). To replicate the interface between the crown and the preparation, each crown was cemented on its corresponding clinical preparation with ultra-flow silicone. Each crown was embedded in acrylic resin to stabilise the registered interface and then cut in 2 mm thick slices in a buco-lingual orientation. The internal gap was determined as the vertical distance from the internal surface of the crown to the prepared tooth surface at four points (marginal gap, axial gap, crest gap, and occlusal fossa gap) using stereomicroscopy with a magnification of 40×. Data was analysed by using Wilcoxon signed rank test ($\alpha = 0.05$).

Results: Internal adaptation values were significantly affected by the impression technique ($p = 0.001$). Mean marginal gap was 76.33 ± 65.32 μm for the crowns of the IDI group and 91.46 ± 72.17 μm for the CI group.

Conclusion: All-ceramic crowns fabricated from intraoral digital impressions with wavefront sampling technology demonstrated better internal fit than crowns manufactured from silicone impressions.

Clinical significance: Impressions obtained from an intraoral digital scanner based on wavefront sampling technology can be used for manufacturing ceramic crowns in the normal clinical practice with better results than conventional impressions with elastomers.

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1. Introduction

Fixed dental prosthesis (FDP) is still mainly produced by casting techniques. The automation of the production process can be achieved by the use of computer-aided design (CAD)/ computer-aided manufacturing (CAM) techniques. These techniques are recognised in general industry as a standard workflow in order to obtain high quality products in terms of accuracy and cost production efficiency.[1,2]

To start with the CAD/CAM workflow a digitalisation process is needed. An optical impression system is a device used to record relevant topographical intraoral surfaces, dental impressions, or stone cast for use in the computer assisted design and manufacturing of dental restorative prosthetics.[3] In recent years, various optical impression systems have been developed with which direct impressions could be made in the oral cavity. The most commonly used intraoral dental scanners among others are: Cerec AC (Sirona, Behnheim, Germany), Lava Chairside Oral Scanner (Lava COS, 3M ESPE, St Paul, MN, USA), E4D Dentist (D4D Technologies LLC, Richardson, TX, USA), and iTero (Cadent, Carlstadt, NJ, USA). Intraoral scanners play an important role in the development of digital dental technology because they are the first step towards a full digital workflow of prosthetic fabrication.[4] Intraoral digital impressions improve patient acceptance, reduce possible distortion of impression materials, allow for three-dimensionally (3D) previsualisation of the preparation, decrease potential cost, and increase efficacy.[5]

Also, one of the most significant advances in this field has been the production of high resistance all-ceramic restorations that until today can only be produced with CAD/CAM systems. The popularity of these materials, such as zirconia, has increased significantly in the last decade due to their esthetic, mechanical and biocompatibility properties.[6–8] In addition to the physical properties and biocompatibility, the predictable production of suitable marginal inter-phases is one of the most important factors for long-term success of restorations.[9–13] Poor marginal adaptation between the tooth and the restoration increases plaque retention and changes the distribution of the microflora, which can induce the onset of periodontal disease.[14,15] Poor marginal fit can also cause secondary caries and lead to clinical failure of fixed prosthodontics.[16] Microleakage from the oral cavity may cause endodontic inflammation.[17]

Although marginal adaptation is a fundamental factor in the clinical success of the FDPs, there is no consensus on what constitutes a clinically acceptable maximum marginal gap width. The values reported on the maximum acceptable gap in scientific literature range from 50 to 200 μm so, there does not seem to be an objective limit based on scientific evidence.[10,13,18] At present, many investigators still use the limit established by McLean and Von Fraunhofer of 120 μm.[18]

Lava Chairside Oral Scanner (3M ESPE) intraoral scanner is based on the principle of active (optical) wavefront sampling which obtains 3D information from a single lens imaging system by measuring depth based on the defocus of the primary optical system. This device has three sensors, which capture the surface to be scanned from different perspectives. With these three images captured at the same time, 3D surface patches are generated by proprietary image processing algorithms by using the in-focus and out-of-focus information.[19] With this technology, twenty 3D datasets per second can be captured with over 10,000 data points in each, resulting in over 24 million data points for obtaining an accurate scan of the dental preparation, soft tissues and hard tissues. According to the manufacturer specifications, the high data redundancy resulting from many overlapping pictures together with special image processing algorithms allows us to obtain optimal image quality and high accuracy.

At present, the number of clinical studies that evaluate the fit of the restorations manufactured with an intraoral scanner is still limited.[11,12,20] The aim of this in vivo prospective study was to evaluate the accuracy of a digital intraoral impression workflow based on the principle of active wavefront sampling technology and to compare it with a conventional silicone impressions workflow by measuring the marginal and internal misfits of the zirconia-ceramic crowns generated with both systems. The null hypothesis was that there is no difference in marginal and internal misfit between crowns obtained from digital and from silicone impressions.

2. Materials and methods

2.1. Study design

This in vivo prospective clinical trial was previously approved by the local ethical committee. The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice (GCP). This study included participants aged between 16 and 65 needing a single crown in a posterior tooth, with acceptable standards of oral hygiene, not requiring additional extended treatment of endodontic or periodontics in the study tooth, and who gave informed consent. In contrast, participants with an advanced periodontal attachment loss affecting the mobility of the teeth (mobility degree 1 or higher), severe wear facets or marginal preparation located deeper than 1 mm subgingivally were excluded.

Thirty participants were enrolled into the study and were fitted with 34 zirconia-ceramic single crowns (Lava, 3M ESPE). For each of the 34 teeth in this study, three crowns were made: two crowns for the study, one made by each impression method (intraoral digital impression – IDI and conventional two-step silicone impression – CI); and one crown to be finally cemented produced exactly like the study crown for the CI group. 102 crowns were made in total.

2.2. Tooth preparation

Sixteen molars and eighteen premolars were treated, 15 in the maxilla and 19 in the mandible. All participants received local anesthesia prior to tooth preparation for a ceramic crown. Distinct chamfer finish lines were prepared and placed at gingival level, not exceeding a subgingival depth of 1 mm. The axial reduction of the tooth substance was between 1 and 1.5 mm, in accordance with the remaining hard tissue. Occlusal reduction was approximately 1.5 mm. All internal edges were rounded. The preparation had a divergence angle of around 6%.[21] After tooth preparation a provisional restoration was

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