Clinical and laboratory evaluation of CAD/CAM All-ceramic crowns
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Citation for published version (APA):

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Summary and Conclusions

In the year 2000, a combined project between the Department of Oral Function and the Department of Dental Material Science (Academic Center of Dentistry, Amsterdam) was started to study the clinical and laboratory behavior of CAD/CAM partially produced all-ceramic crowns. It was the first time that CAD/CAM technology was included in a research program at ACTA. This thesis shows the results of this first combined project.

The general introduction in Chapter 1 presents some background information about ceramic crowns and gives a brief description of CICERO and Procera AllCeram CAD/CAM systems.

Considering that the preparation of the tooth by the dentist is the first clinical step to create an all-ceramic crown, it was of high importance to evaluate in a clinical field-test the ability of the implementation of manufacturer’s preparation guideline. The preparation guideline of the CICERO all-ceramic CAD/CAM system was used as the case for this study (Chapter 2). General dental practitioners from the northwest region of the Netherlands were asked to make all-ceramic crowns preparations in accordance with the specific guidelines of CICERO system. A sample of 3446 tooth preparations was three-dimensionally evaluated with regard to shoulder angle, shoulder width and top angle. It was concluded that general dental practitioners are able to follow recommended guidelines for the shoulder preparation. It was also observed that the anatomy and position of the tooth in the mouth are the main reasons for deviations from the guideline.
In Chapter 3 a retrospective clinical study is presented. The performance of all-ceramic crowns made with CICERO CAD/CAM copings was evaluated after a period of one-year. 70 all-ceramic crowns were fabricated for 55 patients (47 women and 8 men). Crowns were made for the anterior and posterior regions. A general dental practitioner treated all patients and the CAD/CAM copings were veneered with aesthetic porcelain by one dental technician. Crowns were evaluated using the modified California Dental Association's quality assessment system. The results of this study supported the hypothesis that all-ceramic crowns based on CICERO CAD/CAM aluminum oxide copings are recommendable for all areas of the mouth.

A laboratory study was performed with the purpose to find the optimal choice of luting cement to Synthoceram, an aluminum oxide reinforced glass ceramic material used for the fabrication of CICERO CAD/CAM copings. Chapter 4 shows the results of the evaluation of the bond strength of five different commercial luting cements to the ceramic material. Shear bond strength tests were performed using the ceramic material as substrate with each of the luting cements. The effect of surface treatments: etching, sandblasting, silanizing and combinations of these treatments on the morphology of the material were investigated by scanning electron microscopy (SEM). Based on the results of this study, it is recommended to use resin composite based cements in combination with a ceramic surface treatment of etching and/or sandblasting followed by silanization for cementation of Synthoceram copings.

The CAD/CAM fabrication of ceramic restorations involves a number of precise steps that under normal conditions lead to the creation of a restoration which size and shape meet the predefined requirements. Each laboratory step should be controlled and the risk of failure should be minimized. For this reason, it was necessary to evaluate the continuous relation between CAD and CAM of the systems involved in this thesis. Chapter 5 describes a study that compares the design parameters (CAD); namely, accuracy of internal fit and coping thickness, with the final manufacturing parameters (CAM) of the produced restoration. Moreover the influence of the scanning and the production methods on the accuracy of the design parameters of the produced restoration was evaluated. To reach this goal a metal die prepared for an ordinary all-ceramic restoration was the master for the creation of epoxy-working dies. Forty copings (20 CICERO and 20 Procera AllCeram) were produced independently at the respective central production centers, according to the
manufacturer's conditions. The copings were cemented and were sectioned in three horizontal slices at top, middle and bottom. The cement space and the coping thickness were measured mesially, distally, buccally and lingually in each slice by using SEM. Within the limitations of the study, it was possible to conclude that CICERO and Procera AllCeram systems could produce copings with the pre-established coping thickness. The CICERO system could produce cement spaces as pre-established within acceptable borders, while the Procera system creates significantly thicker cement spaces.

The last chapter of this thesis, Chapter 6, describes a prospective clinical trial. It evaluated and compared the clinical behavior of all-ceramic crowns partially fabricated by CAD/CAM systems. 94 All-ceramic anterior and posterior crowns (48 CICERO and 46 Procera AllCeram) were placed in 44 patients in a dental practice of a general dental practitioner. He treated all patients. They were evaluated after two years using the California Dental Association quality evaluation system. X-rays, stone models and intra-oral photographs were registered for the long-term assessment. Patients' opinion regarding their CAD/CAM crowns was also evaluated. The study demonstrated a comparable clinical behavior of both systems and indicates a good prognosis. The crowns based on CICERO and Procera AllCeram CAD/CAM copings performed well in all areas of the mouth. This is particularly true in view of the very high patient satisfaction. Finally CICERO is recommendable to use in all areas of the mouth as it meets the ADA-criteria for clinical evaluation.

Future prospects

Based on the findings in this study, further research branching into several scientific disciplines is necessary to answer the many questions arising from this modern restorative concept. The major advantage of CAD/CAM technique is the automated production process, which may be accompanied with a diminution of production errors due to the exclusion of the 'human' factor. Looking towards the future, progress in the field of Computerized Dentistry appears as a promising and realistic option, while just 20 years ago it was considered a fashion technique. Nowadays CAD/CAM has established its own place in dentistry and it is likely that it will continue to grow giving more options to the different areas of dental care.
Summary and Conclusions