A Novel Computer-Aided Design/Computer-Assisted Manufacture Method for One-Piece Removable Partial Denture and Evaluation of Fit

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Purpose: To investigate a computer-aided design/computer-aided manufacturing (CAD/CAM) process for producing one-piece removable partial dentures (RPDs) and to evaluate their fits in vitro. ***Materials and Methods:*** A total of 15 one-piece RPDs were designed using dental CAD and reverse engineering software and then fabricated with polyetheretherketone (PEEK) using CAM. The gaps between RPDs and casts were measured and compared with traditional cast framework RPDs. ***Results:*** Gaps were lower for one-piece PEEK RPDs compared to traditional RPDs. ***Conclusion:*** One-piece RPDs can be manufactured by CAD/CAM, and their fits were better than those of traditional RPDs. *Int J Prosthodont 2018;31:149–151. doi: 10.11607/ijp.5508*

A removable partial denture (RPD) is a conventional and important treatment for partially edentulous jaws. Computer-aided design and computer-aided manufacture (CAD/CAM) techniques have been applied in dentistry for about four decades and exhibit various advantages. However, the development of CAD/CAM techniques for RPDs has been relatively slow, and although it is mainly focused on the feasibility of CAD/CAM techniques for the design and manufacture of RPD frameworks,[1] there have been no reports of the design and manufacture of whole RPDs using CAD/CAM technologies.

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Polyetheretherketone (PEEK) has been widely tested in a number of dental applications, such as PEEK dental implants, PEEK obturators, and PEEK RPD frameworks. PEEK has a relatively low Young's modulus of 3 to 4 GPa, which is close to that of human bones, and its tensile properties are similar to those of bone, enamel, and dentin.[2] These properties make it a suitable material for fixed and removable prostheses.

The purposes of this study were to explore a novel CAD/CAM method for producing one-piece RPDs fabricated with PEEK and to evaluate the in vitro fits of these RPDs compared with traditional cast framework RPDs.

Materials and Methods

A standard stone cast of a partially edentulous mandible (Fig 1a) was scanned using a lab scanner (D800, 3Shape). Frameworks for RPDs were designed using commercial dental CAD software (Dental System 2015, 3Shape) (Fig 1b) according to general principles, but there were some differences from metal frameworks due to the properties of PEEK: First, tips of clasps had to be placed in an undercut of 0.5 mm[3]; and second, the cross-sectional areas of clasps and connectors had to be greater than those of metal clasps to provide adequate retention and strength.[4] Artificial teeth were also created in Dental System (Fig 1c). Following this, the digital cast, framework, and artificial teeth were exported as standard tesselation language (STL) files and imported into reverse engineering software (Geomagic Studio 2012, Geomagic), in which the denture bases were designed (Fig 1d). All assemblies were then combined using the Boolean function to form a complete RPD exported as an STL file (Fig 1e).

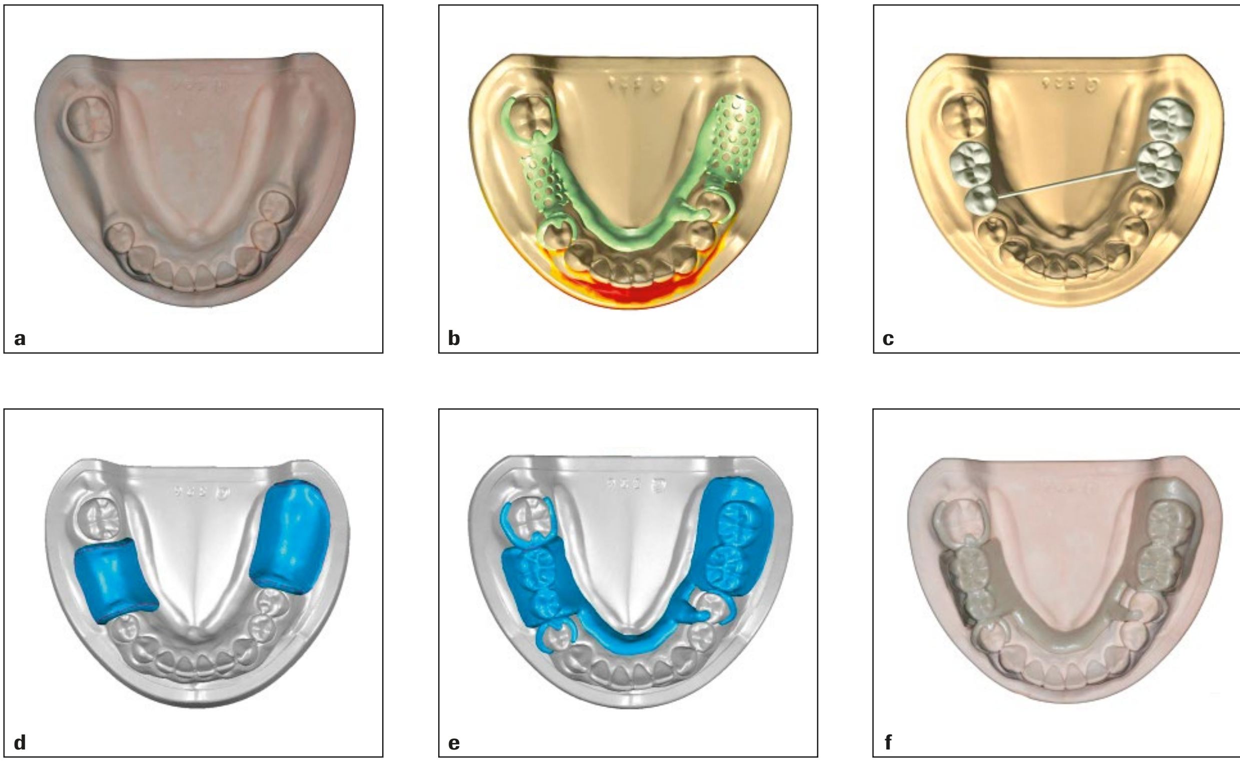

Fig 1 Computer-aided design/computer-aided manufacture (CAD/CAM) process for one-piece polyetheretherketone (PEEK) removable partial denture (RPD). **(a)** Standard stone cast of partially edentulous mandible. **(b)** Framework designed in Dental System. **(c)** Arrangement of artificial teeth in Dental System. **(d)** Denture base created in Geomagic Studio. **(e)** Digitally designed RPD. **(f)** One-piece PEEK RPD was well-seated on the stone cast.

Table 1 Mean ± Standard Deviation (SD) Thickness of Silicone in Different Areas of the Removable Partial Dentures (RPD) and Statistical Results

Areas	PEEK RPD (μm)	Traditional RPD (μm)	*P*
Occlusal rest	86.2 ± 22.6	133.9 ± 49.7	.003
Major connector	52.8 ± 44.6	131.1 ± 87.1	.005
Denture base	37.4 ± 31.0	129.3 ± 49.2	.000
Entirety	42.8 ± 29.4	130.9 ± 50.5	.000

The STL data of RPDs were transferred to a five-axis milling machine (Organical Multi, R+K), and 15 RPDs were milled from PEEK blocks. Another 15 cast framework RPDs were fabricated based on the same cast, but using traditional methods. All finished RPDs were seated on stone casts (Fig 1f) to be evaluated qualitatively and quantitatively. The former evaluation was comprised of a visual inspection and pressing test, and the latter entailed duplicating the gaps between RPDs and stone casts using silicone impression material (Variotime Light Flow, Heraeus) and adopted 3D digital analyses using a dedicated software (Geomagic Qualify 2012, Geomagic). In this way, gaps were measured for the whole RPD and for each area, including the occlusal rest, the major connector, and the denture base.

An independent samples *t* test was used to compare the average gap thicknesses of the whole RPD and the occlusal rests, major connectors, and denture bases between the two groups in SPSS 20.0 (IBM).

Results

A total of 15 one-piece PEEK RPDs were successfully designed, fabricated, and well-seated on stone casts. The average thicknesses of silicone between RPDs and stone casts in different areas are shown in Table 1, along with the results of the independent samples *t* tests. For the entirety of the RPD and for each area, PEEK RPD gaps were less than those of cast framework RPDs ($P < .01$).

Discussion

This study explored a novel CAD/CAM method for producing one-piece PEEK RPDs that is efficient and fully digitized. Moreover, one-piece PEEK RPDs exhibited satisfactory retention force, strength, and esthetics. Most importantly, one-piece PEEK RPDs showed better fit than traditional metal cast framework RPDs. Further studies should be performed to evaluate the mechanical properties of PEEK RPDs, as well as the abrasive properties of PEEK artificial teeth, the improvement of color, and in vivo fits.

Conclusions

This study has demonstrated that RPDs can be designed using digital methods and fabricated using PEEK. The in vitro fits of one-piece PEEK RPDs were found to be better than those of traditional cast framework RPDs.

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References

1. Williams RJ, Bibb R, Eggbeer D, Collis J. Use of CAD/CAM technology to fabricate a removable partial denture framework. J Prosthet Dent 2006;96:96–99.
2. Sandler J, Werner P, Shaffer M, Demchuk V, Altstädt V, Windle AH. Carbon-nanofibre-reinforced poly(ether ether ketone) composites. Compos Part A Appl Sci Manuf 2002;33:1033–1039.
3. Zoidis P, Papathanasiou I, Polyzois G. The use of a modified poly-ether-ether-ketone (PEEK) as an alternative framework material for removable dental prostheses. A clinical report. J Prosthodont 2016;25:580–584.
4. Arda T, Arikan A. An in vitro comparison of retentive force and deformation of acetal resin and cobalt-chromium clasps. J Prosthet Dent 2005;94:267–274.
5. Ye H, Ning J, Li M, et al. Preliminary clinical application of removable partial denture frameworks fabricated using computer-aided design and rapid prototyping techniques. Int J Prosthodont 2017;30:348–353.

Literature Abstract

Association of Oral Microbiome With Risk for Incident Head and Neck Squamous Cell Cancer

Case-control studies show a possible relationship between oral bacteria and head and neck squamous cell cancer (HNSCC). Prospective studies are needed to examine the temporal relationship between the oral microbiome and subsequent risk of HNSCC; therefore, the aim of this study was to prospectively examine associations between the oral microbiome and incident HNSCC. This nested case-control study was carried out in two prospective cohort studies: the American Cancer Society Cancer Prevention Study II Nutrition Cohort (CPS-II) and the Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial (PLCO). Among 122,004 participants, 129 incident patient cases of HNSCC were identified during an average 3.9 years of follow-up. Two controls per patient case (n = 254) were selected through incidence density sampling, matched on age, sex, race/ethnicity, and time since mouthwash collection. All participants provided mouthwash samples and were free of cancer at baseline. Oral microbiome composition and specific bacterial abundances were determined through bacterial 16S rRNA gene sequencing. Overall oral microbiome composition and specific taxa abundances were compared for the case group and the control group using PERMANOVA and negative binomial generalized linear models, respectively, controlling for age, sex, race, cohort, smoking, alcohol, and oral human papillomavirus-16 status. Taxa with a 2-sided false discovery rate (FDR)-adjusted P value (Q value) < .10 were considered significant. Incident HNSCC was the main outcome measure. A total of 58 patient cases from CPS-II (mean [SD] age = 71.0 [6.4] years; 16 [27.6%] women) and 71 patient cases from PLCO (mean [SD] age = 62.7 [4.8] years; 13 [18.3%] women) were included. HNSCC cases and controls were similar with respect to age, sex, and race. Patients in the case group were more often current tobacco smokers and tended to have greater alcohol consumption (among drinkers) and be positive for oral carriage of papillomavirus-16. Overall microbiome composition was not associated with risk of HNSCC. Greater abundance of *Corynebacterium* (fold change [FC] = 0.58; 95% confidence interval [CI] = 0.41–0.80; Q = .06) and *Kingella* (FC = 0.63; 95% CI = 0.46–0.86; Q = .08) were associated with decreased risk of HNSCC, potentially owing to carcinogen metabolism capacity. These findings were consistent for both cohorts and by cohort follow-up time. The observed relationships tended to be stronger for larynx cancer and for individuals with a history of tobacco use. This study demonstrates that greater oral abundance of commensal *Corynebacterium* and *Kingella* is associated with decreased risk of HNSCC, with potential implications for cancer prevention.

Hayes RB, Ahn J, Fan X, et al. *JAMA Oncol* 2018 [epub ahead of print Jan 11] doi: 10.1001/jamaoncol.2017.4777. **References:** 37.
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