Volumetric Measurements of Removed Tooth Structure Associated with Various Preparation Designs

Afnan F. Al-Fouzan, BDS, MS[a]/Esam A. Tashkandi, BDS, MS, FDS RCS, PhD[b]

The amount of tooth structure that is removed as a consequence of tooth preparation has rarely been quantified. The aim of this study was to quantify the volume of reduction of tooth structure associated with different commonly used preparation designs. Eighty extracted teeth were divided into eight groups according to the type of preparation design and tooth type. Each specimen underwent pre- and postpreparation scanning using microcomputed tomography. The volume of the resultant tooth structure removed was analyzed. Significant differences in the amount of tooth structure removal were noted between types of coverage and types of teeth. *Int J Prosthodont 2013;26:545–548. doi: 10.11607/ijp.3221*

Dental clinicians frequently deal with replacing missing tooth structure or missing teeth with crowns or fixed partial dentures. Clinicians believe that partial veneers are less invasive than full veneer crowns, which may lead to a lower number of endodontic complications.[1] Preservation of tooth structure is one of the principles of tooth preparation as described by Shillingburg.[2] Yet, there is a paucity of information in published studies related to the quantification of the amount of tooth structure removed during tooth preparation. Therefore, the aim of this study was to quantify the volume loss associated with different tooth preparation designs. The null hypothesis was that there is no difference in the volume of tooth reduction between partial and complete veneer preparations.

Materials and Methods

Eighty extracted permanent teeth were used in this study. Teeth were stored in saline solution (0.9% sodium chloride) at room temperature from time of extraction to time of conducting the investigation to prevent desiccation. The specimens contained four different morphologies (maxillary first molar, mandibular first premolar, maxillary central incisor, and mandibular central incisor) distributed into eight subgroups according to tooth morphology and preparation design (ceramic crown, ceramic onlay, or ceramic veneer). Upon completion of the preliminary pilot study, the SD was found to be 6.5. The level of significance was set to be .05, and the power of the study was found to be 0.9, type II error = 0.1. From these data, the sample size was computed to be 10 specimens for each group. Teeth were randomly distributed to the preparation groups (eight groups): randomization was done with 80 opaque containers (20 containers for each tooth morphology), and teeth were distributed randomly by an independent blind investigator into two subgroups (crown or veneer and crown or onlay) for each tooth morphology.

Each specimen was aligned vertically in a polyvinyl chloride tube with dental plaster (Sheraalabaster, Shera Werkstoff Technologie). A dental surveyor (J. M. Ney) was used to position the long axis of each anatomical crown of the tooth parallel to the tube.

Micro-CT Examination

A microcomputed tomography (micro-CT) machine was used in this study (Model 1172, Skyscan) for scanning the tooth specimens. The specimens were scanned with a beam accelerating a voltage of 100 kV and x-ray beam current of 100 uA, using a 0.5-mm aluminum filter.

Using SkyScan analyzer software, version 1.6.3.1, three-dimensional reconstruction was processed from the two-dimensional images. Using SkyScan analyzer software, version 1.10.1.0, the volume of the tooth crowns was obtained.

[a]*Lecturer, Department of Prosthodontics, King Saud University, Riyadh, Saudi Arabia.*
[b]*Associate Professor, Department of Prosthodontics, King Saud University, Riyadh, Saudi Arabia.*

Correspondence to: *Dr Afnan Al- Fouzan, Department of Prosthodontics, College of Dentistry, King Saud University, PO Box 60169, Riyadh 11545, Saudi Arabia. Email: afnan477@hotmail.com*

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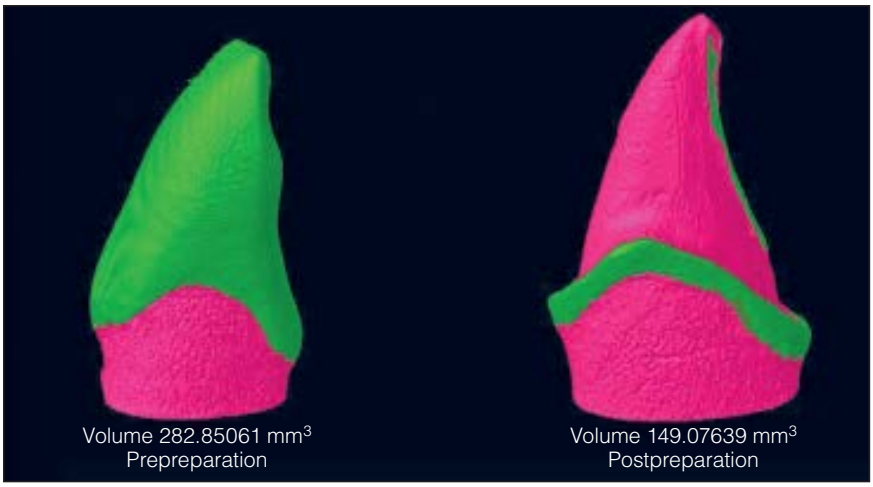

Fig 1 *(left)* Measuring the volumetric reduction of tooth structure using a three-dimensional model of a maxillary central incisor (green = enamel, pink = dentin).

Fig 2 *(below)* Measuring the volumetric reduction of tooth structure using a three-dimensional model of a maxillary first molar (dark blue = enamel, light blue = dentin).

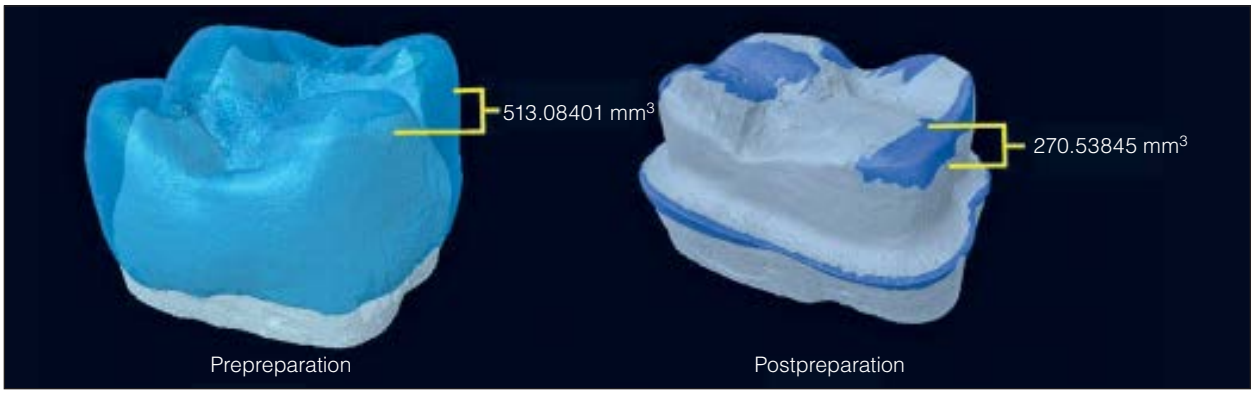

Table 1 Guidelines for Tooth Preparation[3,4]

Design	Guidelines
Porcelain veneer	Design: veneer with incisal overlap Margin: 0.5 mm incisal to CEJ Finish line: chamfer Facial reduction: Cervical third: 0.3 mm Middle third: 0.5 mm Incisal third: 0.7 mm Incisal clearance Maxillary central incisor: 2 mm Mandibular central incisor: 1.5 mm Lingual overlap: 1 mm
All-ceramic crown	Finish line: rounded shoulder Margin: 0.5 mm incisal from CEJ Margin depth: 1 mm Axial reduction: 1.5 mm Incisal/occlusal clearance: 1.5 mm
Ceramic onlay	Finish line: chamfer Margin: 0.5 mm occlusal to CEJ Occlusal isthmus depth: 2 mm Occlusal isthmus floor width Molar: 3 mm Premolar: 2 mm Proximal box Molar: (height) 5.0 × (width) 4.0 × 1.5 mm (depth) Premolar: (height) 5.0 × (width) 3.0 × 1.0 mm (depth) Occlusal reduction: 1.5 mm (functional cusps) 1.0 mm (nonfunctional cusps)

CEJ = cementoenamel junction.

Tooth Preparation

All the preparations were controlled with a transparent template (0.020 inches, Buffalo Dental Manufacturing) and a scaled periodontal probe (Williams SE Perio Probe, Hu-Friedy). All teeth were prepared by one clinician according to suggested guidelines for standardized preparation design (Table 1).

The preparation was done using diamond burs (Drendel + Zeweiling). All specimens were rescanned and reconstructed to determine the postpreparation volume.

Volume Measurement

The volume was calculated as follows: volume of the reduced tooth structure = volume of the crown before preparation – volume of the crown after preparation (Figs 1 and 2).

Table 2 Mean Percentage Values and SDs of the Volume of Tooth Structure Reduction

Preparation design	n	Mean	SD	Minimum	Maximum	Mean difference	95% CI of the difference of the mean		*P*
							Lower bound	Upper bound	
MCC	10	65.26	4.14	58.43	71.83	25.20	18.01	32.39	.000
MCV	10	40.06	9.61	21.00	59.41				
MMC	10	49.84	7.96	36.82	61.42	11.77	3.38	20.17	.009
MMO	10	38.06	9.77	32.53	65.37				
MPC	10	62.11	7.52	47.95	77.40	26.42	20.45	32.38	.000
MPO	10	35.69	4.68	27.95	41.82				
MXCC	10	52.67	3.35	47.30	58.23	22.39	18.02	26.77	.000
MXCV	10	30.28	5.54	22.13	38.42				

CI = confidence interval; MCC = mandibular central incisor, all-ceramic crown; MCV = mandibular central incisor, ceramic veneer; MMC = maxillary first molar, all-ceramic crown; MMO = maxillary first molar, ceramic onlay; MPC = mandibular first premolar, all-ceramic crown; MPO = mandibular first premolar, ceramic onlay; MXCC = maxillary central incisor, all-ceramic crown; MXCV = maxillary central incisor, ceramic veneer.

Statistical analysis

Descriptive statistics were used to describe the volume percent of tooth structure reduction. The Student *t* test was used to compare the mean values of percent of tooth structure reduction between each type of coverage, and a P value of $< .05$ was considered statistically significant.

Results

Table 2 presents the mean percentage values and SDs of the volume of tooth structure reduction associated with different preparation designs. The all-ceramic crown preparation design for the mandibular central incisors had the highest percentage (65.26% ± 4.14%) of tooth structure reduction, while the lowest percentage of tooth structure reduction was associated with the ceramic veneer preparation design for maxillary central incisors (30.28% ± 5.54%).

The percentage reduction of tooth structure had a statistically significant difference between restoration designs, in which the mean percentage reduction of tooth structure was significantly higher for the complete coverage design compared with partial coverage.

Discussion

The proposed hypothesis of this study was rejected after the volume of tooth structure removed was measured. Edelhoff and Sorensen attempted to quantify the weight of tooth structure removed from acrylic resin teeth associated with different preparation designs. They reported that there were significant differences in the amount of tooth structure removed between different preparations.[3,4]

There was a statistically significant difference between complete and partial coverage of teeth, which is in agreement with Hussain et al[5] and Murphy et al.[6] The present study suggests that partial coverage designs, even the most invasive designs of porcelain veneers (incisal overlap preparation), offer a significant advantage over complete coverage preparations (all-ceramic crown preparations). Ceramic restorations were selected in this study for two reasons: first, due to their increasing popularity among clinicians, and, secondly, to make the choice of complete coverage (all-ceramic crown) comparable to ceramic veneers and onlays.

Different methods have been described in the literature to measure removed tooth structure associated with endodontic and restorative procedures.[3–6] Gravimetric analysis was used; however, natural teeth may not be suitable for this type of analysis because of the presence of the pulp chamber, intertubular dentin, and dentinal tubules, which may influence the gravimetric measurements.[3–5]

Volumetric analysis was used on duplicate dies for root-treated teeth using a laser profilometer; an undercut, however, cannot be read using this technique, and blocking out techniques were required to proceed with the scanning. This was considered a limitation.[6]

The volume of tooth structure reduction in the present study was measured from a three-dimensional image obtained from micro-CT. Since the finish line for all preparation designs was 0.5 mm insical to the cementoenamel junction and because micro-CT allows clear recognition of enamel, dentin, and pulp, it was easy to analyze the crown volume of the teeth before and after preparation using the remaining enamel as a reference margin.

Conclusion

The study's limitations are acknowledged and the following conclusions suggested: *(1)* the volume of tooth structure removed during preparation varies according to the preparation design, *(2)* tooth preparation for all-ceramic crowns required a greater amount of tooth structure removal compared with porcelain veneers and onlays, and *(3)* the partial coverage preparation designs preserved a statistically significantly greater amount of tooth structure.

Acknowledgment

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Literature Abstract

Associations between smoking and tooth loss according to the reason for tooth loss

The authors conducted a study on 1,106 postmenopausal women attending a Women's Health Initiative conference. They were examined for number of teeth missing and self-reported the reasons for tooth loss. Information on smoking habits was obtained via questionnaire and statistical analysis was done to assess the relationship between smoking and tooth loss due to caries or periodontal disease. Participants' characteristics were measured, including height, weight, body mass index (BMI), race, education, family income, history of diabetes, calcium supplements, vitamin D supplements, oral health behavior, and bone mineral density. Of these, age, BMI, education, family income, history of diabetes, calcium and vitamin D supplements, gingival surgery, and dental visit frequency were factors significantly different according to tooth loss. For smoking status, heavy smokers had an increase in tooth loss. Those women who smoked two or more packs per day had 10 times elevated odds of experiencing tooth loss due to periodontal disease. Those with the heaviest pack-years of smoking had 7 times elevated odds of experiencing tooth loss due to periodontal disease. There was no clear association between smoking and tooth loss due to caries. An unusual finding compared to most other studies was that this study did not find that current smokers had higher odds of experiencing tooth loss compared with never smokers. The authors found this difficult to explain citing differences in study population, lower levels of smoking in this cohort, and methodologic differences as possible reasons. This paper reaffirms the now established link between smoking and periodontal disease and, despite the limitations recognized by the authors, the population examined might be unique in this subject area.

Xiaodan M, Wactawski-Wende J, Hovey KM, LaMonte MJ, Chen C, Tezal M, Genco R J. *J Am Dent Assoc* 2013;144:252–265. **References:** 62. **Reprints:** Dr Wacktawski-Wende, Department of Social and Preventive Medicine, School of Public Health and Health Professions, University at Buffalo, The State University of New York, 270 Farber Hall, Buffalo, NY 14214. **Email:** jww@buffalo.edu—*Steven Soo, Singapore*