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Impression Evaluation and Laboratory Utilization for Single-Unit Crowns: Findings from The National Dental Practice-Based Research Network

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Abstract

Background—Objectives were to: (1) determine the likelihood that a clinician accepts an impression for a single-unit crown; and (2) document crown remake rates.

Methods—A questionnaire was developed that asked dentists about techniques used to fabricate single-unit crowns. Dentists were shown photographs of 4 impressions and were asked to accept or reject the impression. Answers were correlated with dentist and practice characteristics. Other questions pertained to laboratory usage and crown remake rates.

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Results—Response rate was 83% (1,777 of 2,132 eligible dentists). Of the impressions evaluated, 3 received consistent responses, with 85% agreement. One impression was more equivocal; 47% accepted the impression. The likelihood of accepting an impression was significantly associated with the clinician's sex, race, ethnicity, and practice busyness. Clinicians produce 18 crowns per month on average, and 9% used in-office milling. Most (59%) reported a remake rate of less than 2%, while 17% reported a remake rate >4%. Lower remake rates were significantly associated with more-experienced clinicians, optical impressions, and not using dual-arch trays.

Conclusions—While dentists were largely consistent in their evaluation of impressions (greater than 85%), non-clinical factors were associated with whether an impression was accepted or rejected. Lower crown remake rates were associated with more-experienced clinicians, optical impressions, and not using dual-arch trays.

Practical Implications—These results provide a snapshot of clinical care considerations among a diverse group of dentists. Clinicians can compare their own remake rates and impression evaluation techniques to this sample when developing best practice protocols.

Keywords

Crowns; Impressions; Dental Laboratory; Remake Rates; Practice Network

Introduction

Dentists commonly make single-unit crowns by making a polymeric impression of the prepared tooth and then sending the impression to a commercial laboratory for crown fabrication. Although other options are now available, such as optical impressions and in-office milling, most clinicians still use a traditional impression approach.^{1–3} Before sending the impression to a laboratory, the clinician must evaluate and accept the quality of the impression to ensure a well-fitting, clinically acceptable crown. The quality of the impression can certainly impact the fit of the crown, and some crowns must be remade, leading to increased chair time for both the patient and the dentist,^{2–7} as well as increased operational costs for the practice.

Little data exist to correlate the clinician's perceived quality of the impression to the characteristics of the dentist's practice. Indeed, while there is some general consensus about what constitutes a "good" quality impression, laboratories sometimes conclude that the impressions they receive are sub-optimal.⁸ Evaluating impressions submitted to dental laboratories, one study found 89% of impressions contained errors in the registration of the preparation which could potentially impact the accuracy of the restorations.⁹ This was echoed in several articles examining impressions submitted to laboratories in Great Britain, with approximately 44% of impressions deemed unsatisfactory.^{4, 8, 10} A call for improved impressions has also been made in the United States,^{5, 6} and has apparently been a concern for decades.¹¹ In contrast, Mitchell et al. rated 85% of impressions submitted to a commercial laboratory as good or excellent.¹²

When considering what constitutes a clinically acceptable impression, the evaluation should include both material and clinical factors. The material chosen to make the impression must capture adequate surface detail, be dimensionally stable through disinfection and over time, offer dimensional accuracy, and provide elastic recovery.² These qualities are generally achieved using polymeric impression materials, which account for the majority of impressions made today in general dental practice.¹² Clinical factors are those that the dentist can either control in some manner, or evaluate and analyze for clinical acceptability. These clinical factors include visible defects such as: incomplete margin detail, air bubbles, voids, pulls, unset impression material, contamination with blood or saliva, cords or cotton rolls trapped in the impression, inadequate union of materials, improper tray selection, and debris in the impression.^{5, 9, 13} Other errors that distort the impression, but which might be harder to visualize, include impression recoil, detachment of the impression material from the tray, and plastic deformation.¹³ Impression recoil occurs when an impression is inserted with some pressure, which upon release changes the dimension of the impression; it is typically associated with a two-stage putty wash technique.¹³

An accurate impression is required for consistent crown fabrication.¹⁴ Several articles give instructions to clinicians on how to achieve an acceptable impression, one that accurately reproduces the prepared tooth. These include considerations as diverse as moisture control to patient comfort,⁷ and are considered important for clinical success.¹⁵ A comprehensive understanding of the materials used may facilitate impression making,¹⁶ as well as a consistent protocol among team members.¹⁷ Careful soft tissue management, both prior to and during tooth preparation, can improve outcomes.^{6, 18}

Dentists sometimes must remake a crown instead of inserting it, for example if the crown rocks on the tooth, or the shade is incorrect. Errors in fabricating crowns can be made by the dentist or the laboratory, but both groups, as well as the patient, are negatively impacted by crown remakes. Common problems related to unacceptable crowns include: inadequate impressions, inadequate preparations, inaccurate jaw relation records, disregarded prescriptions (miscommunication with the lab regarding materials, shade, etc.), poor clinical shade match, poor fit, and unsatisfactory anatomical form.^{19–21}

The purpose of this study was to ask dentists to evaluate the quality of polymeric impressions based on questionnaire photographs and correlate their responses to the characteristics of these dentists and their practices. Laboratory remake rates were estimated based on survey responses, and clinician's opinions regarding reasons for remaking crowns were documented.

Materials and Methods

This study is based on enrollment and study questionnaires completed by dentists in the National Dental Practice-Based Research Network (PBRN; “network”). The network is a consortium of dental practices and dental organizations focused on improving the scientific basis for clinical decision-making.²² Detailed information about the network is available on its web site.²³ The network's applicable Institutional Review Boards approved the study; all

participants provided informed consent after receiving a full explanation of the procedures. Methods are published in detail elsewhere,²⁴ and are summarized below.

Enrollment Questionnaire

Practitioners completed an Enrollment Questionnaire to describe themselves, their practice(s), and their patient population. This questionnaire is publicly available at “<http://www.nationaldentalpbrn.org/study-results.php>” under the heading “Factors for Successful Crowns”. Questionnaire items, which had documented test/re-test reliability, were taken from our previous work in a practice-based study of dental care.^{25, 26}

Study Questionnaire Development

The questionnaire for this study was developed by a study team of the authors, other dentists with clinical experience, statisticians, and laboratory technicians. The purpose of the questionnaire was to measure current practices in treatment planning, preparing, and fabricating single-unit crowns on natural teeth. The survey was reviewed by IDEA Services (Instrument Design, Evaluation, and Analysis Services, Westat, Rockville, MD), a group with expertise in questionnaire development and implementation, as well as National Institute of Dental and Craniofacial Research (NIDCR) program officers and practitioners with prosthodontic content expertise. After extensive internal review, IDEA Services pre-tested the questionnaire via cognitive interviewing by telephone with a regionally diverse group of eight practicing dentists. Cognitive interviewers probed the dentist’s comprehension of each question. The interviewers also asked practitioners to identify items of clinical interest that were not addressed in the survey. Results from the pretest prompted further modification of the questionnaire.

Dentists enrolled in the network were eligible for the study if they met all of these criteria: (1) completed an Enrollment Questionnaire; (2) were currently practicing and treating patients in the United States; (3) were in the network’s “limited” or “full” network participation category; and (4) had reported on the Enrollment Questionnaire that they currently do at least some restorative dentistry in their practices. A total of 2,299 network clinicians met these criteria. If desired, practitioners or their business entities were remunerated \$75 for completing the questionnaire. Data were collected from February 2015 to August 2015.

Questionnaire Content

The first question of the survey confirmed that the invited clinician did at least one crown in a typical month. The Questionnaire is publicly available (<http://www.nationaldentalpbrn.org/study-results.php>) under the heading “Factors for Successful Crowns”.

Clinicians were asked to rank photographs of 4 impressions, and indicate if the impressions were adequate to be sent to a laboratory to fabricate a crown (acceptable), or if the impression should be remade (unacceptable). Specifically, clinicians were asked: “Assume you have made the impression pictured here. What is the next step? (Choose only one.) Send to the lab for Crown fabrication. Modify or remake the impression.” Photographs are shown in Figure 1. For data analysis, acceptable decisions were coded as 1, and unacceptable were

coded as 0. The results for each clinician were added, producing a value for each clinician that ranged from 0–4. In other words, if a clinician responded that each impression was acceptable, that clinician would have a composite score of 4. If another clinician chose to reject every impression, his/her score would be 0. A similar methodology was used previously to determine the likelihood for recommending crowns based on restoration size.²⁴ Once assigned a composite score, clinicians were stratified into 2 groups, those who were more likely to reject an impression (score 0–2) and those who were more likely to send it to the laboratory (score 3–4). These groups were evaluated statistically to determine differences in practice and practitioner characteristics between dentists who are more likely to accept or to reject an impression.

Clinicians were also asked the following questions: how many crowns they produced each month; what percentage of crowns needed to be remade; and to rank the primary reasons for remaking crowns in their offices. Answers regarding crown remakes were stratified into 3 categories: less than 2%, 2–4%, and more than 4%. These groups were analyzed to see if significant differences exist among dentists based on their self-reported crown remake rates.

Statistical Analyses

Power analysis was conducted based on an anticipated sample size of 1,500 completed questionnaires. This sample size would yield sufficient precision to estimate response percentages within $\pm 2.53\%$, at the 95% confidence level. To document test/re-test reliability of the questionnaire items, 47 respondents completed the questionnaire twice online. For categorical responses, kappa and weighted kappa were used; for numeric items, Pearson's correlation coefficient was calculated to assess test-retest reliability. Descriptive statistics are presented as counts and percentages for categorical variables, and as means and standard deviations for continuous measures. Dentist and practice characteristics were compared across survey responses using chi-square analysis.

Results

For this study, 2,299 dentists were selected to participate. Of these dentists, 101 were deemed ineligible before beginning the questionnaire (no longer in active practice; deceased; specialists who do not do single-unit permanent crowns). An additional 66 completed part of the questionnaire, but reported doing less than 1 crown per month, and were therefore deemed ineligible for the study. This left a total of 2,132 eligible persons, of whom 1,777 responded, for a response rate of 83%. Among the 47 test/re-test participants, the mean (SD) time between test and re-test was 15.5 (3.0) days. For categorical variables, agreement between time 1 and time 2 showed a mean weighted kappa of 0.62 (IQR: 0.46, 0.79). Mean test-retest reliability for numeric variables was 0.75.

Dentist and practice characteristics are published.^{3, 24} The majority of respondents were male, and many had been in practice for over 20 years. Most of the respondents, 73%, were practice owners. Respondents were distributed fairly evenly across regions, and the majority work full time (86%). Only 3% of respondents were specialists, including 32 prosthodontists. The vast majority of dentists (86%) reported that more than 40% of their patients have private dental insurance.

Clinicians ranked each of the impression photographs shown in Figure 1 as follows. Figure 1A: Acceptable, 85%; Unacceptable 14%. Figure 1B: Acceptable, 92%; Unacceptable, 8%. Figure 1C: Acceptable, 47%; Unacceptable, 52%. Fig 1D: Acceptable, 2%; Unacceptable, 98%. Careful consideration of the images shows the following. Figure 1A is an impression of a maxillary molar. There is a defect in the facial margin that is clearly visible; the defect cuts through the finish line and onto the axial wall. Some areas of the margin may be indistinct. The anatomy of the adjacent tooth is missing on the facial aspect due to a large void. Figure 1B is a clean impression of a premolar, with apparently intact margins. The contours of the adjacent tooth are suspect. Figure 1C shows an impression of a tooth which seems to be mostly covered by the wash material. There is an obvious void in the middle of the axial wall about 2 mm in diameter. The margins appear mostly intact, although some areas are indistinct in the photograph. Figure 1D represents a premolar impression with a large defect on the margin of the preparation. Marginal detail is lacking in other areas as well.

Factors associated with a clinician's willingness to reject an impression are shown in Table 1. Significant factors associated with rejecting an impression were dentist sex, race, ethnicity, and practice busyness (the latter of which was marginally significant). About 52% of females tended to reject the impressions, compared to 46% of males. White clinicians tended to reject the impressions 46% of the time, while Black/African-American clinicians demonstrated a higher tendency to reject impressions at 61%. Hispanics were more likely to reject impressions (62%) compared to non-Hispanic clinicians (47%). About 6% of clinicians reported feeling too busy, and 18% were burdened with their clinical load; about half of the clinicians reported a balanced practice busyness. Clinicians who reported being too busy were less likely to reject an impression, at only 37%. Non-significant factors were years since graduation, specialty status, network region, percentage of patients in the practice who have private dental insurance, and type of practice. Responses to each of the four questions can be found in an appendix under the heading "Factors for Successful Crowns" at <http://www.nationaldentalpbrn.org/study-results/>.

Dentists categorized their clinical remake rates for crowns, and these results are presented in Table 2. The majority reported a remake rate of less than 2%, and 17% reported a remake rate of 4% or greater. Significant association existed between remake rates and various dentist, practice, and technique factors. Female dentists had a generally higher remake rate than males, while Hispanics had lower remake rates than non-Hispanic dentists. Having been in practice more years was associated with a lower remake rate. While 30% of new graduates reported a remake rate greater than 4%, only 13% of practitioners who had been in practice for more than 15 years reported this rate. Clinicians who only use optical impressions had the lowest remake rates, with 89% of clinicians reporting less than 2% remakes.

Clinicians who do not use dual-arch (triple tray) impression techniques reported significantly fewer remakes. Clinical reasons for remakes are ranked in Table 3, along with factors that clinicians deem valuable when choosing a laboratory. Both reflect an importance of marginal fit and esthetics. Clinicians report a mean production ($\pm$ SD) of 18 ($\pm$ 14) crowns per month. The range was 1 to 150; the upper quartile was 25 and the lower quartile was 10.

Regarding laboratory use, 88% of clinicians reported using a commercial laboratory to fabricate most of their crowns. Three percent use an in-house laboratory technician, and 9% report using in-office milling for most of their crowns. The mean distance for sending out cases to a commercial lab was 322 miles, although the median was 20 miles.

Discussion

These results are unique in that they describe opinions from a large cohort of dentists regarding whether or not specific impressions are acceptable, and correlate these opinions to dentist and practice characteristics. Most studies have engaged a small number of clinicians to evaluate a large number of impressions.

The photograph with the most consistent response was Figure 1C, which was rejected by 98% of clinicians. The overwhelming overall concern for clinicians seems to be marginal integrity. With an obvious defect at the finish line and general lack of marginal detail, most dentists condemned the impression. Figure 1B presented good marginal detail, with 92% of clinicians accepting the impression; some may have rejected the impression because of the inadequate capture of the occlusal surface of the adjacent molar. The most equivocal presentation was Figure 1C. About half chose to accept the impression.

Overall, the opinions of the respondents were consistent with the opinions of the authors. Our general conclusion is that dentists in the network are rejecting impressions in a way that is consistent with standard of care in dental practice. Impressions with marginal errors were largely rejected. The most equivocal response was noted on Figure 1C, where about half of dentists accepted and half rejected the impression. This is understandable, given the void on the axial wall and light marginal detail. In the other 3 examples, dentists are largely consistent in their responses.

We can only speculate as to why some dentist characteristics – gender, race, and ethnicity – were associated with the likelihood of rejecting an impression. In general, minorities had a higher tendency to reject an impression. The strongest correlation was with Hispanic ethnicity. It is possible that Hispanic cultural aspects of work ethic²⁷ and cooperation²⁸ create a desire to avoid potential future conflict as a result of a crown that does not fit. With regard to differences between male and female dentists, it is possible that sex differences in clinical practice^{29, 30} acceptance of practice guidelines^{31, 32}, or desire to deflect perceived scrutiny^{29–32} affect the likelihood of rejecting an impression. However, such conclusions about race, ethnicity, and sex would require focused investigation with larger stratified samples sizes and confirmation in other studies.

The tendency to reject an impression also correlated with practice busyness. Clinicians who felt burdened by their workload were more likely to accept an impression. This might reflect the pressure of waiting patients pushing clinicians towards accepting an impression and reducing chair time. Other factors examined in this study were not significantly correlated with the likelihood of accepting an impression.

The overall remake rate was relatively low, with the majority of clinicians reporting less than 2% remakes. This is lower than other studies; however, these studies included dental school

remakes and fixed partial dentures, which would likely show higher remake rates.^{21, 33} Personal communication with dental laboratories suggests an industry goal of 2% or less in remakes, which is consistent with 60% of our survey respondents. Larger commercial laboratories may report slightly higher numbers, for example 3%, due to a wider variety of clinician techniques and work quality. The use of dual-arch trays, which is somewhat controversial in the literature,^{34–38} was associated with a higher remake rate. The ranking of reasons for remaking crowns was not widely dispersed, although marginal misfit and esthetic failures were the highest-ranked reasons for remaking crowns. Occlusal errors were not an important factor for remakes.

When choosing a commercial laboratory, a larger spread in rankings was noted. Quality of fit stood alone in the rankings, in addition to esthetics. Clearly dentists are most concerned about clinical aspects of the indirect restoration. Surprisingly, cost was not an important factor in choosing a laboratory. This may reflect a growing trend to utilize technology in the dental laboratory, offering a more-consistent product across the industry at a price that has not changed greatly in a decade.

Technology continues to advance in clinical dentistry, with about 9% of clinicians reporting the use of in-office optical impression scanners. The acceptable fit and function of in-office milled crowns have been well documented in the literature.^{39–41} The widespread use of intra-oral scanners and milling may be on the horizon.¹

The number of crowns produced per month, 18, was surprising. Assuming 155,000 general dentists in the United States⁴² and a representative sample, this implies that over 30 million crowns are done each year, at a consumer cost of over \$20 billion. This a significant portion of the entire dental health care cost. Clearly any science that can improve the fit or function of crowns, if even slightly, will have an important impact on patient care.

This study has limitations. This research is based on self-reported data, which may differ from figures obtained from actual clinical records. This may be of particular interest regarding self-reported crown remake rates. The impressions evaluated in this article were represented by a single photograph, without the possibility of looking at the impression from different angles or with magnification. Although network practitioners have much in common with dentists at large^{43, 44} it may be that their crown procedures are not representative of a wider representation of dentists. Network members are not recruited randomly, so factors associated with network participation (*e.g.*, an interest in clinical research) may make network dentists unrepresentative of dentists at large. While we cannot assert that network dentists are entirely representative, we can state that they have much in common with dentists at large, while also offering substantial diversity in these characteristics. This assertion is warranted because: 1) substantial percentages of network general dentists are represented in the various response categories of the characteristics in the Enrollment Questionnaire; 2) findings from several network studies document that network general dentists report patterns of diagnosis and treatment that are similar to patterns determined from non-network general dentists^{45–47} and 3) the similarity of network dentists to non-network dentists using the 2010 ADA Survey of Dental Practice.⁴⁸

Conclusions

This study offers insight into the clinical practice of a diverse group of dentists, with regards to evaluating impressions and accepting crowns clinically. Dentists largely accept or reject impressions in a consistent manner. Three impressions had 85% agreement or more. However, one impression was split in the likelihood of accepting or rejecting it, with 47% of clinicians rejecting the impression, so differences of opinion regarding impression quality do exist. Dentist characteristics significantly associated with accepting or rejecting an impression were practice busyness and the clinician's race, gender, and ethnicity. Dentists produce a large number of crowns each year, averaging 18 crowns per month. The majority report a remake rate of <2%, and 17% reported a remake rate of 4% or more. Lower remake rates were significantly associated with more-experienced clinicians, optical impressions, and not using dual-arch trays.

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APPENDIX (to be posted on the network's web page at <http://nationaldentalpbrn.org/study-results/>)

Table 1A

Responses to accept or reject an impression, by specific impression A–D, given in number (percent). This Table references the 4 impressions displayed in Figure 1.

Characteristics	Tends to Reject	Tends to Accept	<i>P</i> Value*	Total [†]
Figure 1A				
Total	259 (15)	1508 (85)		1767
Sex of the Dentist				
Male	190 (15)	1084 (85)	0.68	1274 (73)
Female	68 (14)	413 (86)		481 (27)
Race of the Dentist				
White	216 (15)	1227 (85)	0.25	1443 (82)
Black/African-American	14 (18)	63 (82)		77 (4)
Asian	22 (14)	138 (86)		160 (9)
Other	5 (7)	65 (93)		70 (4)

Characteristics	Tends to Reject	Tends to Accept	<i>P</i> Value*	Total ^I
Ethnicity of the Dentist				
Hispanic	13 (13)	88 (87)	0.62	101 (6)
Non-Hispanic	242 (15)	1408 (85)		1650 (94)
Years Since Graduation				
<5	8 (11)	62 (89)	0.08	70 (4)
5–15	52 (12)	392 (88)		444 (25)
>15	198 (16)	1052 (84)		1250 (71)
Type of Practice				
Owner of Private Practice	195 (15)	1091 (85)	0.02	1286 (73)
Associate in Private Practice	21 (10)	186 (90)		207 (12)
Health Partners	9 (21)	34 (79)		43 (2)
Permanente	5 (7)	65 (93)		70 (4)
Public Health, Community	17 (27)	47 (73)		64 (4)
Academic	6 (12)	42 (88)		48 (3)
Other	2 (8)	22 (92)		24 (1)
Network Region in which the practice is located				
Western	25 (9)	267 (91)	0.003	292 (17)
Midwest	27 (15)	151 (85)		178 (10)
Southwest	47 (15)	264 (85)		311 (18)
South Central	48 (15)	281 (85)		329 (19)
South Atlantic	44 (14)	280 (86)		324 (18)
Northeast	68 (20)	265 (80)		333 (19)
Practice Busyness				
Too busy	22 (22)	79 (78)	0.16	101 (6)
Burdened	42 (13)	282 (87)		324 (18)
Balanced	128 (14)	776 (86)		904 (51)
Not busy	67 (15)	369 (85)		436 (25)
Percentage of Patients in the Practice Who Have Private Dental Insurance				
<40% Private Insurance	9 (17)	43 (83)	0.48	52 (3)
40–79% Private Insurance	101 (13)	650 (87)		751 (43)
80%+ Private Insurance	144 (15)	798 (85)		942 (54)
Figure 1B				
Total	1628 (92)	144 (8)		1772
Sex of the Dentist				
Male	1171 (92)	106 (8)	0.33	1277 (73)
Female	447 (93)	36 (7)		483 (27)

Characteristics	Tends to Reject	Tends to Accept	<i>P</i> Value*	Total ^I
Race of the Dentist				
White	1331 (92)	115 (8)	0.0001	1446 (82)
Black/African-American	61 (79)	16 (21)		77 (4)
Asian	155 (96)	6 (4)		161 (9)
Other	64 (91)	6 (9)		70 (4)
Ethnicity of the Dentist				
Hispanic	89 (88)	12 (12)	0.16	101 (6)
Non-Hispanic	1522 (92)	131 (8)		1653 (94)
Years Since Graduation				
<5	67 (96)	3 (4)	0.002	70 (4)
5–15	427 (96)	17 (4)		444 (25)
>15	1131 (90)	124 (10)		1255 (71)
Type of Practice				
Owner of Private Practice	1169 (91)	121 (9)	0.02	1290 (73)
Associate in Private Practice	195 (94)	12 (6)		207 (12)
Health Partners	43 (98)	1 (2)		44 (2)
Permanente	70 (100)	0		70 (4)
Public Health, Community	58 (91)	6 (9)		64 (4)
Academic	47 (98)	1 (2)		48 (3)
Other	23 (96)	1 (0.7)		24 (1)
Network Region in which the practice is located				
Western	278 (95)	14 (5)	0.005	292 (26)
Midwest	172 (96)	8 (4)		180 (10)
Southwest	272 (87)	39 (13)		311 (18)
South Central	302 (92)	26 (8)		328 (19)
South Atlantic	295 (90)	31 (10)		326 (18)
Northeast	309 (92)	26 (8)		335 (19)
Practice Busyness				
Too busy	96 (95)	5 (5)	0.29	101 (6)
Burdened	304 (93)	23 (7)		327 (18)
Balanced	824 (91)	84 (9)		908 (51)
Not busy	402 (93)	32 (7)		434 (25)
Percentage of Patients in the Practice Who Have Private Dental Insurance				
<40% Private Insurance	9 (17)	43 (83)	0.48	52 (3)
40–79% Private Insurance	101 (13)	650 (87)		751 (43)
80%+ Private Insurance	144 (15)	798 (85)		942 (54)

Figure 1C

Characteristics	Tends to Reject	Tends to Accept	<i>P</i> Value*	Total ^I
Total	842 (48)	926 (52)		1768
Sex of the Dentist				
Male	631 (50)	643 (50)	0.01	1274 (73)
Female	206 (43)	276 (57)		482 (27)
Race of the Dentist				
White	715 (50)	728 (50)	0.01	1443 (82)
Black/African-American	26 (34)	51 (66)		77 (4)
Asian	65 (41)	95 (59)		160 (9)
Other	32 (46)	38 (54)		70 (4)
Ethnicity of the Dentist				
Hispanic	34 (34)	67 (66)	0.004	101 (6)
Non-Hispanic	800 (48)	850 (52)		1650 (94)
Years Since Graduation				
<5	32 (46)	38 (54)	0.80	70 (4)
5–15	206 (47)	237 (54)		444 (25)
>15	602 (48)	650 (52)		1250 (71)
Type of Practice				
Owner of Private Practice	634 (49)	652 (51)	0.03	1286 (73)
Associate in Private Practice	93 (45)	114 (55)		207 (12)
Health Partners	23 (52)	21 (48)		43 (2)
Permanente	36 (51)	34 (49)		70 (4)
Public Health, Community	21 (33)	43(67)		64 (4)
Academic	19 (40)	29 (60)		48 (3)
Other	6 (25)	18 (75)		24 (1)
Network Region in which the practice is located				
Western	142 (49)	149 (51)	0.09	291 (16)
Midwest	95 (53)	84 (47)		179 (10)
Southwest	149 (48)	162 (52)		311 (18)
South Central	169 (52)	159 (49)		328 (18)
South Atlantic	146 (45)	178 (55)		324 (18)
Northeast	141 (42)	194 (58)		335 (19)
Practice Busyness				
Too busy	51 (51)	50 (50)	0.33	101 (6)
Burdened	144 (44)	182 (56)		326 (18)
Balanced	427 (47)	480 (53)		907 (51)
Not busy	218 (50)	214 (50)		432 (25)

Characteristics	Tends to Reject	Tends to Accept	<i>P</i> Value*	Total ^I
Percentage of Patients in the Practice Who Have Private Dental Insurance				
<40% Private Insurance	20 (38)	32 (62)	0.055	52 (3)
40–79% Private Insurance	381 (51)	369 (49)		750 (43)
80%+ Private Insurance	434 (46)	510 (54)		944 (54)
Figure 1D				
Total	33 (2)	1739 (98)		1772
Sex of the Dentist				
Male	25 (2)	1252 (98)	0.67	1277 (73)
Female	8 (2)	475 (98)		483 (27)
Race of the Dentist				
White	25 (2)	1421 (98)	0.19	1446 (82)
Black/African-American	1 (1)	76 (99)		77 (4)
Asian	6 (4)	155 (96)		161 (9)
Other	0	70 (100)		70 (4)
Ethnicity of the Dentist				
Hispanic	2 (2)	99 (98)	0.90	101 (6)
Non-Hispanic	30 (2)	1623 (98)		1653 (94)
Years Since Graduation				
<5	1 (1)	69 (99)	0.09	70 (4)
5–15	8 (2)	436 (98)		444 (25)
>15	24 (2)	1231 (98)		1255 (71)
Type of Practice				
Owner of Private Practice	27 (2)	1263 (98)	0.31	1290 (73)
Associate in Private Practice	3 (1)	204 (99)		207 (12)
Health Partners	1 (2)	43 (98)		44 (2)
Permanente	0	70 (100)		70 (4)
Public Health, Community	0	64 (100)		64 (4)
Academic	0	48 (100)		48 (3)
Other	1 (4)	23 (96)		24 (1)
Network Region in which the practice is located				
Western	4 (1)	288 (99)	0.38	292 (16)
Midwest	2 (1)	178 (99)		180 (10)
Southwest	8 (3)	303 (97)		311 (18)
South Central	10 (3)	318 (97)		328 (19)
South Atlantic	4 (1)	322 (99)		326 (18)
Northeast	5 (1)	335 (19)		335 (19)

Characteristics	Tends to Reject	Tends to Accept	P Value*	Total ^I
Practice Busyness				
Too busy	2 (2)	99 (98)	0.96	101 (6)
Burdened	5 (2)	322 (98)		327 (18)
Balanced	18 (2)	890 (98)		908 (51)
Not busy	8 (24)	426 (98)		434 (24)
Percentage of Patients in the Practice Who Have Private Dental Insurance				
<40% Private Insurance	0	52 (100)	0.59	52 (3)
40–79% Private Insurance	15 (2)	738 (98)		753 (43)
80%+ Private Insurance	18 (2)	927 (98)		945 (54)

^ITotals may vary due to missing data.

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Figure 1.

Table 1

Association between dentist/ practice characteristics and willingness to accept or reject an impression, number (percent).

Characteristics	Tends to Reject	Tends to Accept	P Value*	Total ^f
Total	840 (48)	922 (52)		1762
Sex of the dentist				
Male	586 (46)	684 (54)	0.04	1270 (73)
Female	248 (52)	232 (48)		480 (27)
Race of the dentist				
White	661 (46)	778 (54)	0.02	1439 (82)
Black/African-American	47 (61)	30 (39)		77 (4)
Asian	80 (50)	79 (50)		159 (9)
Other	40 (57)	30 (43)		70 (4)
Ethnicity of the dentist				
Hispanic	63 (62)	38 (38)	0.002	101 (6)
Non-Hispanic	772 (47)	873 (53)		1645 (94)
Years Since Dental School Graduation				
<5	37 (53)	33 (47)	0.65	70 (4)
5–15	213 (48)	230 (52)		443 (25)
>15	589 (47)	657 (53)		1246 (71)
Type of Practice				
Owner of Private Practice	596 (47)	685 (53)	0.159	1281 (73)
Associate in Private Practice	108 (52)	99 (48)		207 (12)
Health Partners	16 (37)	27 (63)		43 (2)
Permanente	30 (43)	40 (57)		70 (4)
Public Health, Community	35 (55)	29 (45)		64 (4)
Academic	25 (52)	23 (48)		48 (2)
Other	15 (63)	9 (37)		24 (1)
Network Region in which the practice is located				
Western	137 (47)	154 (53)	0.25	291 (17)
Midwest	73 (41)	104 (59)		177 (10)
Southwest	154 (50)	157 (50)		311 (18)
South Central	147 (45)	181 (55)		328 (19)
South Atlantic	166 (51)	157 (49)		323 (18)
Northeast	163 (49)	169 (51)		332 (19)
Practice Busyness				
Too busy	37 (37)	64 (63)	0.05	101 (6)
Burdened	165 (51)	159 (49)		324 (18)

Characteristics	Tends to Reject	Tends to Accept	<i>P</i> Value*	Total ^I
Balanced	442 (49)	461 (51)		903 (51)
Not busy	196 (45)	236 (55)		432 (25)
Percentage of Patients in the Practice Who Have Private Dental Insurance				
<40% Private Insurance	29 (56)	23 (44)	0.31	52 (3)
40–79% Private Insurance	344 (46)	403 (54)		747 (43)
80%+ Private Insurance	455 (48)	486 (52)		941 (54)

^ITotals may vary due to missing data. Percentages may not add to 100% due to rounding.

Table 2
Dentist, practice, and technique factors associated with self-reported crown remake rates. Number (%)

Characteristics	Crown Remake Rates			P Value	Total ¹
	<2%	2–4%	>4%		
Total	1047 (59)	429 (24)	301 (17)		1777
Sex of the dentist					
Male	782 (61)	316 (25)	184 (14)	<.0001	1282 (73)
Female	259 (54)	110 (23)	114 (24)		483 (27)
Race of the dentist					
White	869 (60)	346 (24)	236 (16)	0.45	1451 (82)
Black/African-American	41 (53)	23 (30)	13 (17)		77 (4)
Asian	39 (56)	17 (24)	14 (20)		70 (4)
Other	86 (53)	40 (25)	35 (22)		161 (9)
Ethnicity of the dentist					
Hispanic	72 (71)	14 (14)	15 (15)	0.02	101 (6)
Non-Hispanic	964 (58)	410 (25)	284 (17)		1658 (94)
Years Since Dental School Graduation					
<5	31 (44)	18 (26)	21 (30)	<0.0001	70 (4)
5–15	201 (45)	135 (30)	108 (24)		444 (25)
>15	814 (65)	276 (22)	170 (13)		1260 (71)
Type of Practice					
Owner of Private Practice	788 (61)	310 (24)	197 (15)	<0.0001	1295 (73)
Associate in Private Practice	99(48)	59 (29)	49 (24)		207 (12)
Health Partners	17 (39)	15 (34)	12 (27)		44 (2)
Permanente	30 (43)	24 (34)	16 (23)		70 (4)
Public Health, Community	45 (70)	5 (8)	14 (22)		64 (4)
Academic	37 (77)	7 (15)	4 (8)		48 (3)
Other	20 (59)	7 (21)	7 (21)		34 (2)

Characteristics	Crown Remake Rates			P Value	Total ¹
	<2%	2–4%	>4%		
Impression Technique for Capturing Tooth					
Optical Impression Only	33 (89)	3 (8)	1 (3)	0.009	37 (2)
Ultra-Light	122 (56)	49 (23)	45 (21)		216 (12)
Light	802 (58)	338 (25)	231 (17)		1371 (78)
Medium	87 (62)	33 (23)	21 (15)		141 (8)
Dual-Arch Tray					
Do Not Use	200 (69)	48 (17)	41 (14)	0.002	289 (16)
Metal Frame	227 (55)	111 (27)	77 (19)		415 (23)
Plastic Frame	618 (58)	269 (25)	183 (17)		1070 (60)

Table 3

Reasons for crown remakes, ranked from 1 to 5, with 1 being the most common (mean rankings $\pm$ SD), and factors that dentists consider important when choosing a commercial laboratory, ranked in a similar manner, with 1 being the most important.

Most Common Reasons for Crown Remakes	Mean Ranking ($\pm$SD)
Marginal misfit and/or open margins	2.3 (1.3)
Esthetics and/or shade mismatch	2.7 (1.4)
Proximal misfit, including open contacts	2.8 (1.3)
Crown not fitting tooth, including rocking	3.2 (1.4)
Occlusal errors	3.9 (1.2)
Importance of Factors when Choosing a Commercial Dental Laboratory	
Quality of fit	1.3 (0.7)
Esthetics	2.5 (0.9)
Relationship with lab/ customer service	3.9 (1.6)
Cost	4.0 (1.4)
Delivery time	4.4 (1.1)
Pick-up/ ease of shipping	5.0 (1.0)