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*J Am Dent Assoc*. Author manuscript; available in PMC 2020 June 01.

Published in final edited form as:

*J Am Dent Assoc*. 2019 June ; 150(6): 522–530. doi:10.1016/j.adaj.2019.01.021.

# Choice of cement for single-unit crowns: Findings from the National Dental Practice-Based Research Network

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## Abstract

**Background:** This report presents clinical factors associated with the type of cement practitioners use for restoration of single-unit crowns.

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Disclosure. None of the authors reported nay disclosures.

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**Methods:** A total of 202 dentists in the National Dental Practice-Based Research Network recorded clinical details (including cement type) used for 3,468 single-unit crowns. The crowns were classified as bonded if a resin cement was used. Associations between various clinical factors and the dentist's decision to bond were assessed by mixed-model logistic regression.

**Results:** 38.1% of crowns were bonded and 61.9% were non-bonded. 39.1% (79/202) of dentists never bonded a crown and 20.3% (41/202) of dentists bonded every crown in the study. Crowns with excessive occlusal reduction (as judged by laboratory technicians) were more likely to be bonded (p=.02); however, there was no association with bonding and excessive taper (p=. 15) or axial reduction (p=.08). Crowns were more likely to be bonded if they were fabricated from leucite-reinforced glass ceramic (76.5%) or lithium disilicate (70.9%), as compared to layered zirconia (38.8%), full contour zirconia (30.1%), full metal (14.7%), or porcelain-fused-to-metal (13.8%) (p<.01). There was no significant association between choice to bond and location of crown margin (p=.35). Crowns in the anterior maxilla were more likely to be bonded (p<.01).

**Conclusions:** Excessive occlusal tooth preparation, anterior location of a crown, and the use of glass ceramic crowns were significantly associated with the decision to bond.

**Practical implications:** This study identifies factors significantly associated with the clinical decision made by practicing dentists when selecting a cement for restoration of single-unit crowns.

### Keywords

resin cements; glass ionomer cements; dental bonding; restorative dentistry: fixed prosthetics; crowns

## Introduction

The cements used in dentistry can be characterized as resin-based cements and water-based acid-base cements. Resin-based cements are typically used with a tooth primer that forms a hybrid layer with collagen in dentin. Self-adhesive resin cements constitute a sub-category of resin-based cements capable of partially demineralizing and hybridizing with tooth structure without a separate primer.[1] Therefore, the use of a resin cement is termed *bonding* a crown since there is a hybrid layer formed at the tooth-cement interface.[2]

Current water-based acid-base cements include zinc phosphate, glass ionomer, and resin-modified glass ionomer (RMGI) cements. Zinc phosphate cement is not capable of chemically bonding to tooth.[3] Glass ionomer and RMGI cements contain polyacrylic acid which can form an ionic bond with calcium ions in hydroxyapatite of enamel and dentin.[4] Based on bond strength studies, the bond of glass-ionomer based materials to dentin is significantly lower than the bond of resin-based materials to dentin.[5] Although there is a chemical bond between glass ionomer and RMGI cements and tooth structure, cementation of crowns with water-based acid-base cements is not termed *bonding*. The clinician's choice to bond a crown may depend on several clinical factors, such as the need for additional retention, the need to improve the strength of the crown, and whether adequate isolation can be achieved.

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Several laboratory studies have determined that bonding crowns with resin cements increases the retention strength of the crown more than cementing with glass ionomer or zinc phosphate cements.[6,7] The two most-critical elements of a crown preparation that affect its retentiveness are its taper and height.[6–10] Clinicians may choose to compensate for non-retentive preparations by selecting materials which they believe can be bonded. Although several systematic reviews have summarized the multitude of laboratory studies showing an effective bond to zirconia with resin cements, many clinicians may not bond zirconia due to a lack of clinical evidence.[11–15]

For some ceramic crown materials, it is necessary to bond the crown to tooth structure in order to strengthen the restoration. Feldspathic porcelain and leucite-reinforced glass ceramic crowns achieve significantly higher crown fracture strength when bonded with a resin cement than when cemented with glass ionomer or zinc phosphate cements.[15–18] This increase in strength has been credited to either the ability of the cement to fill defects and prevent crack propagation in the ceramic or to the better mechanical properties of the resin cement (increased strength and lower water sorption).[15,19] Lithium disilicate crowns have shown similar[20,21] or higher[18,19] fracture strength when bonded than when not bonded, assuming a thickness of 1.5 mm (manufacturer's recommended material thickness for non-bonded restorations). If their occlusal thickness is below 1.5 mm, bonding lithium disilicate crowns significantly improves their overall fracture strength.[20] Several studies have shown that zirconia crowns do not show a significantly higher fracture strength when bonded with resin cements than when cemented with glass ionomer or zinc phosphate cements, even at a 0.5 mm occlusal thickness.[21,23] For PFM single-unit crowns, the 5-year cumulative fracture rate of the metal coping is very low (0.03%) compared to lithium disilicate (2.3%) and zirconia (0.4%) copings.[14] It is therefore unlikely that the strength of PFM crowns plays any role in cement selection.

Bonding to dentin with a resin-based material in a relatively moisture-controlled field can produce a greater bond of the crown to the tooth structure than using a resin-modified glass ionomer cement; however, if dentin becomes contaminated with saliva, the bond to the resin-based material will fall below that of the resin-modified glass ionomer.[24] Therefore, a significant contra-indication for the use of a resin cement would be the inability to achieve adequate moisture control. Due to the proximity to salivary glands and the tongue as well as gravitational pooling, achieving salivary isolation is often more challenging in the posterior aspect of the mouth, particularly in the mandibular arch. Isolation of subgingival margins is also difficult as it places the crown margin in direct contact with sulcular fluid. Thus, the choice of cement for use when placing a dental crown is dependent upon several variables that must be considered by the clinician.

The goal of this study was to record preferences and theorize rationales that clinicians employ for cement selection for the restoration of single-unit crowns. This goal was achieved by examining practice, practitioner, and clinical factors for restoration of crowns performed in a practice-based research network and their association with the decision to bond the crown. The aims of this study were to determine if factors related to the retention of the crown (preparation taper and occlusal reduction), crown strength (occlusal reduction, axial reduction, material choice), or ability to isolate from saliva (tooth location and margin

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location) were associated with the use of resin cements (bonding) or water-based acid-base cements (non-bonding).

## Materials and methods

This study was completed by dentists in the National Dental Practice-Based Research Network (PBRN; "network", http://nationaldentalpbrn.org). [25] This study is based on a prospective cohort study focused on the acceptability of crowns restored in routine clinical practice. Network Regional Coordinators (RCs) were asked to recruit 200 network dentists to participate in this study. Data were collected about each practitioner/practice using the network's Enrollment Questionnaire. Network dentists were eligible for this study if they: (1) were currently treating patients in the United States; (2) were in the "full" network participation category; (3) completed the Stage 1 questionnaire;[26] and (4) reported doing at least 7 crowns per month. Practitioners were required to complete human subjects training and were asked to secure the participation of at least one dental laboratory for technical evaluation of crown preparations done in the study.

The network's applicable Institutional Review Boards approved the study, and all participants provided informed consent. Once a clinician began the study, he/she was trained by the RC's and then asked to enroll 20 total patients within 3 months. Dentists or their practices were remunerated $50 per patient for patient enrollment and completion of the study's data forms, and $25 per patient for completion of the insertion visit data forms. All data forms are publicly available at "http://nationaldentalpbrn.org/study-results/factors-for-successful-crowns.php". The study was launched on March 1, 2016 and patient follow-up was closed on February 28, 2017.

### Study Population.

Clinicians recruited patients consecutively from among their current pool of patients who needed a crown. Patients were: (1) 18 years old or older; (2) able to provide informed consent; and (3) in need of a single-unit crown on a natural tooth. Of the 3,883 patients who were approached to participate, 3,806 (98.02%) provided informed consent.

### Patient Treatment.

Once enrolled in the study, clinicians prepared the tooth for a crown and completed a crown preparation data form regarding clinical aspects of the procedure, including the tooth number, an estimate of the deepest margin of the preparation (either above the crest of the gingival tissue, at the crest of the gingival tissue, 1 mm below the gingival tissue, 2 mm below the gingival tissue, or 3 mm or more below the gingival tissue), and the type of restorative material selected for the crown (either leucite-reinforced glass ceramic, lithium disilicate, layered zirconia, full contour zirconia, PFM, or other). The study recruited only one single-unit crown per patient. The impression was then sent to the dental laboratory selected by the clinician along with an anonymous data collection form to be completed by the dental technician. This form included information regarding the taper of the preparation, occlusal reduction, and axial reduction. The technician was asked to rate each of these aspects of the preparation as excessive, adequate or insufficient. Laboratory technicians

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employed at 155 different locations evaluated the crown preparations. Clinicians were then asked to insert the crown within 6 weeks of preparation.

### Outcomes.

At the time of insertion, clinicians were asked to report the type of cement used for the crown on a second data form. The primary outcome for this study was the decision to bond the crown (the use of resin cement or self-adhesive resin cement) or not (use of resin-modified glass ionomer cement, glass ionomer cement, or zinc phosphate cement). In order to test associations between practitioner and practice characteristics and the decision to bond or not, practitioners were categorized as those who never bonded (in the study), sometimes bonded (at least one bonded crown in the study), and always bonded (in the study).

### Statistical analysis.

The associations between clinical factors and the decision to bond the crown were evaluated with mixed-model logistic regression analysis ($\alpha$=0.05). The models included a random effect to account for clustering of patients within individual clinicians. Because crowns/patients were clustered within practitioners, outcomes from patients treated by the same practitioner would be expected to be correlated. The margin location was re-coded into three categories as (1) at or above, (2) 1 mm below, or (3) 2 mm or more below the gingival crest. The location of the tooth was categorized as posterior maxilla (teeth #1-5 and #12-16), anterior maxilla (teeth #6-11), posterior mandible (teeth #17-21 and #28-32), or anterior mandible (teeth #22-27).

## Results

A total of 3,468 single-unit crowns were cemented in this study. 38.1% of crowns were bonded (29.2% with resin and 8.9% with self-adhesive resin cement) and 61.9% were non-bonded (52.2% with resin-modified glass ionomer, 8.3% with glass ionomer, and 1.4% with zinc phosphate cement). The percentages and counts are presented in Table 1.

A total of 202 dentists cemented at least one crown. The characteristics of these dentists are presented in Table 2. Most were owners of a private practice (76.6%) and worked full-time (88.4%). The majority had been in practice for over 20 years (59.7%). There were no associations between practitioner or practice characteristics and the decision to bond. Some dentists demonstrated no intra-dentist variability within the study: 39.1% of dentists reported that they never bonded a crown and 20.3% reported that they bonded every crown. Sensitivity analyses were conducted to evaluate the effect of these non-varying dentists. Analyses were conducted that were limited to clinicians who showed variability in their decision to bond. The analyses included 1,462 crowns placed by 82 dentists, and showed little difference in effect sizes or significance levels compared to the results obtained from analyses including all dentists and crowns.

The number and percentage of bonded crowns for each clinical criterion are presented in Table 3. There were significant differences in the percentages of bonded crowns based on occlusal reduction (p=.02), restorative material (p<.01) and the location of the tooth in the arch (p<.01), but not for taper (p=.15), location of gingival margin (p=.35) or axial reduction

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(p=.08). Crowns with an occlusal reduction deemed to be excessive were more likely to be bonded than those that were adequate or with insufficient reduction. Leucite-reinforced glass ceramic and lithium disilicate crowns were more likely to be bonded than layered zirconia, full contour zirconia, full metal, PFM, and "other" crowns. Materials in the "others" category included CAD/CAM resin composites (Paradigm MZ100 and Cerasmart). Crowns with margins 2 mm or more subgingival had a slightly lower likelihood of being bonded (29.7%) than those at or above the crest (39.9%) or 1 mm subgingival (40.4%); however, the differences were not statistically significant. There was a significant association between bonding and the tooth location, with more crowns bonded in the anterior maxilla than the posterior mandible or maxilla.

## Discussion

In this study, 38.1% of crowns were bonded with resin cement. Of these, 23.3% were bonded with self-adhesive resin cement. This percentage is low compared to the results of a 2015 non-peer reviewed survey of 907 dentists in which the most commonly used resin cement for PFM, zirconia and lithium disilicate cements was Rely X Unicem, which is a self-adhesive resin cement.[27] It is possible that this discrepancy is due to practitioners incorrectly identifying the classification of their resin cement as not self-adhesive, but we have no information on that. Of the crowns cemented with water-based acid-base cements, 84.4% were cemented with RMGI, 13.3% with glass ionomer, and 2.3% with zinc phosphate cement. These percentages are in agreement with the 2015 survey, which reported the most commonly used product in this category was Rely X Luting Plus, a RMGI cement.[27]

The first aim of this study was to determine if there was an association between preparation taper or occlusal reduction and the decision to bond the restoration. Preparations with an increased taper and excessive occlusal reduction were more likely to be bonded, but only excessive occlusal reduction showed a statistically significant association. Based on laboratory studies, a preparation with a taper greater than 12° and height below 3 mm may have decreased resistance form that may benefit from bonding.[28,29] Determination of preparation taper and height is often easier to achieve with direct vision in the dental laboratory. In this study, laboratory technicians reported that 6.0% of crown preparations had excessive taper and 9.7% of crown preparations had excessive occlusal reduction. Therefore, it may be beneficial for laboratories to alert the practitioner of issues with preparation taper and height in order to optimize cement selection.

Insufficient occlusal and axial reduction were not associated with the decision to bond. Possibly, clinicians compensated for insufficient restorative space by choosing a crown material which they did not believe benefited from adhesive bonding. Of the preparations with insufficient occlusal reduction, 39.3% were restored with zirconia, 31.5% with PFM, and 6.7% with all metal, whereas only 19.7% were restored with lithium disilicate and none with leucite reinforced glass ceramic.

The second aim of this study was to determine if there was an association between the crown material and the choice of the cement. In this study, there was a considerable preference to bond crowns fabricated from leucite reinforced glass ceramic and lithium disilicate, whereas

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bonding was less common for crowns fabricated from full contour zirconia, layered zirconia, and PFM. These findings are consistent with a non-peer reviewed 2013 survey of 1394 dentists reporting that 39% of dentists typically use a resin cement and 55% use RMGI cement with zirconia crowns, and 63% use resin cement and 32% use RMGI cement with lithium disilicate crowns.[30] There are several possible explanations for these preferences. Zirconia has twice the strength of lithium disilicate;[31] therefore, many clinicians may choose not to bond zirconia crowns as it is not necessary for strength improvement. The same justification would be used for PFM and full metal crowns. Some clinicians may choose not to bond to zirconia because they do not believe it is possible to reliably bond to this material. This opinion is not found in current scientific literature as review papers have summarized laboratory studies reporting effective methods for bonding to zirconia[11–15] and the chemical basis of the bond between zirconia and MDP.[32–35] The clinicians may be more likely to use resin cement with leucite-reinforced glass ceramic and lithium disilicate crowns, as these materials are translucent and may require a more-esthetic resin cement.

The final aim of this study was to determine if the choice to bond a restoration was related to a clinician's ability to achieve isolation, specifically based on the location of the prepared tooth and the location of the margin of the crown relative to the crest of the gingival tissue. There was a higher percentage of restorations that were bonded in the maxillary anterior portion of the mouth as compared to the posterior portion. This association could be due to the challenge in achieving isolation in the posterior part of the mouth and the clinician's awareness of the literature reporting the significant reduction in bond strength that occurs with salivary contamination.[36–38] It is also possible that this trend is due to increased use of lithium disilicate and leucite-reinforced restorations for anterior teeth, or the choice to use esthetic shaded resin cements for anterior teeth. In this study, 19.8% of crowns were placed on preparations that had at least a portion of the margin 2 mm or more subgingival. Although a lower percentage of these crowns were bonded with resin cement, it was not significantly different than crowns with margins located more coronally.

There was a large degree of inter-dentist variability in the decision to bond, as 39.1% of dentists never bonded a crown and 20.3% of dentists bonded every crown in this study. Several practice and practitioner characteristics were examined for an association with the decision to bond; however, none was found. In the 1970's, zinc phosphate cement and other water-based cements were favored for luting restorations, but by the 1990's, glass ionomer and adhesive resin cements were replacing their use.[39,40] Despite differences in the cement materials that may have been taught during their training, there was no trend in bonding preference with practitioners when considering years since graduation from dental school. There were no regional differences in the preference to bond restorations despite differences in clinical techniques that may be present at different centers of clinical education. There was a slight trend, although not statistically significant, for practitioners in less-busy practices to always bond. As bonding is often more technique sensitive, less-busy practitioners may have more time to utilize resin cements.

There are several limitations of this study. A major assumption of the analysis was that all crowns that were placed with a resin cement were indeed bonded. It is possible that a dentist used a resin cement without the intention of bonding the crown, forgoing the steps of

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priming the ceramic surface and achieving adequate isolation. Additionally, there exists a level of subjectivity in the evaluation of the crown preparations and location of gingival margin as the evaluations were all performed by different clinicians and technicians, and these evaluators may have different interpretations of these categories. A weakness of this method is that it uses the technicians' assessment of the crown preparation to infer the causes of practitioners' decision-making. As noted previously, there may also exist errors from clinicians incorrectly categorizing their cements.

Although network practitioners have much in common with dentists at large[41,42]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 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 based on previous studies.[43–46]

## Conclusions

38.1% of single-unit crowns were bonded with resin cement. Excessive occlusal tooth preparation, anterior location of a crown, and the use of glass ceramic crowns were significantly associated with the decision to bond single-unit crowns.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgements

This work was supported by NTH grant U19-DE-22516. An Internet site devoted to details about the nation's network is located at http://NationalDentalPBRN.org. We are very grateful to the network's Regional Coordinators who interacted with the participating practitioners throughout the study (Midwest Region: Tracy Shea, RDH, BSDH; Western Region: Stephanie Hodge, MA; Northeast Region: Christine O'Brien, RDH; South Atlantic Region: Danny Johnson, BA, Deborah McEdward, RDH, BS, CCRP; South Central Region: Claudia Carcelén, MPH, Shermetria Massengale, MPH, CHES, Ellen Sowell, BA; Southwest Region: Stephanie Reyes, BA, Meredith Buchberg, MPH, Colleen Dolan, MPH). The study was launched March 1, 2016; clinician training was completed by August 15, 2016; all patients had been enrolled by December 31, 2016; and patient follow-up was closed on February 28, 2017. Opinions and assertions contained herein are those of the authors and are not to be construed as necessarily representing the views of the respective organizations or the National Institutes of Health. The informed consent of all human subjects who participated in this investigation was obtained after the nature of the procedures had been explained fully.

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**Table 1.**

Percentage and number of crowns that were cemented with various types of cements (N= 3468)

| Cement type | Crowns, % (n) |
|---|---|
| Resin - bonded | 38.1 (1321) |
| Resin cement | 29.2 (1013) |
| Self-adhesive resin cement | 8.9 (308) |
| Acid-Base – non bonded | 61.9 (2147) |
| Resin-modified glass ionomer cement | 52.2 (1811) |
| Glass ionomer cement | 8.3 (286) |
| Zinc phosphate cement | 1.4 (50) |

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**Table 2.**

Percentage and number of dentists who never bonded any of the crowns enrolled in the study, sometimes bonded or always bonded based, overall and by practice or practitioner characteristic

| Practice or practitioner characteristic | N* | Never bonded, % (n) | Sometimes bonded, % (n) | Always bonded, % (n) | Comparisons |
|---|---|---|---|---|---|
| Overall | 202 | 39.7 (79) | 40.6 (82) | 20.6 (41) | -- |
| **Dentist gender** | | | | | p = .69 |
| Male | 145 | 38.6 (56) | 39.3 (57) | 22.1(32) | |
| Female | 54 | 42.6 (23) | 40.7 (22) | 16.7 (9) | |
| **Years since dental school graduation** | | | | | p = .37 |
| <10 | 28 | 42.9 (12) | 35.7 (10) | 21.4 (6) | |
| 10-19 | 53 | 32.1 (17) | 52.8 (28) | 15.1 (8) | |
| 20-29 | 42 | 35.7 (15) | 35.7 (15) | 28.6 (12) | |
| 30+ | 78 | 44.9 (35) | 35.9 (28) | 19.2 (15) | |
| **Network region** | | | | | p = .57 |
| Western | 27 | 33.3 (9) | 59.3 (16) | 7.4 (2) | |
| Midwest | 33 | 45.5 (15) | 33.3 (11) | 21.2 (7) | |
| Southwest | 39 | 33.3 (13) | 41.0 (16) | 25.6 (10) | |
| South Central | 45 | 40.0 (18) | 33.3 (15) | 26.7 (12) | |
| South Atlantic | 32 | 40.6 (13) | 43.8 (14) | 15.6 (5) | |
| Northeast | 25 | 44.0 (11) | 36.0 (9) | 20.0 (5) | |
| **Practice type** | | | | | p = .20 |
| Owner of Private Practice | 151 | 37.8 (57) | 39.7 (60) | 22.5 (34) | |
| Associate in Private Practice | 22 | 36.4 (8) | 36.4 (8) | 27.3 (6) | |
| Health Partners** | 8 | 62.5 (5) | 37.5 (3) | 0.0 (0) | |
| Permanente** | 8 | 25.0 (2) | 75.0 (6) | 0.0 (0) | |
| Public Health, Academic, Other | 8 | 62.5 (5) | 37.5 (3) | 0.0 (0) | |
| **Practice busyness** | | | | | p = .19 |
| Too busy | 10 | 60.0 (6) | 40.0 (4) | 0.0 (0) | |
| Overburdened | 39 | 30.8 (12) | 53.9 (21) | 15.4 (6) | |
| Not overburdened | 117 | 42.7 (50) | 35.9 (42) | 21.4 (25) | |
| Not busy | 35 | 31.4 (11) | 40.0 (14) | 28.6 (10) | |
| **Employment time commitment** | | | | | p = .36 |
| Full time | 176 | 37.5 (66) | 40.9 (72) | 21.6 (38) | |
| Part time | 23 | 52.2 (12) | 34.8 (8) | 13.0 (3) | |

* N = Numbers of practitioners in row category. Total sample sizes vary due to the presence of missing values for some characteristics.

** Either HealthPartners Dental Group in greater Minneapolis, MN or Permanente Dental Associates in greater Portland, OR.

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**Table 3.**

Percentage* and number of crowns that were bonded or not, overall and by crown or preparation characteristic

| Crown or preparation characteristic | N*** | Bonded crowns, % (n) | Non-bonded crowns, % (n) | Comparisons |
|---|---|---|---|---|
| Overall | 3468 | 38.1 (1321) | 61.9 (2147) | -- |
| **Preparation taper** ** | | | | p = .15 |
| Excessive | 194 | 62.9 (122) | 37.1 (72) | |
| Adequate | 2924 | 35.0 (1025) | 65.0 (1899) | |
| Insufficient | 92 | 32.6 (30) | 67.4 (62) | |
| **Occlusal reduction** ** | | | | p = .02 |
| Excessive | 310 | 75.8 (235) | 24.2 (75) | a |
| Adequate | 2734 | 33.0 (901) | 67.0 (1833) | b |
| Insufficient | 165 | 24.2 (40) | 75.8 (125) | b |
| **Axial reduction** ** | | | | p = .08 |
| Excessive | 202 | 67.3 (136) | 32.7 (66) | |
| Adequate | 2920 | 34.5 (1008) | 65.5 (1912) | |
| Insufficient | 87 | 37.9 (33) | 62.1 (54) | |
| **Restorative material** | | | | p < .01 |
| Leucite-reinforced | 17 | 76.5 (13) | 23.5 (4) | a |
| Lithium disiliciate | 1012 | 70.9 (717) | 29.1 (295) | a |
| Layered zirconia | 268 | 33.8 (104) | 61.2 (164) | b |
| Full contour zirconia | 1131 | 30.1 (340) | 69.9 (791) | b |
| Full metal | 177 | 14.7 (26) | 85.3 (151) | c |
| PFM | 857 | 13.8 (118) | 86.2 (738) | c |
| Other | 2 | 100 (2) | 0 (0) | --- |
| **Location in arch** | | | | p < .01 |
| Anterior maxilla | 228 | 43.0 (98) | 57.0 (130) | a |
| Posterior maxilla | 1609 | 37.6 (605) | 62.4 (1004) | b |
| Anterior mandible | 39 | 41.0 (16) | 59.0 (23) | a,b |
| Posterior mandible | 1585 | 37.8 (599) | 62.2 (986) | b |
| **Crown margin location** | | | | p = .35 |
| At or above | 1432 | 39.9 (572) | 60.1(860) | |
| gingival crest | | | | |
| 1 mm below gingival crest | 1344 | 40.4 (543) | 59.6 (801) | |
| 2 mm or more below gingival crest | 688 | 29.7 (204) | 70.35 (484) | |

* Raw percentages are presented. P-values reflect adjustment for clustering within clinician, using mixed-model logistic regression. Categories with the same letter are not significantly different.

** Based on assessment of the crown impression by the laboratory technician who made the prosthetic crown.

*** N = Numbers of crowns in row category. Total sample sizes vary due to the presence of missing values for some characteristics.