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Evaluation of the Porcelain Thickness in Single-Unit Crowns Reconstructed by Dental Technicians

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Abstract

Objective: The rise in aesthetic expectations and technological progress has significantly improved communication between dental technicians and dentists. The clinician's choice of color is vital for aesthetic success in restorations, as tooth color results from light interacting with dentin and enamel. Ceramic materials used in restorations must mimic these tissues to ensure color harmony.
Adequate porcelain thickness is crucial for both aesthetic appeal, by matching the natural tooth color, and clinical durability. Studies recommend a minimum thickness of 1.5 mm for metal-supported porcelain restorations to meet aesthetic and functional requirements.
Materials and Methods: This study analyzed A2-colored restorations processed in the same furnace and returned from clinics to ensure standardization. Measurements from the buccal and occlusal surfaces provided average values. Porcelain thickness was measured using an HW-300S thickness gauge, with statistical analysis conducted via SPSS 20.0.
Results: The study included 26 anterior, 26 premolar, and 27 posterior crowns. Anterior buccal thickness averaged 1083.07 µm, premolar 1413.46 µm, and molar 1496.48 µm, showing a trend of increasing thickness from the front to the back of the mouth. However, molar thickness was less than expected, highlighting a potential discrepancy in aesthetic and functional design.
Conclusion: While porcelain thickness generally increased from anterior to posterior regions, unexpected variations suggest the need for careful consideration of both aesthetic and clinical factors in restoration design..

Keywords

Aesthetic, Porcelain Thickness, Dental Technicians

INTRODUCTION

In contemporary dental practice, rising aesthetic expectations and technological advancements have increasingly emphasized the importance of collaboration between dentists and dental technicians. Insufficient collaboration can often result in the need for corrections or remakes, particularly in fixed prosthetic restorations. Research indicates that poor communication between dentists and dental technicians is one of the primary factors contributing to the remaking of prosthetic restorations [1].

Tooth color is one of the key components of aesthetic satisfaction. Studies show that the desire for whiter teeth is a major determinant of overall aesthetic satisfaction, with satisfaction decreasing as the degree of discoloration increases [2]. White teeth are associated with more positive perceptions regarding social competence, intellectual capability, psychological adjustment, and relationship status [3,4]. Therefore, accurate shade selection is crucial for achieving aesthetic success in dental restorations.

Color perception in dental restorations is a result of light interacting with the dentin and enamel layers, passing through and reflecting off the enamel surface. For optimal color harmony, the ceramic material used must exhibit optical properties similar to those of natural dentin and enamel. Factors such as translucency, surface characteristics, shape, chemical composition, and the thickness of the ceramic material significantly influence the aesthetic outcome of the restoration. A careful assessment of these parameters is critical for achieving successful aesthetic restorations.

Research has shown that porcelain thickness can directly affect color. Studies examining ceramic thicknesses from 0.5 to 2 mm report that increased thickness leads to less color change after multiple firing procedures [5, 6, 7]. The role of porcelain thickness in dental restorations is critical from both an aesthetic and clinical perspective. Aesthetically, sufficient porcelain thickness ensures color harmony with the natural tooth and meets patient expectations. Proper porcelain thickness allows for optimal light transmission and reflection, creating a more natural appearance. Clinically, adequate thickness contributes to the restoration’s mechanical strength and longevity.

In metal-ceramic restorations, clinically acceptable porcelain thickness is defined by specific standards and ranges. Literature suggests that a minimum porcelain thickness is essential for achieving satisfactory results. Some studies recommend a minimum thickness of 1.5 mm, with the metal substructure being thin yet durable, and perfectly adapted to the prepared tooth. The fired porcelain layer should range between 1.5 mm and 2 mm in thickness, shaped to replicate the anatomical and optical properties of a natural tooth [8]. This thickness provides the necessary durability and strength to meet both aesthetic and clinical demands.

If the porcelain layer is too thin, issues such as fracture,

cracking, opaque appearance, and insufficient contour may occur. On the other hand, if the porcelain is too thick, it may lead to over-contouring and poor aesthetic compatibility. Therefore, determining the appropriate thickness is essential for achieving optimal results in both aesthetics and mechanical durability.

Hypothesis: Our hypothesis is that the porcelain thickness of crowns requiring remakes, regardless of their location, will be below the standard and clinically inadequate.

MATERIAL AND METHOD

Some crowns returned from the laboratory were deemed clinically unacceptable and required remakes by dentists. The primary objectives of this study were to determine the regions in which these single-unit crowns were located and to evaluate their buccal and occlusal porcelain thicknesses. To ensure standardization, the study focused on restorations with shade A2, processed in the same furnace, and returned from clinics. Since the crowns measured were unused and classified as discarded materials, ethical committee approval was not

necessary. Measurements were taken from three points on the buccal surface and three points on the occlusal surface, and the average values were calculated. Porcelain thickness was measured using the HW-300S (Mistaha) thickness gauge, which was calibrated prior to each measurement (Figure 1). The device has a measurement range of 0-2000 µm.

Statistical analyses were conducted using SPSS 20.0 (IBM Inc, Chicago, IL, USA). Descriptive statistics were calculated, and normality of data distribution was tested using Kolmogorov-Smirnov tests. As the data did not follow a normal distribution, the Kruskal-Wallis test was applied to assess differences between groups. Post-hoc analyses were conducted using the Mann-Whitney U test, and a p-value of <0.05 was considered statistically significant.

Results

The Kolmogorov-Smirnov test indicated that the data for both Buccal and Occlusal Thickness did not follow a normal distribution, with p-values of 0.0078 and 0.00078, respectively. The Kruskal-Wallis test results for Buccal and Occlusal Thickness across three regions (Posterior, Premolar, Anterior) are summarized in Table 1:

- **Buccal Thickness:** H(2) = 4.42, p = 0.110. No significant difference was found between the regions.
- **Occlusal Thickness:** H(2) = 9.58, p = 0.008. A significant difference was observed between the regions.

The Mann-Whitney U test results are as follows:

Buccal Thickness:

- Posterior vs Premolar: U = 357.0, p = 0.908 (no significant difference).
- Posterior vs Anterior: U = 472.0, p = 0.062 (no significant difference, but close to the threshold).
- Premolar vs Anterior: U = 418.0, p = 0.081 (no significant difference).

Occlusal Thickness:

- Posterior vs Premolar: U = 388.5, p = 0.497 (no significant difference).
- Posterior vs Anterior: U = 537.5, p = 0.003 (statistically significant difference).
- Premolar vs Anterior: U = 439.5, p = 0.031 (statistically significant difference).

CONCLUSION

Significant differences were found in Occlusal Thickness between the Posterior and Anterior regions, and between the Premolar and Anterior regions. No significant differences were found in Buccal Thickness among the regions (Graphic 1).

The crowns evaluated in the study included 26 crowns from the anterior region, 26 from the premolar region, and 27 from the posterior region. The average buccal thickness in the anterior region was 1083.07 µm (±437.6), while the average incisal thickness was 728.07 µm (±241.3). In the premolar region, the average buccal thickness was 1413.46 µm (±672.95), and the average occlusal thickness was 1135.96 µm (±662.7). In the posterior region, the average buccal thickness was 1496.48 µm (±1001.54), and the average occlusal thickness was 1037.27 µm (±750.57) (Table 3).

The highest failure rates were observed in tooth numbers 26 (7 cases), 34 (5 cases), and 27 (5 cases). Insufficient or mismatched occlusal areas were commonly cited as the reasons for the crowns' return.

Table 1: Kruskal-Wallis Test Results (Buccal & Occlusal Thickness)

Test	Groups	H (df)	Test Statistic	p-value
Kruskal-Wallis (Buccal Thickness)	Posterior vs Premolar vs Anterior	H(2)	4.422	0.109
Kruskal-Wallis (Occlusal Thickness)	Posterior vs Premolar vs Anterior	H(2)	9.577	0.008

Table 2: Mann-Whitney U Test Results

Groups	Test Statistic	p-value
Posterior vs Premolar (Bukkal)	357.0	0.907
Posterior vs Anterior (Bukkal)	357.0	0.062
Premolar vs Anterior (Bukkal)	418.0	0.080
Posterior vs Premolar (Okluzal)	388.5	0.497
Posterior vs Anterior (Okluzal)	537.5	0.002
Premolar vs Anterior (Okluzal)	439.5	0.031

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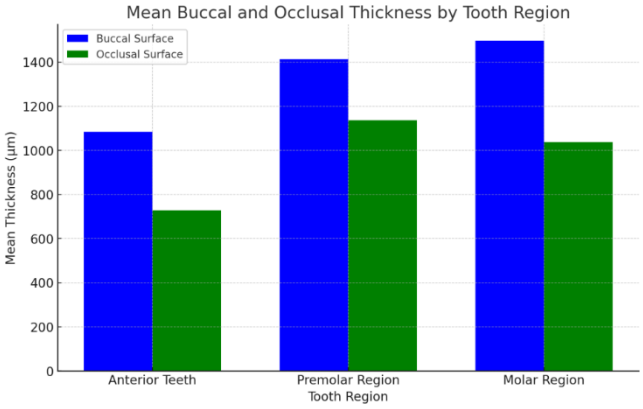
Figure 1: Device Measuring Porcelain Thickness by Reflecting from Metal

Table 3: Buccal and Occlusal Surface Thickness of Tooth Region

Tooth region		Buccal surface	Occlusal surface
Anterior	Mean	1083,0769	728,0769
	N	26	26
	Std. Deviation	437,69185	241,31339
Premolar	Mean	1413,4615	1135,9615
	N	26	26
	Std. Deviation	672,95136	662,70660
Molar	Mean	1496,4815	1240,0000
	N	27	27
	Std. Deviation	1001,54094	750,57926
Total	Mean	1333,1013	1037,2785
	N	79	79
	Std. Deviation	757,06133	629,72766



Graphic 1: Buccal and Occlusal Thickness by tooth region

DISCUSSION

Most dentists report a crown remake rate of less than 2%, while approximately 17% report a remake rate greater than 4% [9]. The reasons for crown remakes are varied, including marginal discrepancies, aesthetic failures, proximal issues, and other technical errors [9]. Interestingly, factors such as the dentist's gender and ethnicity, as well as technical factors like the use of double-arch trays, can influence remake rates [10,11]. Additionally, patient expectations and aesthetic demands play a major role in determining the clinical success.

Clinicians in this study identified laboratory errors as the most common cause of remakes, often due to miscommunication between the dentist and the lab. In fact, communication issues contribute to up to 50% of remakes [12,13]. Even when prescriptions are accurately written, dental laboratories may not always use the materials or techniques requested by the dentist [14]. Other reasons for crown failures, such as inaccurate impressions, poor shade selection, and improper mold production, align with the findings of this study [15,16,17]. These errors often result in crowns with unacceptable marginal or proximal discrepancies. Research shows that more experienced clinicians tend to have higher success rates with crowns, suggesting that experience reduces errors and remakes. On the other hand, recently graduated dentists may be more critical of the clinical fit and more likely to reject crowns that don't meet higher standards. This is reflected in Goodness of Fit (GOF) evaluations, where recent graduates scored lower than more experienced clinicians. Interestingly, clinicians with less busy practices rated their crowns more favorably, often twice as highly as their busier counterparts, suggesting that spending more time on crown procedures may result in better [18].

The thickness of porcelain layers plays a critical role in the durability of restorations. Thinner porcelain layers provide greater flexibility, but they may lack sufficient resistance to cracking, whereas thicker layers offer enhanced durability and crack resistance. Similarly, thinner porcelain tends to have lower fracture resistance, but increasing its thickness significantly improves this property [19]. Thermal stresses also significantly influence the longevity of porcelain restorations. Thicker porcelain layers are better able to resist thermal stresses, which reduces the likelihood of cracks caused by temperature fluctuations. This increased resistance helps to prevent fractures that may occur due to thermal shock [20].

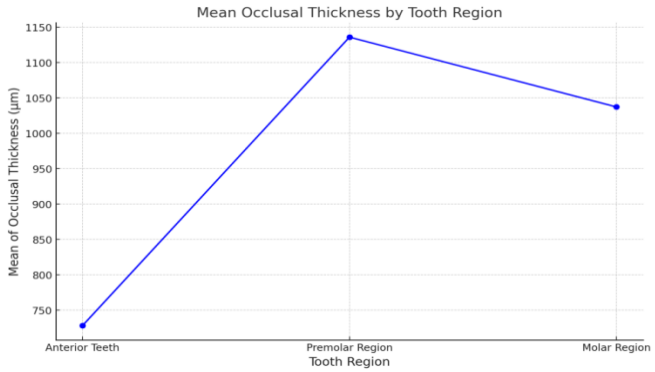
Mechanical stresses, such as compressive and tensile forces, also have a notable impact on the durability of porcelain restorations. Thicker layers generate compressive stresses, which enhance the material's mechanical strength and resistance to cracking. On the other hand, tensile stresses tend to accelerate crack propagation, highlighting the importance of managing these forces to prolong the lifespan of the restoration [21].

Clinically, ceramic restorations need to replicate the translucency and color of natural teeth [18]. Several elements influence the final aesthetic result, including translucency, opalescence, fluorescence, surface texture, and form [18]. Many ceramic systems use layered veneer porcelains to improve aesthetics, as the opaque core materials can significantly affect the overall color of the restoration [22]. Managing the translucency of both the core and veneer materials is essential for achieving the desired aesthetic outcome [23]. Factors such as thickness [24,25,26],

microstructure, and the number of firing cycles [27] all play a role in determining the translucency of ceramic restorations.

CONCLUSION

Although occlusal thickness increased from anterior to posterior, as expected, a thinner porcelain thickness was observed in the molar region. The buccal thickness of the teeth, which directly relates to the aesthetic outcome, was greater than expected in the premolar region compared to other regions (Graphic 2). This finding is significant as buccal thickness is crucial for the visual appeal of the porcelain restoration.



Graphic 2: Thickness Variation Graph by Region

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