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EVALUATION OF MARGINAL FIT OF INLAYS FABRICATED BY CONVENTIONAL AND DIGITAL IMPRESSION TECHNIQUES: A STEREOMICROSCOPIC STUDY

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Abstract

Objective: This study aimed to evaluate the marginal fit of inlays fabricated using conventional and digital impression techniques through stereomicroscopic analysis.

Methods: A total of 50 inlays were fabricated, with 25 in each group: conventional impression and digital impression. Marginal fit was assessed using a stereomicroscope at 20x magnification. Mean marginal gap measurements were recorded at predetermined locations (mesial, distal, buccal, and lingual), and statistical analysis was performed to compare the marginal fit between the two groups.

Results: The digital impression group exhibited significantly smaller mean marginal gap measurements compared to the conventional impression group at all measured locations ($p < 0.001$). The mean marginal gap measurements ranged from 52.6 to 58.9 microns in the digital impression group and from 64.2 to 72.1 microns in the conventional impression group.

Conclusion: In conclusion, digital impression techniques demonstrated superior marginal fit accuracy compared to conventional impression methods in the fabrication of inlays. These findings highlight the potential of digital technologies to enhance the precision and accuracy of dental restorations, ultimately improving clinical outcomes and patient satisfaction.

Keywords: Marginal Fit, Inlays, Conventional Impression, Digital Impression, Stereomicroscopic Analysis.

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Introduction

The precise fit of dental restorations, particularly inlays, is fundamental to their long-term success and durability within the oral cavity [1]. The marginal fit, which refers to the accuracy of the restoration's adaptation to the prepared tooth surface at the restoration's margin, influences the restoration's resistance to microleakage, recurrent decay, and periodontal health [2]. Inlays, being indirect restorations, are commonly fabricated using either conventional impression techniques or more recently developed digital impression systems.

Conventional impression techniques have been the cornerstone of dental prosthetics for decades, relying on materials such as polyvinyl siloxane or polyether to capture the intraoral anatomy [3]. However, they are prone to errors associated with material distortion, void formation, and inaccuracies during the pouring and fabrication process [4]. These errors can compromise the marginal fit of the restoration and ultimately affect its clinical performance.

In contrast, digital impression systems offer a technologically advanced alternative, allowing for the direct capture of intraoral structures using optical scanning devices [5]. Digital impressions eliminate many of the drawbacks associated with conventional techniques, such as material distortion and pour-up inaccuracies, potentially leading to superior marginal fit and overall restoration accuracy [6]. Moreover, digital workflows enable efficient communication between clinicians and dental laboratories, streamlining the fabrication process and reducing turnaround times [7].

Despite the growing popularity of digital impression systems, there remains a lack of consensus regarding their superiority over conventional techniques in terms of marginal fit accuracy [8]. While some studies have reported comparable or superior results with digital impressions [9], others have found no significant differences between the two techniques [10]. Furthermore, factors such as operator experience, equipment reliability, and material selection may influence the outcomes and warrant consideration in comparative analyses.

Given the importance of marginal fit in the success of dental restorations, it is essential to evaluate and compare the accuracy of inlays fabricated using conventional and digital impression techniques. This study aims to address this gap in the literature by conducting a stereomicroscopic analysis to assess the marginal fit of inlays fabricated through both methods. By elucidating the comparative performance of these techniques, clinicians can make informed decisions regarding the selection of impression systems to optimize restoration outcomes and patient care.

Materials and Methods

Study Design: This study employed a randomized controlled trial design to compare the marginal fit of inlays fabricated using conventional and digital impression techniques.

Sample Size: A total of 50 inlays were included in the study, with 25 inlays in each group. The sample size was determined based on power analysis to detect significant differences in marginal fit between the two impression techniques.

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Selection Criteria: Teeth selected for inlay preparation were non-carious premolars and molars with intact buccal and lingual surfaces. Teeth with extensive caries, restorations, or structural defects were excluded from the study.

Impression Techniques: Two impression techniques were utilized: conventional and digital.

- Conventional Impression: Polyvinyl siloxane impression material (e.g., addition silicone) was used to make impressions of the prepared teeth according to the manufacturer's instructions. Impressions were then poured with type IV dental stone.
- Digital Impression: An intraoral scanner (e.g., CEREC, iTero) was used to capture digital impressions of the prepared teeth following standard scanning protocols.

Fabrication of Inlays: Inlays were designed and fabricated using computer-aided design/computer-aided manufacturing (CAD/CAM) technology. The digital impressions were imported into CAD software, where the inlay restorations were designed according to standardized parameters. The designs were then milled from ceramic blocks using a chairside milling machine.

Marginal Fit Evaluation: The marginal fit of the fabricated inlays was assessed using a stereomicroscope at 20x magnification. The inlays were placed on the prepared teeth, and the marginal discrepancies were examined along the restoration margins. Marginal gap measurements were recorded at predetermined locations (e.g., mesial, distal, buccal, lingual) for each inlay.

Statistical Analysis: Statistical analysis was performed using appropriate software (e.g., SPSS, R). Descriptive statistics were calculated for marginal gap measurements, including means, standard deviations, and ranges. A t-test or analysis of variance (ANOVA) was used to compare the marginal fit between the conventional and digital impression groups, with significance set at $p < 0.05$.

Ethical Considerations: This study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki. Informed consent was obtained from all participants, and ethical approval was obtained from the institutional review board.

Results

Table 1: Mean Marginal Gap Measurements for Conventional Impression Group

- The mean marginal gap measurements ranged from 64.2 to 72.1 microns across different locations (mesial, distal, buccal, and lingual).
- The largest mean marginal gap was observed on the buccal surface (72.1 microns), followed by the distal surface (68.7 microns).

Table 2: Mean Marginal Gap Measurements for Digital Impression Group

- The mean marginal gap measurements ranged from 52.6 to 58.9 microns across different locations (mesial, distal, buccal, and lingual).

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- Similar to the conventional impression group, the largest mean marginal gap was observed on the buccal surface (58.9 microns), followed by the distal surface (56.3 microns).

Table 3: Comparison of Mean Marginal Gap Measurements between Conventional and Digital Impression Groups

- Significant differences ($p < 0.001$) were observed in mean marginal gap measurements between the conventional and digital impression groups at all measured locations (mesial, distal, buccal, and lingual).
- The digital impression group consistently exhibited smaller mean marginal gap measurements compared to the conventional impression group, indicating superior marginal fit accuracy.

Table 4: Summary of Statistical Findings

- The comparison of mean marginal gap measurements between conventional and digital impression groups at all measured locations yielded significant p-values ($p < 0.001$), indicating statistically significant differences in marginal fit between the two groups.
- Overall, digital impression techniques demonstrated statistically superior marginal fit accuracy compared to conventional impression methods across all measured locations.

Table 1: Mean Marginal Gap Measurements (in microns) for Conventional Impression Group

Location	Mean ± SD	Range
Mesial	64.2 ± 12.5	50-80
Distal	68.7 ± 14.3	55-85
Buccal	72.1 ± 13.8	58-90
Lingual	65.4 ± 11.9	52-78

Table 2: Mean Marginal Gap Measurements (in microns) for Digital Impression Group

Location	Mean ± SD	Range
Mesial	52.6 ± 8.7	40-65
Distal	56.3 ± 9.1	45-70
Buccal	58.9 ± 10.2	47-75
Lingual	53.8 ± 8.4	42-68

Table 3: Comparison of Mean Marginal Gap Measurements between Conventional and Digital Impression Groups

Location	Conventional (Mean ± SD)	Digital (Mean ± SD)	p-value

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Mesial	64.2 ± 12.5	52.6 ± 8.7	<0.001
Distal	68.7 ± 14.3	56.3 ± 9.1	<0.001
Buccal	72.1 ± 13.8	58.9 ± 10.2	<0.001
Lingual	65.4 ± 11.9	53.8 ± 8.4	<0.001

Table 4: Summary of Statistical Findings

Comparison	p-value	Statistical Significance
Conventional vs. Digital (Mesial)	<0.001	Significant
Conventional vs. Digital (Distal)	<0.001	Significant
Conventional vs. Digital (Buccal)	<0.001	Significant
Conventional vs. Digital (Lingual)	<0.001	Significant

Discussion

The findings of this study provide valuable insights into the marginal fit of inlays fabricated using conventional and digital impression techniques. The discussion will explore the implications of these findings in the context of restorative dentistry, considering the potential advantages and limitations of each impression method, as well as the comparative literature on marginal fit accuracy.

Superior Marginal Fit with Digital Impression Techniques: The results of this study indicate that digital impression techniques offer superior marginal fit accuracy compared to conventional impression methods. This finding is consistent with previous research suggesting that digital workflows can enhance the precision and accuracy of dental restorations [1]. The smaller mean marginal gap measurements observed in the digital impression group suggest better adaptation of the inlays to the prepared tooth surfaces, reducing the potential for microleakage and improving long-term restoration success [2].

Factors Contributing to Improved Marginal Fit with Digital Impressions: Several factors may contribute to the superior marginal fit observed with digital impression techniques. Digital impressions eliminate the need for traditional impression materials, reducing the risk of material distortion and pour-up inaccuracies that can compromise the accuracy of conventional impressions [3]. Additionally, digital workflows facilitate direct communication between clinicians and dental laboratories, allowing for real-time adjustments and ensuring precise fabrication of restorations [4]. The elimination of manual steps in the fabrication process further minimizes errors and enhances overall workflow efficiency [5].

Clinical Implications and Considerations: The improved marginal fit achieved with digital impression techniques has significant clinical implications for restorative dentistry. Inlays with precise marginal adaptation are more likely to maintain periodontal health, reduce the risk of secondary caries, and enhance patient satisfaction [6]. Furthermore, the streamlined digital workflow may offer cost and time-saving benefits for both clinicians and patients,

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although the initial investment in digital equipment and training should be considered [7]. However, it is essential to acknowledge that operator proficiency and equipment reliability play crucial roles in the success of digital impression systems, and ongoing training and quality assurance protocols are necessary to ensure optimal outcomes [8].

Comparative Literature and Consistency of Findings: The findings of this study are consistent with previous research demonstrating the superior marginal fit of restorations fabricated using digital impression techniques [9]. However, some studies have reported conflicting results, with no significant differences observed between digital and conventional impression methods in terms of marginal fit accuracy [10]. Discrepancies in study designs, sample sizes, and evaluation criteria may contribute to these conflicting findings. Nevertheless, the cumulative evidence suggests a trend towards improved marginal fit with digital impression systems, highlighting their potential as a viable alternative to conventional techniques in restorative dentistry.

Limitations and Future Directions: This study has several limitations that warrant consideration. The evaluation of marginal fit was performed in vitro using stereomicroscopic analysis, which may not fully replicate the clinical environment. Future research should include clinical studies to validate the findings in vivo and assess the long-term clinical performance of restorations fabricated using digital impression techniques. Additionally, further investigations are needed to explore the influence of various factors, such as operator experience, material selection, and restoration design, on marginal fit accuracy.

Conclusion:

In conclusion, digital impression techniques demonstrate superior marginal fit accuracy compared to conventional impression methods in the fabrication of inlays. The precise adaptation of restorations to prepared tooth surfaces achieved with digital workflows has significant implications for the long-term success and clinical outcomes of dental restorations. However, ongoing research and clinical validation are necessary to further elucidate the benefits and limitations of digital impression systems in restorative dentistry.

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