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Original Article

Frequency and Patterns of Inappropriate Maxillary Incisor Abutment Preparation for Metal-Ceramic Retainers in Fixed Dental Prostheses: A Cross-Sectional Study

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Abstract

Background: The maxillary central incisor is a common abutment for metal-ceramic fixed dental prostheses (MC-FDPs). Successful outcomes require precise tooth preparation, but clinical practices often deviate from recommended guidelines, potentially compromising function, esthetics, and longevity of the prosthesis. Limited local data exist on the prevalence and types of inappropriate tooth preparation.

Objective: To determine the frequency and patterns of inappropriate preparation of maxillary central incisor abutments for metal-ceramic retainers in fixed dental prostheses.

Methodology: This descriptive cross-sectional study was conducted in the Department of Prosthodontics, Saidu College of Dentistry, Swat, from January to May 2025. A total of 174 adult patients requiring fixed prostheses were included using consecutive sampling. Inclusion criteria were sound or restored maxillary central incisors with Class I occlusion. Exclusion criteria included malaligned teeth, periodontal pathology, post-retained crowns, or defective casts. Preparations were evaluated using visual inspection and standard measuring tools (vernier calipers and dividers) for adequacy of incisal, labial, palatal, and proximal reductions, finish line design, and axial convergence. All procedures were supervised by an experienced prosthodontist.

Results: The mean age of participants was 34.5 ± 12.27 years, with 55.7% males and 44.3% females. Inappropriate preparations were observed on proximal (48.9%), labial (40.8%), palatal (39.1%), and incisal (38.5%) surfaces. Improper finish lines (78.2%) and inappropriate axial convergence angles (65.5%) were highly prevalent. First-year residents consistently showed higher rates of error compared to second-year residents, but differences were not statistically significant ($p > 0.05$).

Conclusion: Despite established preparation guidelines, a majority of abutments demonstrated one or more inappropriate features, especially in finish line placement and axial convergence. These findings emphasize the need for enhanced clinical training and stricter adherence to preparation standards among dental trainees.

Keywords: Abutment, Fixed dental prosthesis, Metal-ceramic crown, Prosthodontics, Tooth preparation.

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Introduction

Esthetic considerations are often the primary motivation for patients seeking prosthodontic treatment [1]. The morphology and dimensions of maxillary anterior teeth are critical for both dental esthetics and overall facial harmony [2]. Rehabilitation of anterior dentition should therefore be planned in a manner that complements the patient's facial features, as emphasized by Young, who defined esthetics through beauty, harmony, natural appearance, and individual personality [3].

Among the various restorative options available, fixed dental prostheses (FDPs) remain a popular choice due to their ability to restore function and esthetics simultaneously [4]. Proper tooth preparation is fundamental to the success of FDPs, requiring precision, spatial awareness, and three-dimensional visualization skills. The challenge is heightened when working with anterior teeth, where esthetic demands are higher and deviations from ideal preparation can compromise both function and appearance [5–7].

Metal-ceramic fixed dental prostheses (MC-FDPs) have long been considered the gold standard because they combine esthetic properties of porcelain with the strength of a metal substructure [5]. Their affordability, durability, and ease of fabrication further contribute to their widespread use [6]. However, success is highly dependent on accurate tooth preparation, which ensures sufficient reduction for material strength without unnecessarily compromising tooth structure [8].

Despite clear preparation guidelines, clinicians often show inconsistency in practice, leading to compromised prosthesis quality and detrimental effects on both abutments and surrounding soft tissues [8,9]. Factors contributing to these deviations include limited access, anatomical variations, visual errors, and inadequate operator training. Studies have documented high rates of inadequacy in tooth preparation, including over- or under-preparation, improper finish line design, and inappropriate axial convergence angles [10].

To date, there has been no local study examining the frequency and patterns of inappropriate preparation of maxillary incisor abutments for MC-FDPs in Pakistan. Understanding these patterns in a local teaching hospital setting is essential to highlight training deficiencies and propose strategies for improvement. The objective of this study was to determine the various aspects of inappropriate preparation of maxillary incisor abutments for metal-ceramic retainers of fixed dental prostheses in a local population treated at a teaching dental hospital.

Methodology

Study Design

This was a descriptive cross-sectional study conducted to evaluate the aspects of inappropriate preparation of maxillary incisor abutments for metal-ceramic retainers of fixed dental prostheses. The design was chosen to provide a snapshot of the prevalence and distribution of errors in tooth preparation among residents in a teaching dental institution.

Ethics

Ethical approval was obtained from the Institutional Ethical Review Committee of Saidu College of Dentistry, Swat (Ref. No. 76-B-25/SCD/Ethical/Certificate, dated 01-01-2025). All participants were informed about the study objectives, procedures, potential benefits, and risks. Written informed consent was taken from each participant prior to inclusion, and confidentiality of personal information was strictly maintained.

Setting

The study was carried out in the Department of Prosthodontics, Saidu College of Dentistry, Swat, Pakistan, between January 1, 2025, and May 15, 2025. The department provides both undergraduate and postgraduate prosthodontic training, and all tooth preparations were performed within the clinical setting under the supervision of senior faculty.

Participants

A total of 174 adult patients requiring fixed dental prostheses were included using a consecutive non-probability sampling technique. Eligible participants were those with sound or properly restored maxillary central incisors serving as abutments and exhibiting a Class I occlusal relationship. Patients below 15 years of age, with malaligned incisors, gingival or periodontal pathology, or requiring post-retained crown retainers were excluded. Additionally, impressions or casts with pouring defects or physical damage were omitted from analysis to avoid measurement errors.

Variables

The main outcome variables were the presence or absence of inappropriate preparation features, including insufficient or excessive reduction of incisal, labial, palatal, and proximal surfaces; improper finish line design or placement; and inappropriate axial convergence angle. Demographic variables such as age and gender, along with the training year of residents performing the preparations, were also recorded.

Data Sources/Measurement

For each participant, a detailed dental history, intraoral examination, and radiographs were obtained. Full-arch impressions of the maxillary dentition were taken before and after abutment preparation, and casts were prepared. The tooth preparations were first assessed visually, followed by precise measurements using vernier calipers and dividers. Standardized criteria were used: incisal reduction considered appropriate at 1.5–2.0 mm, labial and palatal reductions appropriate at ~1.5 mm, proximal surfaces requiring 1.5 mm clearance, and finish line continuity with correct gingival margin placement (≤0.5 mm subgingival, shoulder on labial, chamfer on palatal). Axial convergence was considered appropriate when ≤20°. Preparations and evaluations were supervised and validated by a prosthodontist with over five years of experience.

Bias

To minimize bias, clear inclusion and exclusion criteria were applied to avoid confounding from malalignment, periodontal disease, or defective impressions. All evaluations were performed by a single trained prosthodontist to maintain consistency, though this may introduce observer bias. Consecutive sampling was used, which reduces selection bias but limits generalizability.

Study Size

The sample size of 174 was calculated using the WHO sample size calculator, based on a 13% expected proportion of under-preparation of abutments, a 95% confidence interval, and a 5% margin of error. This ensured adequate power to detect differences in preparation errors between resident training years.

Quantitative Variables

Age was treated as a continuous variable (mean ± SD) and also categorized into age groups for descriptive purposes. Categorical variables included gender, residency year, and the presence of inappropriate preparation aspects for each tooth surface and feature.

Statistical Methods

Data were analyzed using IBM SPSS Statistics (version 22.0). Frequencies and percentages were calculated for categorical variables, while means and standard deviations were reported for continuous variables. The chi-square test was applied to compare the prevalence of inappropriate preparation features between first- and second-year residents. A p-value of less than 0.05 was considered statistically significant.

Results

Participants

A total of 174 patients participated in the study, fulfilling the inclusion and exclusion criteria. All participants required fixed dental prostheses with a maxillary central incisor serving as an abutment. Both male and female patients were included, ensuring representation of different age groups and genders within the study population.

Descriptive Data

The mean age of the participants was 34.5 ± 12.27 years, with ages ranging from 16 to 66 years. The sample consisted of 97 males (55.7%) and 77 females (44.3%). The largest proportion of participants belonged to the younger age group of 16–26 years (32.2%), followed closely by the 27–36 year group (31.0%). In contrast, only 6.3% of the participants were in the 57–66 year category, indicating that the majority of the study population was young to middle-aged adults.

Outcome Data

Assessment of tooth preparations revealed a high frequency of inappropriate abutment features across different tooth surfaces and preparation parameters. Specifically, inappropriate preparations were observed in 38.5% of incisal surfaces, 40.8% of labial surfaces, 39.1% of palatal surfaces, and 48.9% of proximal surfaces. Errors in marginal design were even more pronounced, with 78.2% of abutments demonstrating inappropriate finish lines. Similarly, 65.5% of abutments showed axial convergence angles exceeding the recommended limit of 20°, compromising the resistance form of the prepared teeth.

Main Results

When compared by level of training, inappropriate preparations were more frequently observed among first-year FCPS residents compared to second-year residents across all surfaces and parameters. For instance, inappropriate finish lines were recorded in 81.6% of cases prepared by first-year residents compared to 74.7% by second-year residents. Likewise, axial convergence angles were more frequently inappropriate in first-year residents (70.1%) than in second-year residents (60.9%). Although the second-year residents showed relatively better outcomes, the differences between the two groups did not reach statistical significance ($p > 0.05$).

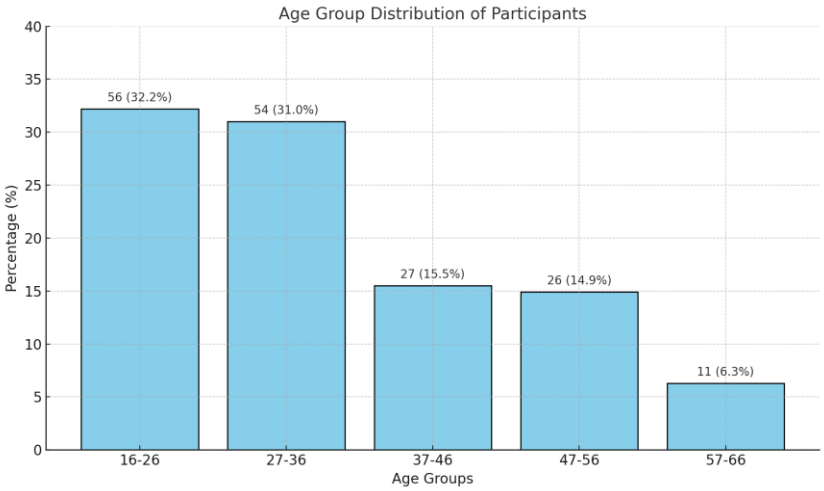


Figure 1: Age distribution of the participants

Table 1: Assessment of maxillary central incisor abutment preparation for metal-ceramic retainers in fixed partial dentures

Prepared Surface/Feature	Appropriate	Inappropriate
Incisal Surface	107 (61.5%)	67 (38.5%)
Labial Surface	103 (59.2%)	71 (40.8%)
Palatal Surface	106 (60.9%)	68 (39.1%)
Proximal Surface	89 (51.1%)	85 (48.9%)
Finish Line	38 (21.8%)	136 (78.2%)
Axial Convergence Angle	60 (34.5%)	114 (65.5%)

Table 2: Assessment of maxillary central incisor abutment preparation for metal-ceramic retainers in fixed partial dentures by residency year

Prepared Surface/Feature	1st years FCPS resident		2nd years FCPS resident		P-value
	Appropriate	Inappropriate	Appropriate	Inappropriate	
Incisal Surface	50 (57.5%)	37 (42.5%)	57 (65.5%)	30 (34.5%)	0.08
Labial Surface	48 (55.2%)	39 (44.8%)	55 (63.2%)	32 (36.8%)	0.1
Palatal Surface	49 (56.3%)	38 (43.7%)	57 (65.5%)	30 (34.5%)	0.09
Proximal Surface	41 (47.1%)	46 (52.9%)	48 (55.2%)	39 (44.8%)	0.11
Finish Line	16 (18.4%)	71 (81.6%)	22 (25.3%)	65 (74.7%)	0.14
Axial convergence Angle	26 (29.9%)	61 (70.1%)	34 (39.1%)	53 (60.9%)	0.07

*Chi-square test

Discussion

Tooth preparation that strictly follows established clinical guidelines is fundamental for the long-term success of metal-ceramic fixed dental prostheses (MC-FDPs), which remain widely used for both functional and esthetic rehabilitation [11]. The present study assessed various aspects of maxillary central incisor abutment preparations and revealed a high frequency of inappropriate features, particularly related to finish line design and axial convergence angle.

In this study, 38.5% of the abutments showed inappropriate incisal reduction, which may negatively impact porcelain thickness and occlusal clearance. Adequate incisal reduction is critical for achieving proper esthetics and preventing mechanical failure [11]. Comparable results were reported by Al-Dwairi et al., who observed under-preparation in 18% of cases [10]. The higher rate in the present study may be attributed to the fact that most procedures were performed by residents still in their learning phase.

Labial surface preparation was also problematic, with 40.8% of abutments inadequately prepared. This is consistent with international findings, where improper labial reduction was reported in up to 83% of cases [10]. Insufficient labial reduction may result in bulky crowns that compromise esthetics and periodontal health, while over-preparation jeopardizes tooth vitality and retention [12,13]. These findings highlight the need for enhanced esthetic awareness and skill refinement during training.

Palatal surface preparation errors were observed in 39.1% of cases, often due to insufficient clearance in excursive movements. Such inadequacies can lead to chipping of the ceramic veneer and eventual prosthesis failure [14,15]. Similarly, proximal surface errors were frequent (48.9%), reflecting the technical difficulty of achieving ideal form without damaging adjacent teeth. Prior studies have shown that proximal surfaces are particularly vulnerable to over-preparation, especially along the mesiodistal plane [10].

The most prevalent error in this study was related to finish line design, which was inappropriate in 78.2% of cases. This finding aligns with earlier reports where a majority of teeth lacked adequate shoulder or chamfer design [16]. Inadequate finish lines compromise marginal adaptation, plaque control, and the mechanical strength of restorations [16]. Likewise, 65.5% of abutments demonstrated axial convergence angles exceeding the recommended limit, which undermines resistance form and retention of crowns [17,18]. These findings are consistent with studies from other teaching institutions, where high rates of taper errors were recorded [10,18].

Collectively, these results emphasize that despite the availability of preparation guidelines, clinical performance by trainees is often suboptimal. The observed differences between first- and second-year residents, though not statistically significant, indicate progressive improvement with training, but also reveal the need for more structured clinical supervision, competency-based assessments, and feedback mechanisms.

Conclusion

This study demonstrated that inappropriate preparation of maxillary central incisor abutments for metal-ceramic retainers is highly prevalent in a teaching dental hospital setting. The most frequent errors were observed in finish line design and axial convergence angle, followed by inadequate surface reductions across incisal, labial, palatal, and proximal aspects. Although second-year residents performed slightly better than first-year residents, a substantial proportion of errors persisted across both groups, indicating that extended clinical exposure alone is insufficient to ensure optimal preparation outcomes.

The findings underscore the urgent need for strengthening prosthodontic training programs through enhanced supervision, incorporation of objective assessment tools, and simulation-based learning modules. By ensuring adherence to established preparation guidelines, practitioners can significantly improve the functional and esthetic outcomes of metal-ceramic fixed prostheses and ultimately enhance patient satisfaction.

Authors' Contributions:

All authors meet the ICMJE criteria for authorship. They have reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Author 1: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 2: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 3: Analysis and interpretation of data, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 4: Analysis and interpretation of data, critical revision, final approval, agreed to be accountable for all the work.

Author 5: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 6: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.

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