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Original research

TREATMENT OUTCOMES OF CAD/CAM HYBRID CERAMIC OVERLAYS ON POSTERIOR TEETH

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ABSTRACT

Background: *CAD/CAM hybrid ceramic restorations have been developed enormously in recent years. This study aimed to evaluate the treatment outcomes of CAD/CAM hybrid ceramic overlays (Shofu HC).*

Methods: *A prospective, descriptive clinical trial study has been conducted on 30 permanent posterior teeth with cavities that need to be restored by overlay. All 30 teeth were prepared and restored by CAD/CAM hybrid ceramic overlays (Shofu disc HC). The treatment outcomes were assessed in the period of 3 months with 3 times of evaluating (immediately after cementation and 1-month, 3-month after cementation) following the USPHS criteria (marginal adaptation, color match, anatomic form, cavo-surface marginal discoloration, secondary caries).*

Results: *76.7% of the restorations were rated as having perfect marginal adaptation (score 0), while 23.3% showed slight discrepancies. 46.7% of the restorations were deemed to have perfect color match (score 0). All restorations maintained their anatomic form (score 0) perfectly at all time points, with no deviations noted. There were no cases of marginal discoloration immediately after placement. No instances of secondary caries (score 0) were recorded at any time point.*

Conclusions: *Result of this study showed that 27 out of 30 restorations (90%) were clinically acceptable, only 3 overlays were clinically unacceptable with the color match criterion.*

Keywords: *CAD/CAM, hybrid ceramic, overlay.*

I. INTRODUCTION

The ongoing development of computer-aided design and computer-aided manufacturing (CAD/ CAM) technology has significantly revolutionized the restorative dentistry by introducing novel materials and techniques that can improve both effectiveness and treatment outcomes of dental restorations. In particular, hybrid ceramics have gained recognition among those innovations as promising materials, blending the advantages of ceramics and composite resins. CAD/ CAM hybrid ceramics are distinguished for their mechanical strength, aesthetic qualities and biocompatibility, making them suitable for fabricating dental aesthetic indirect restorations like overlays for posterior teeth [1,2].

The use of CAD/CAM hybrid ceramic overlays for posterior teeth restoration has gained significant interest due to their ability of making durable and aesthetically restorations. Materials such as poymer-infiltrated ceramic-network (PICN) systems and resin nanoceramics, are designed to replicate the natural properties of tooth enamel and dentin, improving their overall performance and longevity. However, while these hybrid ceramics offer theoretical benefits, their clinical effectiveness, particularly regarding marginal integrity, marginal discoloration and fracture resistance, remains under investigation [2,3].

This study aimed to evaluate the treatment outcomes of CAD/CAM hybrid ceramic overlays on posterior teeth, with assessments carried out at three different time intervals: immediately after placement, one month and two months after placement. When assessing the treatment outcomes

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of these restorations over 3-month period, the study focused on generating evidence regarding their clinical effectiveness and identifying their potential improvements in restorative dentistry. This study seeks to fill the existing gap in the literature concerning the short-term clinical performance of CAD/CAM hybrid ceramic overlays and provide valuable insights for their use in routine dental practice [1,3].

II. MATERIALS AND METHODS

2.1. Subjects

This study was performed on permanent molars and premolars of patients aged 15 to 60. All procedures performed in this study involving human participants were in accordance with the ethical committee of Hue University of Medicine and Pharmacy, Viet Nam.

Inclusion criteria

- Teeth with lesions that matched these criteria: Permanent molars and premolars having type II cavity with large dimensions, loss of whole marginal ridges, lateral walls or having excessive thin lateral walls (<=3mm of endodontic treated teeth, <=2mm of vital teeth); Teeth with short crown or limited restoration space that cannot be restored by full crown; Teeth roots were still firmly attached to alveolar bone.
- Teeth with severe occlusal wear.
- Patients had good hygiene behaviors.
- Patients had no parafunctional habits such as grinding or chewing hard food.
- Patients co-operated with follow-up procedures.

Exclusion criteria

- Teeth with progressing apical periodontitis and/or furcation involvement, visible on Xray image and having clinical symptoms.
- Poorly endodontic treated teeth, and/or with roots crack.
- Patients with psychological difficulties, could not co-operate with clinicians.
- Patients with systemic diseases.
- Patients could not manage to follow-up.

2.2. Methods

This is a prospective, descriptive clinical trial study. All the procedures were carried out at the General Dentistry Department, Odonto Stomatology Clinic of Hue University of Medicine and Pharmacy Hospital from May 2022 to May 2024.

Sampling and sample size determination: Convenience, non-probability sampling. The sample size was 30 teeth restored by CAD/CAM hybrid ceramic overlay.

Procedures: All patients were screened to identify the teeth matched the inclusion criteria. The indicated teeth were then prepared and restored by CAD/CAM hybrid ceramic overlays, followed by these steps:

1. Cavity preparation [4]: Applied local anesthesia. Then assessed occlusal alignment and chose the appropriate tooth shade. Removed thoroughly old restoration, removed caries if presenting, then prepared the cavity without finishing the margins of the cavity. All the thin walls and cusps with less than 1.5mm thickness (and less than 2mm with root canal treated teeth) were removed, followed the guidelines as in Figure 1. Examine the interocclusal space in centric and lateral movements. With posterior teeth, minimum thickness for functional cusps is 1.5mm, for other cusps is 1mm. Isolated the tooth indicated using a rubber dam, and for subgingival margins, using a metal matrix. To omit all the retentions inside the cavity, applied bonding resin and light-cured for 20 seconds (FL II bond - Shofu) then applied a thin layer of composite resin to cover the retentions, as well as relocate margins supragingivally, if necessary. Light-cured each increment of composite resin for 40 seconds. Finished tooth margins with specific burs (onlay preparation, table top…), margins could be shoulder, bevel or chamfer depending on location of the margins. In our study, we chose bevel margin at buccal and lingual surfaces, shoulder margin at proximal surfaces. Made sure that the cavity satisfied 5 criteria: Detailed sharp margins; Absence of undercuts; Accessibility of subgingival margins; Absence of contact between the cavity and the adjacent teeth; (After rubber dam removal) Adequate interocclusal space in centric and during lateral movements. Applied gingival retraction cord and took impression with putty and light body silicone (Silagum putty, Honigum lightfast, DMG), then sent it to the laboratory for making CAD/CAM hybrid ceramic overlays.

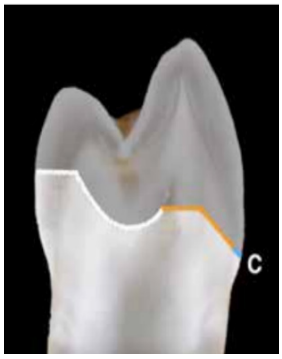

Figure 1: Guideline for full buccal cusp coverage

2. Cementation procedures [5]

- After receiving the CAD/CAM hybrid ceramic overlays (Shofu disc HC) from laboratory, examined the restoration on the cast for its fit.

- Removed the provisional restoration from the cavity and try-in the overlay. Adjusted the overlay if necessary, then began the adhesive process. No checking for occlusion at this step to avoid fracture.

- Gave patient local anesthesia at the prepared tooth and placed rubber dam.

- Processed the inner surface of overlay: abrasion (50µm Al2O3 particle at 0.3MPa, 10 seconds) and dry, applied bonding resin (Scotchbond Universal, 3M) without light curing.

- Processed the bonding surface of tooth: abrasion (50µm Al2O3 particle at 0.3MPa, 10 seconds) and dry, applied 37% phosphoric acid to etch the enamel surface in 20 seconds, rinse and dry. Then applied bonding resin (Scotchbond Universal, 3M) to bonding surface of tooth without light curing.

- Applied preheated-resin composite to the cavity and inserted the overlay into the cavity, applied pressure first time and removed the excessive resin, then applied pressure last time and completely removed all the excessive resin composite.

- Light cured for 20 seconds per surfaces, covered all surfaces with glycerin, then light cured for totally polymerization.

- Finished the margins with fine diamonds bur and polished with polishing disc (Sof-lex, 3M).

- Removed rubber dam, check again occlusion in centric and lateral movements. Repolished restoration with polishing kit (Diacomp Twist, EVE).

Restoration assessment

+ Restoration assessment: assessed at 3 time points: immediately after placing overlays, after placement 1 month and 3 months; followed modified United States Public Health Service (USPHS) criteria. A restoration was considered clinically acceptable when all the criteria got score 0 and/or score 1, otherwise it was considered clinically unacceptable [6].

a. Immediately after placing restoration

Table 1: Restoration assessment criteria immediately after restoration placement

Criterion	Score	Characteristics
Marginal adaptation of restoration	0	No visible crevice along the margin into which the explorer will penetrate
	1	Visible evidence of a crevice along the margin into which the explorer can penetrate, but the dentin or base is not exposed
	2	Visible evidence of a crevice along the margin into which the explorer can penetrate, the dentin or base is exposed. The restoration is not mobile, fractured or missing.
	3	The restoration mobile, fractured or missing in part or in total
Color match	0	The restoration matches the adjacent tooth in color, shade and/or translucency
	1	Light mismatch in color, shade and/or translucency between the restoration and the adjacent tooth but clinically accepted
	2	Obvious mismatch between restoration and adjacent tooth structure that is outside the acceptable range of tooth color, shade and/or translucency
Anatomic form	0	The restoration is continuous with existing anatomic form.
	1	The restoration is under-contoured, discontinuous with existing anatomic form but still not have the dentin or base exposed.
	2	The restoration is insufficient to expose the dentin or base.

b. After 1 month, 3 months

Table 2: Restoration assessment criteria after 1-month and 3-month period

Criterion	Score	Characteristics
Marginal adaptation of restoration	0	No visible crevice along the margin into which the explorer will penetrate
	1	Visible evidence of a crevice along the margin into which the explorer can penetrate, but the dentin or base is not exposed
	2	Visible evidence of a crevice along the margin into which the explorer can penetrate, the dentin or base is exposed. The restoration is not mobile, fractured or missing.
	3	The restoration mobile, fractured or missing in part or in total
Color match	0	The restoration matches the adjacent tooth in color, shade and/or translucency
	1	Light mismatch in color, shade and/or translucency between the restoration and the adjacent tooth but clinically accepted
	2	Obvious mismatch between restoration and adjacent tooth structure that is outside the acceptable range of tooth color, shade and/or translucency
Anatomic form	0	The restoration is continuous with existing anatomic form.
	1	The restoration is undercontoured, discontinuous with existing anatomic form but still not have the dentin or base exposed.
	2	The restoration is insufficient to expose the dentin or base.
Cavo surface marginal discoloration	0	No obvious discoloration
	1	Minor marginal discoloration, no penetrating along the margin of restoration in a pulpal direction
	2	Obivious marginal discoloration, penetrating along the margin of restoration in a pulpal direction
Secondary caries	0	No evidence of caries contiguous with the margin of the restoration
	2	Caries is evident contiguously with the margin of the restoration

III. RESULTS

Table 3: Treatment outcomes of CAD/CAM hybrid ceramic overlays

STT	Assessment time / Criteria		Immediately after placing restoration		After 1 month		After 3 months	
			n	%	n	%	n	%
1	Marginal adaptation of restoration	0	23	76.7	23	76.7	23	76.7
		1	7	23.3	7	23.3	7	23.3
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
2	Color match	0	14	46.7	14	46.7	14	46.7
		1	13	43.3	13	43.3	13	43.3
		2	3	10.0	3	10.0	3	10.0

STT	Criteria / Assessment time		Immediately after placing restoration		After 1 month		After 3 months	
			n	%	n	%	n	%
3	Anatomic form	0	30	100	30	100	30	100
		1	0	0	0	0	0	0
		2	0	0	0	0	0	0
4	Cavo surface marginal discoloration	0	-	-	29	96.7	29	96.7
		1	-	-	1	3.3	1	3.3
		2	-	-	0	0	0	0
5	Secondary caries	0	-	-	30	100	30	100
			-	-	0	0	0	0

Table 3 shows the treatment outcomes of CAD/CAM hybrid ceramic overlays evaluated at three different time points: immediately after placement, after 1 month, and after 3 months. The following criteria were assessed:

1. Marginal Adaptation of Restoration: At all three time points, 76.7% of the restorations were rated as having perfect marginal adaptation (score 0), while 23.3% showed slight discrepancies (score 1). No cases of significant marginal discrepancies (scores 2 or 3) were observed.

2. Color Match: Consistently across all time points, 46.7% of the restorations were deemed to have perfect color match (score 0). Another 43.3% had slight color mismatches (score 1), and 10% exhibited more noticeable mismatches (score 2).

3. Anatomic Form: All restorations maintained their anatomic form (score 0) perfectly at all time points, with no deviations noted.

4. Cavo Surface Marginal Discoloration: There were no cases of marginal discoloration immediately after placement. However, after 1 month and continuing at 3 months, 96.7% of restorations showed no discoloration, while 3.3% had slight discoloration (score 1). No moderate or severe discoloration (scores 2 or higher) was observed.

5. Secondary Caries: No instances of secondary caries (score 0) were recorded at any time point.

In summary, 90 % of CAD/CAM hybrid ceramic overlays demonstrated clinically acceptable performance over the 3-month period, with most of restorations maintaining good marginal adaptation, anatomic form and marginal discoloration, no secondary caries was detected. There were only 3 out of 30 restorations got clinically unacceptable result with score 2 in color match.

IV. DISCUSSION

The clinical outcomes of 30 CAD/CAM hybrid ceramic overlays on posterior teeth assessed by modified USPHS criteria are shown in table 4. The data showed a consistent performance of hybrid ceramic overlays over the observation time phases, with no changes from the first assessment time to 3 months later on all 5 assessment criteria.

With marginal adaptation of restoration, immediately after placing, 76.7% restorations exhibited excellent marginal adaptation as score 0, this result remained unchanged after 1 month and after 3 months. Only 23.3% restorations showed visible evidence of a crevice along the margin into which the explorer can penetrate, but the dentin or base is not exposed as score 1, and this ratio also remained consistent over 1-month, 3-month period. This means all restorations were considered clinically acceptable with marginal adaptation. This result can be explained by the highly adaptability properties of CAD/CAM hybrid ceramics owing to the merge of ceramic and resin components. Furthermore, the CAD/CAM procedure made the restorations precisely fit for the preparation

teeth, then minimized the marginal gaps as well as microleakage of the restorations. Other clinical studies also have shown that hybrid ceramics had a high level of facture resistance and marginal adaptation, which is a key factor for the durability of dental restorations. Research has presented evidence that CAD/CAM restorations had marginal gaps withing the range of 10-50 μm, which is considered as clinically acceptable [7].

The color match results over a three-month period were the only criterion got score 2 with 3 restorations, comprised 10% of total, making those 3 restorations become clinically unacceptable. However, the remaining restorations got 46.7% score 0 and 43.3% score 1, made the treatment outcomes still get 90% of total clinically acceptable. This variant may be understandable with the core characteristics of hybrid ceramics, which can experience slight changes in restoration shade over time due to the resin component. This aligns with the result of Elmoselhy at al., which has shown that hybrid ceramics can display slight color mismatches under certain conditions [3].

The anatomic form of all restorations remained perfectly in shape with all scored 0 throughout the 3-month-period of the study. This showed attribution to the durablility and wear resistance of CAD/CAM hybrid ceramics, which has the characteristics of retaining shape and function over extended periods. This result is consistent with other studies reporting that these materials demonstrated excellent structural integrity, making them well-suited for long-term restoration in various clinical situations. [3,8].

The treatment outcomes for cavo-surface marginal discoloration and secondary caries, minimal incidence was observed with 3.3% of restorations got score 1 in terms of cavo-surface marginal discoloration and no reported cases of secondary caries. These findings demonstrate that CAD/CAM hybrid ceramics have effective sealing and protection against marginal discoloration and secondary decay. This can be explained with the high level of marginal adaptation of CAD/CAM restorations [7]. Besides, other studies also showed that hybrid ceramic have strong resistance to staining and decay, probably due to their smooth surface finish and low porosity, that can lower the accumulation of plaque and staining agents [3].

IV. CONCLUSION

The findings from this study confirm that CAD/CAM hybrid ceramics, aligns with existing literature on the subject, are highly effective in maintaining marginal adaptation, anatomic form, shade match, cavo-surface marginal discoloration, secondary caries and overall clinical performance over a short-term period. Hybrid ceramics, which combine the desirable characteristics of ceramics and resin composites, offer a favorable substitute to traditional materials. However, a small incidence in color match suggests that further enhancements or stricter material selection may be needed to optimize esthetic results.

Disclosure

The authors report no other conflicts of interest in this work.

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