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Clinical Research

Three-year Clinical Evaluation of Cuspal Coverage with Combined Composite–Amalgam in Endodontically-treated Maxillary Premolars

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Clinical Relevance

The results of a three-year follow-up of a small sample of patients suggest that combined composite-amalgam restoration for cuspal coverage is useful as a conservative, one-appointment complementary procedure for endodontically-treated maxillary premolars.

SUMMARY

This clinical study evaluated the clinical performance of cuspal coverage with combined composite–amalgam restorations in endodontically-treated maxillary premolars over a three-year period. Thirty-six maxillary premolars, each with a Class II cavity in 36 patients ranging in age between 28 and 52 years, were selected after endodontic treatment. After reduction of the buccal and palatal cusps, internal coverage and veneering of the reduced buccal cusp was performed with composite. The remaining cavity and reduced palatal cusp were restored with high-copper amalgam. The restorations were evaluated at baseline and in one-, two- and three-year recalls with USPHS criteria.

Changes in characteristics of the restorations were analyzed with the Cochran Q-test at a significance level of $p<0.05$. Most of the restorations received an overall score of alpha, except two restorations, which showed a slight discrepancy at the composite-amalgam interface after one year ($p>0.05$). Four restorations exhibited slight discoloration of the composite veneering after three years ($p<0.05$). No restoration exhibited fracture after three years. It was concluded that combined composite-amalgam cusp coverage of endodontically-treated maxillary premolars

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showed acceptable clinical performance after three years.

INTRODUCTION

Endodontic treatment of posterior teeth can weaken tooth structure, because of previous caries or restorations, access instrumentation or removal of the pulp chamber roof.[1-2] These factors make the teeth susceptible to fractures, especially the maxillary premolars, because their anatomy facilitates separation of the cusps during mastication. This problem may be exacerbated in teeth with a weakened or missing marginal ridge.[3-4] There is a greater frequency of fracture in two-rooted maxillary premolars than in single-rooted premolars. Lateral excursive forces can shear the remaining cusps or cause vertical root fracture, leading to periodontal surgery or extraction.[5] In addition, loss of the protective feedback mechanism following pulp removal may contribute to tooth fracture.[6] Thus, restoration of an endodontically-treated tooth is a critical step in finishing or complementing endodontic treatment. The restoration should provide functional, esthetic and marginal sealing, and it should protect the remaining tooth structure.[2] However, accomplishing such a restoration has always been challenging for clinicians, especially when excessive tooth structure has not been lost.

Cusp coverage with cemented cast restorations is known to improve the fracture resistance of endodontically-treated teeth.[1,4-5,7] Full metal-ceramic crowns have been recommended as a way to provide good esthetic results in premolars. Tooth preparation for this crown requires a substantial reduction in tooth structure, so that a post is needed to provide core retention.[8] Construction of the post and core casting requires dental laboratory support, resulting in more time-consuming and costly restorations. The difference between the elastic modulus of this casting system and tooth structure may lead to root fracture.[9] Although this treatment is the only choice in endodontically-treated premolars with extensive defects, the preservation of sound tooth structure is considered to be of primary importance for increasing the survival rate of endodontically-treated teeth.[8] In addition, treatment may lead to the emergence of restorative difficulties, such as a cement line that leads to cement dissolving in oral fluid, a lack of consistent optimal adaptation and the need for gingival retraction at subgingival margins.[4,7,10] These disadvantages may also be involved in other indirect esthetic restorations.

It has been suggested that crown coverage should be postponed for the first five years after the endodontic treatment of premolars.[11] In response, and in an attempt to preserve tooth structure, replacing indirect restorations with amalgam-based cusp coverage was suggested. This easily performed and economically more accessible alternative has the advantage of producing a reversible restoration.[7] Full amalgam coverage or amalgam crowns have shown excellent results in *in-vitro* and *in-vivo* studies.[1,7,10-13] Nevertheless, this type of restoration is esthetically less pleasing, particularly in maxillary premolars. Frequently, patients find it hard to accept the appearance of a facial cusp protected with a 2-3 mm layer of amalgam.[11]

Applying a bonded resin composite as an alternative to amalgam in these complex restorations has been suggested, but it presents some limitations. The primary drawback of resin composite is high polymerization shrinkage stress, resulting in marginal gaps and microleakage. Reproducing the anatomic form and proximal contacts is difficult and time-consuming.[14-16] Thus, a combination of the favorable properties of two direct restorative materials may provide good esthetic results in the labial or occlusal aspects of extended amalgam restorations.[17-18]

The combined resin composite-amalgam (hybrid) restoration is not a new technique.[19-21] One popular method is placement of an extended amalgam restoration, followed by window preparation for composite veneering in a second appointment. Composite veneering of a complex amalgam restoration can cause an unesthetic, grayish appearance from the labial view. Although an opacifying agent or resin-modified glass ionomer can be applied on the amalgam surface, masking the metallic color of the amalgam is difficult to accomplish.[22-23] Therefore, composite veneering of the amalgam crown might not provide a fully satisfactory result in terms of esthetics. However, a case report by Abu-Hanna and Mjör[17] indicated that a combined restoration with composite placement at the buccal wall followed by amalgam placement provided an acceptable esthetic outcome in an extended cavity of vital premolars.

Based on previous reports, a single-appointment technique for restoring endodontically-treated maxillary premolars without extensive damage to tooth structure was developed. First, the two cusps are reduced, then the buccal cusp is covered, veneering is applied and the reduced cusp is internally covered with resin composite. After bonding and polymerization of the resin composite, the remaining cavity and reduced palatal cusp are restored with amalgam. The purpose of the current study was to evaluate the clinical performance of this technique in restoring endodontically-treated maxillary premolars after three years.

METHODS AND MATERIALS

The research protocol for the current study was approved by the local ethics committee. Recruited were 36 patients (20 women and 16 men) referred by two endodontists to a private practice in Shiraz (Iran) for the restoration of endodontically-treated premolars. The patients ranged in age from 28 to 52 years (mean

35 years). All the patients were informed of the study and given instructions regarding oral hygiene. The authors excluded patients who identified themselves as smokers, those with medical problems, severe bruxism, periodontal attachment loss, patients with a gingival index greater than one and those who were unable to attend regular interval appointments.

For this trial, the authors selected endodontically-treated maxillary first and second premolars with buccal and palatal cusps that had a relatively intact enamel structure weakened by extended caries on the mesial/distal or two surfaces. These teeth were in occlusion with the opposing teeth and had neighboring teeth without abutment for fixed or removable prostheses. A single operator performed all the clinical procedures.

Restorative Procedures

One week after endodontic treatment, the eugenol-free temporary restoration was removed. A depth of 2-3 mm of gutta-percha was removed using a Gates Glidden drill (#3, Mani, Utsunomiya, Tochigi, Japan). The buccal and palatal cusps were reduced about 2 mm and 3 mm, respectively, using a cylindrical diamond bur (Teescavan Ltd, Tehran, Iran) in a high-speed handpiece with water spray. The remaining buccal cusp was prepared for veneering. Moisture was controlled with cotton rolls and a high-volume evacuator. This preparation and the internal surface of the buccal cusp were etched with 37% phosphoric acid (SDI Ltd, Melbourne, Australia) for 15 seconds, washed with water spray and gently air-dried. Two layers of Single Bond (3M, Dental Products, St Paul, MN, USA) were applied and cured for 40 seconds using a halogen light curing unit (Coltolux 75, Coltène/Whaldent AG, Altstätten, Switzerland) with a light intensity of 450 mW/cm^2. Light intensity output was checked every 10 restorations with a light meter from the same manufacturer.

Before acid etching, a small piece of metal matrix band was placed to protect the adjacent proximal surface from etching and to prevent bonding to this surface during composite placement.

After shade selection, a layer of a microhybrid composite (Z250, 3M Dental Products) was placed on the inner surface of the reduced buccal cusp and cured for 40 seconds. Veneering of the buccal surface was then performed incrementally, with care to minimize the effects of polymerization shrinkage. Finally, the composite was placed on the reduced buccal cusp in two 2-mm increments for reconstruction of the mesial and distal slopes of the reduced cusp. In this way, the reduced cusp was sandwiched between two layers of bonded composite. After occlusal adjustment, finishing and polishing procedures were performed on the external composite surface using fine diamond burs and Sof-Lex discs (3M Dental Products). A final high polish was accomplished with a rubber prophylaxis cup and diamond polishing paste (SDI Limited, Victoria, Australia). A Tofflemire matrix band (#1, Arnel Inc, Hempstead, NY, USA) was stabilized on the tooth, and wooden wedges were applied to secure the interproximal matrix adaptation. The remaining part of the cavity and the reduced palatal cusp were restored with a high copper admix alloy amalgam (GS-80, SDI Limited) (Figure 1).

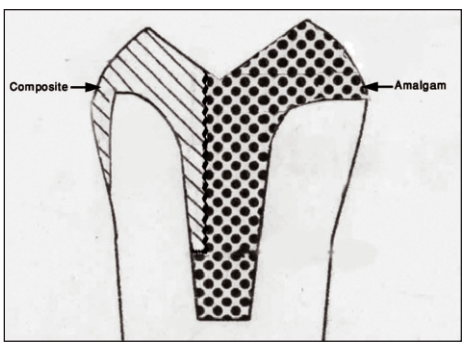

Figure 1. *Schematic view of combined composite–amalgam restoration of a maxillary premolar after endodontic treatment.*

A recall program was arranged for all patients, and the restorations were evaluated one week after placement, followed by one, two and three years.

The operator took preoperative photographs of the cavity preparation and the restored teeth at baseline and at each recall appointment (Figures 2-7). Radiographic examination was also included in the study. The restorations were clinically evaluated with USPHS criteria (Table 1) by two independent examiners according to the following restoration characteristics: color match from the buccal view, marginal discoloration of the composite veneer, anatomical form, marginal adaptation along the restoration margins and amalgam-composite interface, secondary caries. The rating scales in the original USPHS were used for each criterion (Table 1). In this rating, three scores were used, except for marginal adaptation (four scores) and recurrent caries (two scores). In general, alpha ratings indicated excellent results, with no need for restoration replacement. Bravo ratings indicated acceptable results with a possible need for replacement. Charlie ratings indicated a need for replacement of the restoration for prevention. Delta ratings indicated the need for immediate replacement. Charlie and delta ratings indicated clinically unacceptable outcomes.[24-25] Clinical evaluations were conducted by visual inspection and examination using a mirror and sharp explorer. When a disagreement arose during evaluations, consensus evaluations were obtained between the examiners. The proportion of changes from baseline scores across recall periods was compared using the Cochran-Q test ($p<0.05$).

RESULTS

All 36 patients were evaluated at the baseline and at one- and two-year recall, but three patients were unavailable for the three-year recall. Accordingly, a

Table 1: *Criteria Used to Evaluate the Restorations*

Criterion	Rating	Description
Color match (from buccal view)	Alpha (α)	No mismatch in color, shade or translucency between the restoration and the adjacent teeth.
	Bravo (β)	No mismatch in color, shade or translucency outside the normal range of tooth color.
	Charlie (c)	Mismatch in color, shade or translucency between the restoration and the adjacent teeth outside the normal range of tooth color.
Marginal discoloration	Alpha (α)	No discoloration anywhere along the margin between the restoration and tooth structure.
	Bravo (β)	Discoloration present but it has not penetrated towards the pulp along the margin.
	Charlie (c)	Discoloration penetrating towards the pulp.
Anatomic form	Alpha (α)	Restoration is not under-contoured and restorative material is contiguous with tooth anatomy.
	Bravo (β)	Small amounts of restorative material are missing, but tooth structure not exposed.
	Charlie (c)	Missing restorative material exposes tooth structure.
Marginal adaptation	Alpha (α)	No visible evidence of a crevice along the margin that the explorer will penetrate.
	Bravo (β)	Visible evidence of a crevice along the margin that the explorer will penetrate; dentin not exposed.
	Charlie (c)	Dentin is exposed; explorer penetrates but the restoration is not mobile, tooth fractured or missing in part or in toto.
	Delta (δ)	The restoration is fractured or missing in part or in toto.
Secondary caries	Alpha (α)	No evidence of caries* contiguous with the margin of the restoration.
	Charlie (c)	Evidence of caries contiguous with the margin of the restoration.

**An explorer catches or resists removal after insertion with moderate to firm pressure and is accompanied by softness, opacity or etching (white spot).*

Figure 2. *Preoperative cavity in a maxillary second premolar.*

Figure 3. *Cavity preparation with reduced cusps.*

Figure 4. *Restoration from the buccal view at baseline.*

Figure 5. *Restoration from the occlusal view at baseline.*

Figure 6. *Successful combined restoration from the buccal view after three years.*

Figure 7. *Successful combined restoration from the occlusal view after three years.*

total of 33 restorations were evaluated for this report at the one-, two- and three-year recalls. The results of these evaluations are presented in Table 2.

No failures were observed during the three recall appointments, and alpha scores were recorded for most of the criteria. However, two restorations (6%) showed a slight discrepancy and a shallow crevice at the amalgam-composite interface. They were scored as bravo after one year ($p>0.05$). This lack of integrity did not lead to any failures after three years. Gingival inflammation around the restoration, bulk fracture and tooth fracture were not observed at the one-, two- or three-year recall.

The color of the restorations in the buccal view completely matched the adjacent teeth, except in four patients (12%) who had slight discoloration of the composite veneer after about three years ($p<0.05$). Polishing removed this discoloration.

DISCUSSION

Increased cavity depth associated with removal of the pulp chamber roof, marginal ridge and decreased thick-

Table 2: *Number of Restorations Receiving Each Rating at Each Recall*

Criterion	Baseline	One Year	Two Years	Three Years
Color match	33α	33α	33α	29α 4β
Marginal discoloration	33α	33α	33α	33α
Anatomic form	33α	33α	33α	33α
Marginal adaptation at restoration margin at composite- amalgam interface	33α 33α	33α 31α 2β	33α 31α 2β	33α 31α 2β
Secondary caries	33α	33α	33α	33α

ness of the cusp, leading to cusp elongation, can result in deflection of the cusp and increased susceptibility of endodontically-treated maxillary premolars to fracture.[4,11] Full cuspal coverage is advised to protect the remaining cusps from splitting.[1-2,4-5,7] The integrity of reduced cusps can be preserved by preventing the wedge effect between the palatal and buccal cusp, caused by cusp elongation.[4,11,14] Full amalgam coverage of sufficient strength is capable of restoring form and function and providing adequate fracture resistance in restored teeth.[10,13,26] Clinical observations have indicated high survival rates (from four to 15 years) of amalgam restorations with cusp coverage.[12,27]

In the current study, the high performance scores of the restorations after up to three years were related to the favorable mechanical properties, excellent marginal sealing stability and proven clinical longevity of the amalgam. Like the functional (palatal) cusp and critical margins, the gingival margins of the proximal box were restored by amalgam, and no fractures or recurrent caries was observed. Improvements in the dentinal marginal sealing of Class II composite restorations were reported with amalgam filling of the gingival third.[28] Moreover, composite coverage of the buccal cusp, in association with veneering and internal coverage of the reduced cusp with composite by a two-step total etch adhesive, might reinforce the non-functional cusp through bonding to the enamel and dentin. This combination would provide good color matching of the restoration from the buccal view at baseline.

The placement of a composite layer on the internal surface of the buccal cusp prevented contact between the amalgam and buccal cusp. Also, probable corrosion products could not penetrate the dentinal tubules of the buccal cusp. This layer, in association with the composite veneer on the etched enamel surface of the buccal cusp, would mask the amalgam from the buccal view. Thus, the patients in the current study were satisfied with the color of their restorations. In addition, enamel bonding might be responsible for the good marginal adaptation, lack of marginal discoloration and recurrent caries. However, after three years, 12% of patients complained of discoloration of the composite veneer at the gingival half of the buccal surface. This color change may have been related to excessive tea or coffee drinking, which can discolor the composite veneer.

Despite the good marginal adaptation of both the amalgam and composite margins, additional interface between the two materials posed a potential problem, since the interface was located on the occlusal surface. Although there was no chemical interaction between the two materials, in an *in-vitro* study, intimate adaptation was observed at the interface.[29] In the current study, after one year, two restorations (6%) showed a crevice at the composite-amalgam interface. This slight discrepancy appeared to have resulted from the fracture of thin flashes of amalgam that extended over the composite surface of the buccal cusp slope. However, this did not result in any failure after three years.

When the resin composite is first placed and polymerized, amalgam particles can intermix with the oxygen-inhibited layer during amalgam condensation in the cavity. This interlocking may provide bonding and sealing at the composite-amalgam interface. In combined restorations, when the amalgam is placed before the composite, there is no oxygen-inhibited layer, which serves as a disadvantage. This layer may create a stronger link between the two materials.[17]

No data are available from long-term clinical evaluations of combined restorations. A retrospective clinical assessment of 12 combined restorations in extended Class II cavities of vital maxillary posterior teeth reported that the composite-amalgam interface in all the restorations seemed to be clinically acceptable, even in a six-year old restoration.[21]

Avoiding the effect of polymerization shrinkage stress on the interface is a potentially important factor in the integrity of the interface. By first applying the composite, shrinkage would occur before amalgam placement. As the amalgam sets, it does not exert significant stress on the bonding mechanism at the composite-amalgam interface. However, composite veneering of the amalgam crown in a second appointment could produce polymerization stress at the interface.

Because amalgam has an elastic modulus close to that of resin composite and dentin,[15] functional stresses may be evenly distributed through the whole restored tooth, preventing stress concentration and fracture. As a result, the one-appointment combined restoration technique described in the current study yielded clinically acceptable results after a three-year observation period. Follow-up of this group of patients will continue for an

additional four years, for a total of seven years. If satisfactory long-term results are obtained and the rate of complicated failures remains low, combined composite-amalgam coverage of maxillary premolars may become a useful technique to completing endodontic treatment.

CONCLUSIONS

Based on the results of this prospective clinical evaluation and within the limitations of this study, cusp coverage with combined composite-amalgam restorations yielded clinically acceptable restorations for endodontically-treated maxillary premolars without extensive loss of tooth structure after three years.

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References

1. Linn J & Messer HH (1994) Effect of restoration procedures on the strength of endodontically-treated molars *Journal of Endodontics* **20(10)** 479-485.
2. Steele A & Johnson BR (1999) *In vitro* fracture strength of endodontically treated premolars *Journal of Endodontics* **25(1)** 6-8.
3. de Freitas CR, Miranda MI, de Andrade MF, Flores VH, Vaz LG & Guimarães C (2002) Resistance to maxillary premolar fractures after restoration of Class II preparations with resin composite or ceromer *Quintessence International* **33(8)** 589-594.
4. Mondelli RF, Ishikiriama SK, de Oliveira Fillo O & Mondelli J (2009) Fracture resistance of weakened teeth restored with condensable resin with and without cusp coverage *Journal of Applied Oral Science* **17(3)** 161-165.
5. Goerig A & Mueninghoff LA (1983) Management of the endodontically treated tooth. Part I: Concept for restorative designs *The Journal of Prosthetic Dentistry* **49(3)** 340-345.
6. Randow K & Glantz PO (1986) On cantilever loading of vital and non-vital teeth. An experimental clinical study *Acta Odontologica Scandinavica* **44(5)** 271-277.
7. Mondelli RF, Barbosa W, Mondelli J, Franco EB & Carvalho RM (1998) Fracture strength of weakened human premolars restored with amalgam with and without cusp coverage *American Journal of Dentistry* **11(4)** 181-184.
8. Mannocci F, Bertelli E, Sherriff M, Watson TF & Ford TR (2002) Three-year clinical comparison of survival of endodontically-treated teeth restored with either full cast coverage or with direct composite restoration *The Journal of Prosthetic Dentistry* **88(3)** 297-301.
9. Siso SH, Hürmüzlü F, Turgut M, Altundasar E, Serper A & Er K (2007) Fracture resistance of buccal cusps of root filled maxillary premolars teeth restored with various techniques *International Endodontic Journal* **40(3)** 161-168.
10. Assif D, Nissan J, Gafni Y & Gordon M (2003) Assessment of the resistance to fracture of endodontically treated molars restored with amalgam *The Journal of Prosthetic Dentistry* **89(5)** 462-465.
11. Hansen EK, Asmussen E & Christiansen NC (1990) *In vivo* fractures of endodontically-treated posterior teeth restored with amalgam *Endodontics & Dental Traumatology* **6(2)** 49-55.
12. Smales RJ (1991) Longevity of cusp-covered amalgams: Survivals after 15 years *Operative Dentistry* **16(1)** 17-20.
13. Starr CB (1990) Amalgam crown restorations for posterior pulpless teeth *The Journal of Prosthetic Dentistry* **63(6)** 614-619.
14. Soares PV, Santos-Filho PC, Martins LR & Soares CJ (2008) Influence of restorative technique on the biomechanical behavior of endodontically treated maxillary premolars. Part I: Fracture resistance and fracture mode *The Journal of Prosthetic Dentistry* **99(1)** 30-37.
15. Soares PV, Santos-Filho PC, Gomide HA, Araujo CA, Martins LR & Soares CJ (2008) Influence of restorative technique on the biomechanical behavior of endodontically-treated maxillary premolars. Part II: Stress measurement and stress distribution *The Journal of Prosthetic Dentistry* **99(2)** 114-122.
16. Ferracane JL (2005) Developing a more complete understanding of stresses produced in dental composites during polymerization *Dental Materials* **21(1)** 36-42.
17. Abu-Hanna AA & Mjör IA (2004) Combined amalgam and composite restoration *Operative Dentistry* **29(3)** 342-344.
18. Geiger S, Paikin L, Gorfil C & Gordon M (2008) Fracture resistance of endodontically-treated teeth restored with combined composite-amalgam restorations *Quintessence International* **39(2)** e58-e62.
19. Plasmen PJ & Reukers EA (1993) Esthetic veneering of amalgam restorations with composite resin—combining the best of both worlds? *Operative Dentistry* **18(2)** 66-71.
20. Cardash HS, Bichacho N, Imber S & Liberman R (1990) A combined amalgam and composite resin restoration *The Journal of Prosthetic Dentistry* **63(5)** 502-505.
21. Roda RS & Zwicker PF (1992) The combined composite resin and amalgam restoration for posterior teeth: A clinical report *Quintessence International* **23(1)** 9-13.
22. Meiers JC (2004) Salvaging a compromised tooth using a combination amalgam core/composite window technique *Operative Dentistry* **29(4)** 477-480.
23. Demarco FF, Zanchi CH, Bueno M & Piva E (2007) Composite veneering of complex amalgam restorations *Operative Dentistry* **32(1)** 94-98.
24. Cvar J & Ryge G (2005) Reprint of criteria for the clinical evaluation of dental restorative materials *Clinical Oral Investigations* **9(4)** 215-232.
25. Bayne SC & Schmalz G (2005) Reprinting the classic article on USPHS evaluation methods for measuring the clinical research performance of restorative materials *Clinical Oral Investigations* **9(4)** 209-214.
26. Robbins JW (1990) Guidelines for the restoration of endodontically-treated teeth *Journal of the American Dental Association* **120(5)** 558, 560, 562 passim.
27. Robbins JW & Summit JB (1988) Longevity of complex amalgam restorations *Operative Dentistry* **13(2)** 54-57.
28. Demarco FF, Ramos OL, Mota CS, Formolo E & Justino LM (2001) Influence of different restorative techniques on microleakage in Class II cavities with gingival wall in cementum *Operative Dentistry* **26(3)** 253-259.
29. Franchi M, Breschi L & Ruggeri O (1999) Cusp fracture resistance in composite-amalgam combined restorations *Journal of Dentistry* **27(1)** 47-52.