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Clinical Evaluation of Bonded Amalgam Restorations in Endodontically Treated Premolar Teeth: A One-Year Evaluation

Farzaneh Ahrari, DDS, MS; Mahsima Nojoomian, DDS, MS; Horieh Moosavi, DDS, MS

Abstract

Aim: The aim of this clinical study was to compare the fracture resistance, marginal adaptation, and rate of recurrent caries of bonded and nonbonded amalgam restorations in endodontically treated premolar teeth.

Methods and Materials: A total of 36 patients with endodontically treated maxillary first or second premolars were selected and divided into three groups. The treatments in all groups consisted of lingual cusp coverage and cementation of a prefabricated intracanal post (No. 2 long, Dentatus USA, New York, NY, USA). One type of cavity liner was used for each group as follows: copal varnish (Group A), Amalgambond Plus (Group B), and Scotchbond Multi-Purpose (Group C). The teeth were then restored with Cinalux high-copper spherical amalgam (Cinalux, Sh. Dr Faghihi Dental Co., Tehran, Iran). After one year, fracture resistance, marginal adaptation, and secondary caries were evaluated. Fischer's exact test was used for statistical analysis using a 0.05 percent significance level.

Results: There was no significant difference among groups with respect to fracture resistance (p=0.49). However, significant differences in marginal adaptation existed among the three groups (p=0.02) and no recurrent caries were found in any of the restored teeth.

Conclusion: Bonding amalgam restorations using Amalgambond Plus and Scotchbond Multi-Purpose Plus did not improve the fracture resistance or affect the resistance to secondary caries in endodontically treated premolar teeth. However, the teeth in both these bonded groups showed significant improvement in marginal adaptation compared with restorations placed with copal varnish (p=0.02).

Clinical Significance: Amalgambond Plus or Scotchbond Multi-Purpose adhesive resins significantly improved marginal adaptation of amalgam compared with copal varnish, but did not enhance fracture resistance or affect the prevention of secondary caries.

Keywords: Amalgambond, bonded amalgam, bonding agent, fracture resistance, marginal

adaptation, recurrent caries, Scotchbond Multi-Purpose Plus

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Introduction

Amalgam restorations have been used since 1826.[1] The numerous advantages of amalgam include long life, relatively low cost, ease of application, high abrasive resistance, low technical sensitivity, and a self-sealing ability. However, dental amalgam lacks adhesion to tooth surface, so it should be placed in cavities with sufficient mechanical retention. Even when prepared most conservatively, these cavity preparations often require removal of some healthy tooth structure. Another common problem observed in amalgam restorations is microleakage at the interface of amalgam and tooth structure that may lead to secondary caries, pulpal damage, and post-operative sensitivity.[2,3]

A great step in increasing the clinical potential of amalgam restorations has been the development of materials that chemically bond amalgam to tooth structure. To achieve this, and to decrease microleakage and increase retention of amalgam restorations, adhesive resin systems were introduced in the form of cavity liners.[3] It has been claimed that bonding amalgam to tooth structure, has numerous benefits such as decreasing microleakage, increasing retention, reinforcing dental structure, providing better marginal adaptation, and reducing post-operative sensitivity.[3,4]

Several studies have evaluated the effects of bonding agents on improving amalgam restorations.[4–11] In a two-year clinical trial, Belcher and Stewart[4] evaluated the effects of an amalgam adhesive (Amalgambond Plus, Parkell, Edgewood, NY, USA) in complex amalgam restorations. They found that bonding amalgam to tooth structure could serve as a suitable alternative to pin retention. In a laboratory experiment, the application of resin cement caused a significant increase in fracture resistance of premolar teeth with MOD amalgam restorations.[5] Moosavi and Sadeghi[6] noted that the application of a multistep adhesive system was more effective in preventing microleakage than copal varnish. Calamia et al.[7] reported that using Amalgambond Plus caused a significant decrease in cervical sensitivity for at least six months. On the other hand, a six-year clinical evaluation showed that there was no significant difference in failure rate, marginal adaptation, marginal discoloration, secondary caries, tooth sensitivity, or tooth vitality between complex amalgam restorations that were bonded with an adhesive resin and those merely retained with self-threading pins.[8] Latino et al.[9] mentioned that without further improvement in materials technology, clinicians should not rely on restorative materials to support undermined occlusal enamel. In a study by Camacho et al.[10] there was no significant difference in the fracture resistance of premolars between those restored with conventional techniques and those restored with bonded amalgam techniques, and the fracture resistance of both groups was lower than for the teeth with porcelain or resin-based composite restorations. In another clinical study, no significant difference in postoperative sensitivity was found between amalgam restorations bonded with Scotchbond Multi-Purpose and those lined with copal varnish at any postoperative intervals.[11]

Considering the controversial and conflicting results of these various studies of the effects of bonding agents on amalgam restorations, and keeping in mind that most of the previous studies on dentin bonding systems have been performed in the laboratory, and the fact that laboratory conditions cannot accurately simulate the clinical situation, an *in vivo* study was designed on this subject. A clinical study is certainly more suitable for evaluating the performance of amalgam restorations, especially in premolar teeth where endodontic treatment usually results in insufficient structure to resist intraoral conditions. The null hypothesis of the present study was that with the application of copal varnish or an adhesive resin in endodontically treated premolar teeth restored with complex amalgam restorations, there would be no difference in fracture resistance, marginal adaptation, and rate of recurrent caries.

Methods and Materials

Patients in this study had been referred to the Department of Operative Department of the Mashhad Dental School for restoration of maxillary first or second premolar teeth that had undergone endodontic treatment and were to receive complex amalgam restorations. In all of the 36 patients selected for the study, the test teeth had an intact buccal cusp and occluded with natural or restored teeth. Although the presence of a lingual cusp was not necessary, only teeth with no evidence of a subgingival fracture in the lingual surface were selected. An apical endodontic seal and sufficient root length of the teeth were confirmed radiographically, and one amalgam restoration was placed for each patient.

The study was approved by the Ethics Committee of Mashhad University of Medical Sciences and informed consent was obtained from each subject. Patients excluded from the study were those who could not tolerate the procedure, had compromised endodontic treatment, had a periodontal problem with the premolar tooth involved, or would not be available for a recall examination.

The patients were randomly divided into three groups, and the teeth in each group received one type of cavity liner. A rubber dam and cotton rolls were used for isolation and to prevent contamination from saliva. Treatment method was similar in all groups: first caries were removed, then the lingual cusp was reduced nearly 3 mm, and undermined enamel and unsupported tooth structure were removed to increase retention of the amalgam restoration. The canal was prepared to a depth of 6 mm from the buccal cementoenamel junction (CEJ), which was 8 mm from the orifice, considering that the orifice of the canal is located 2 mm above the CEJ. Nos. 2 and 3 Peeso Reamer drills (Dentsply Maillefer, Tulsa, OK, USA) were used to provide sufficient space for post placement. In the case of premolars with two roots, the post was placed in the palatal canal. The appropriate prefabricated post (No. 2 long, Dentatus USA, New York, NY, USA) was chosen and cemented with zinc phosphate cement, followed by placing a stainless steel matrix band (Figure 1). All of the restorations were placed by the same operator using Cinaluxhigh-copper spherical amalgam (Cinalux, Sh. Dr Faghihi Dental Co., Tehran, Iran).

The patients received restorations as follows:

Group A: For the 12 patients in this group, after completing the cavity preparation and cementing the post, two layers of copal varnish (Cooley & Cooley, Ltd., Houston, TX, USA) were applied to the walls of the preparation. Amalgam was inserted, condensed against all walls of the cavity, carved, and shaped. The restoration was checked for proper occlusal contacts (Figure 1).

Group B: After cementing the post, Amalgambond Plus dentin bonding agent (Parkell, Farmingdale, NY, USA) was applied according to the manufacturer's instructions for the 12 patients in this group. Dental amalgam was condensed against the wet resin, the restoration was carved and shaped, and the occlusion was adjusted as needed.

Group C: For the 12 patients of this group, after post cementation, Scotchbond Multi-Purpose adhesive (3M/ESPE, St. Paul, MN, USA) was used according to the manufacturer's instructions. Dental amalgam was immediately placed against the wet resin, condensed, and the restoration was formed. The occlusal contacts were checked and adjusted as needed.

Clinical evaluation: The restorations were evaluated after one week (baseline evaluation) and again one year following placement using the modified Cvar and Ryge[12] criteria for bonded restorations with Alpha, Beta, and Charlie ratings, with Alpha being the highest and Charlie being the lowest rating (Table 1). Restorations were evaluated for (1) retention and reinforcement, (2) marginal adaptation, and (3) the presence of secondary caries. All of the examinations were performed by the same investigator (MN) and photographic documentation was obtained at the one-year recall appointment for all subjects (Figure 2). The examinations were conducted with direct observation to check for any missing tooth structure or restorative material using a sharpened tip explorer (model DE, 5H, D.A.M. Instrument, Elgin, IL, USA) to evaluate the restorations for marginal adaptation and recurrent caries.

Results

After one year, 11 patients from Group A, 11 patients from Group B, and 9 patients from Group C were recalled for clinical examination. Each

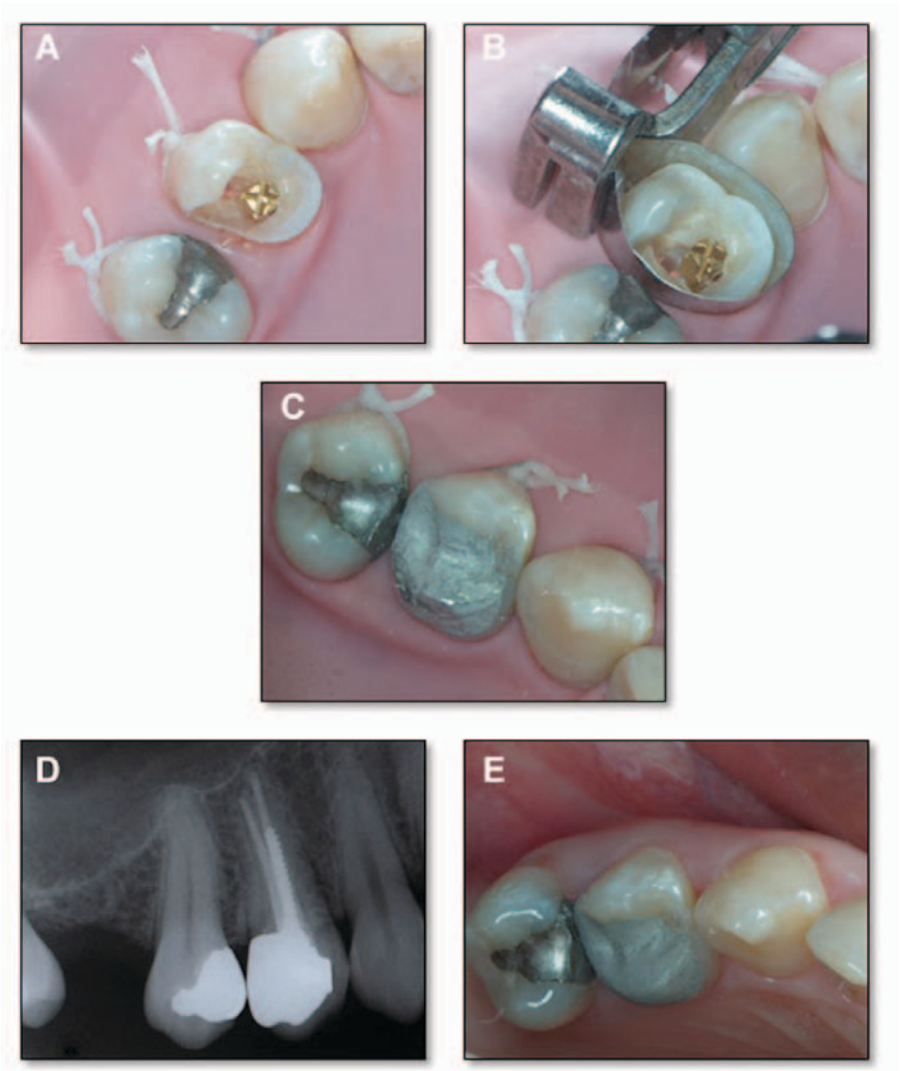

Figure 1. Photographs of a representative tooth from rubber dam isolation to placement of the amalgam restoration to the one-year follow-up examination. **A.** Rubber dam isolation, tooth preparation, and post cementation. **B.** Varnish application followed by placement of a Tofflemire retainer and matrix band. **C.** Restoration immediately after placement. **D.** Radiographic view of completed amalgam restoration. **E.** Same restoration one year after placement.

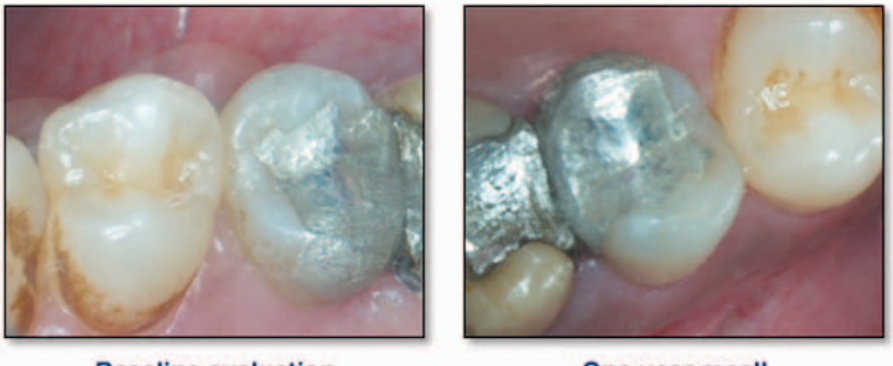

Figure 2. Representative restoration as seen at the baseline evaluation and at the one-year recall appointment.

Table 1. The modified Cvar and Ryge[12] criteria used to evaluate restorations.

Retention and reinforcement	Alpha (α)	Amalgam restoration and remaining tooth structure are intact as restored originally
	Bravo (ß)	Small portions of amalgam restoration or tooth structure are missing. Restoration needs repair. Chairside adjustment is possible
	Charlie (c)	Large portions of amalgam restoration or tooth structure are missing, requiring the restoration to be redone
Marginal adaptation	Alpha (α)	All margins are closed throughout the outline of the preparation; explorer does not catch
	Bravo (ß)	Crevice is seen; explorer penetrates at interface and catches when moved from tooth surface to restoration surface and vice versa; dentin not exposed
	Charlie (c)	Crevice is seen, with dentin exposed
Secondary caries	Alpha (α)	No caries present throughout the entire margin of the preparation
	Charlie (c)	Caries present

Table 2. Clinical ratings of the restorations in the three test groups based on the modified Cvar and Ryge criteria.[12]

Category	Copal Varnish (Group A)		Amalgambond Plus (Group B)		Scotchbond Multi-Purpose (Group C)	
	Baseline	1 year	Baseline	1 year	Baseline	1 year
Fracture resistance	12 α	11 α	12 α	9 α 2 ß	12 α	8 α 1 c
Marginal adaptation	12 α	7 α 4 ß	12 α	11 α	12 α	9 α
Secondary caries	12 α	11 α	12 α	11 α	12 α	9 α

restoration was evaluated for fracture resistance, marginal adaptation, and the occurrence of caries. The results of clinical evaluations are summarized in Table 2.

Fracture Resistance

With respect to fracture resistance, all the restorations in Group A were intact. In Group B, two cases of fracture were observed. In one case, a small repairable fracture occurred in the amalgam restoration while in the nother patient a small repairable fracture was noted in the tooth itself. In Group C, one tooth suffered a significant fracture and the affected tooth was extracted. Fisher's exact test showed no significant difference in fracture resistance among the three groups (p=0.49).

Marginal Adaptation

When marginal adaptation was considered, four teeth from the copal varnish group (Group A) were found to have a detectable gap at the interface of restoration and tooth structure, while the remaining restorations in this group had sealed and flush margins. In Groups B and C, all the restorations exhibited excellent marginal adaptation and received Alpha ratings for this particular parameter. Fisher's exact test showed that the frequency distribution of closed margins was significantly lower in Group A compared with Groups B and C (p=0.02). The application of Amalgambond Plus or Scotchbond Multi-Purpose adhesive resins significantly improved marginal adaptation of amalgam restorations.

Secondary Caries

No case of secondary caries was detected in any of the test groups at the one-year recall visit.

Discussion

In this clinical study, the three parameters of fracture resistance, marginal adaptation, and secondary caries were evaluated against the variable of liner type. These results for each parameter are discussed separately.

Fracture Resistance

This study found that the application of bonding agents does not increase fracture resistance of premolar teeth that had undergone endodontic treatment and the placement of complex amalgam restorations. This outcome was contrary to the findings of Soares et al.,[13] who reported an increase in fracture resistance of endodontically treated premolar teeth that had been restored with adhesive techniques compared to those restored with a nonadhesive technique. In a laboratory experiment, Sagsen and Aslan[14] found that using bonding agents, together with amalgam or composite resin restorations, resulted in a significant increase in fracture resistance of endodontically treated maxillary premolars.

In contrast, the results of the present study are similar to the findings reported by Santos and Meiers.[15] They showed that the fracture resistance of premolars with mesial-occlusal-distal (MOD) amalgam preparations lined with either a 4-META adhesive (Amalgambond) or varnish (Plastodent) was not significantly different under any of the test conditions. Hadavi et al.[16] also reported that using Amalgambond Plus did not significantly increase the strength of repaired high-copper spherical and admixed amalgams. In a laboratory study, there was no significant difference in fracture resistance of maxillary premolars with MOD cavity preparations restored with amalgam without sealer, amalgam bonded with Scotchbond Multi-Purpose, or amalgam bonded with Panavia F.[17] More recently, a clinical study showed that bonded amalgam restorations, compared to conventionally placed amalgam, offered no significant advantages in terms of restoration longevity.[18]

In the present study, two restorations fractured in Group B and one restoration fractured in Group C, while no fracture was seen in Group A patients. If the adhesion between tooth and amalgam was permanent, then no fractures would be expected in the bonded groups (Group B and Group C) compared with the varnish group (Group A). It has been reported that long-term immersion of test specimens in 37°C water significantly decreased adhesive bond strengths.[19] This phenomenon has been attributed to hydrolysis of collagen peptides that were not supported by hydroxylapatite.[20] Santos and Meiers[15] reported that the link between resin and amalgam is lost over time. And although there were cases of fracture in the two bonded-amalgam groups, the differences with the copal group was not statistically significant. Therefore, the adhesives used in this study had no effect on fracture resistance of endodontically treated premolar teeth that were restored with complex amalgam restorations.

Marginal Adaptation

When directly observed by a pointed explorer, all the teeth that were bonded with Amalgambond Plus (Group B) or Scotchbond Multi-Purpose (Group C) had flush margins, and the difference with copal group (Group A) was statistically significant. These findings contradict the results of a previous study[4] on AmalgambondPlus that showed no significant difference in marginal adaptation of bonded and nonbonded amalgam restorations. In another one-year study, Mahler et al.[21] also reported no significant difference in marginal adaptation between bonded and non-bonded amalgam restorations. Similarly, Summitt et al.[8] reported no significant difference in marginal adaptation of pin-retained amalgam restorations versus those bonded with Amalgambond Plus bonding agent.

The opposing results of the present study, compared to other previously published reports, might be attributed to the type of amalgam used or to other variables, such as the size and design of the cavity preparations. For instance, Belcher and Stewart[4] selected molar and premolar teeth that needed pin retention, but none of these teeth required cast restorations. However, the teeth chosen for this study ideally should have been restored with a cast restoration. The findings of the present study did indicate that using Amalgambond Plus or Scotchbond Multi-Purpose may provide better marginal adaptation at the interface between the amalgam and tooth structure compared with copal varnish.

Secondary Caries

Secondary caries can result from microleakage. Several studies have reported that bonded amalgam restorations show less microleakage than restorations without liner or those lined with copal varnish alone.[3,6,22,23] One laboratory study showed that bonding amalgam restorations to the tooth structure decreased microleakage of admixed and spherical amalgam restorations.[24] Cenci et al.[25] found that the bonded amalgam technique is an effective way to prevent microleakage in enamel and cementum/dentin. However, in the study by Myaki et al.,[26] there was no significant difference in microleakage of amalgam restorations bonded with

Scotchbond Multi-Purpose or those lined with copal varnish. In the present study, no secondary caries were found in any groups after one year. Similarly, Belcher and Stewart[4] did not observe any difference in the rate of secondary caries between bonded and nonbonded amalgam restorations, but mentioned they did not expect to see a considerable difference in a two-year study.

The major limitations of the current study were the small sample size and the short assessment period. The inclusion criteria were such that finding a large number of premolar teeth that satisfied the aforementioned criteria was not possible. Because the average lifetime of a complex amalgam restoration is estimated to be 10 years,[27] long-term clinical studies with large sample sizes are needed to identify any significant differences in fracture resistance, marginal adaptation, and rate of secondary caries between bonded and nonbonded amalgam restorations.

Conclusion

After one year, the fracture resistance of endodontically treated premolar teeth restored with complex amalgam restorations that were bonded with Amalgambond Plus or Scotchbond Multi-Purpose adhesive resins was not significantly different from teeth lined with copal varnish (p=0.49). However, the application of Amalgambond Plus or Scotchbond Multi-Purpose adhesives significantly improved marginal adaptation of amalgam restorations compared with copal varnish (p=0.02). None of the teeth in the three groups showed any evidence of developing secondary caries at the one-year recall appointment.

Clinical Significance

The application of Amalgambond Plus or Scotchbond Multi-Purpose adhesive resins significantly improved marginal adaptation of amalgam restorations at the interface between the amalgam and the tooth structure compared with copal varnish, but did not enhance fracture resistance or affect the prevention of secondary caries.

References

1. Craig RG, Powers JM, Wataha JC. Dental materials: properties and manipulation. 8th ed. St Louis: Mosby; 2004. p. 229-50.
2. da Silva AF, Piva E, Demarco FF, Correr Sobrinho L, Osinga PW. Microleakage in conventional and bonded amalgam restorations: influence of cavity volume. Oper Dent. 2006; 31(3):377-83.
3. Staninec M, Holt M. Bonding of amalgam to tooth structure: tensile adhesion and microleakage tests. J Prosthet Dent. 1988; 59(4):397-402.
4. Belcher MA, Stewart GP. Two-year clinical evaluation of an amalgam adhesive. J Am Dent Assoc 1997; 128(3):309-14.
5. Rasheed AA. Effect of bonding amalgam on the reinforcement of teeth. J Prosthet Dent. 2005; 93(1):51-5.
6. Moosavi H, Sadeghi S. Short-term evaluation of resin sealing and rebonding on amalgam microleakage: an SEM observation. J Contemp Dent Pract. 2008; 9(3):32-9.
7. Calamia JR, Styner DL, Rattet AH. Effect of Amalgambond on cervical sensitivity. Am J Dent. 1995; 8(6):283-4.
8. Summitt JB, Burgess JO, Berry TG, Robbins JW, Osborne JW, Haveman CW. Six-year clinical evaluation of bonded and pin-retained complex amalgam restorations. Oper Dent. 2004; 29(3):261-8.
9. Latino C, Troendle K, Summitt JB. Support of undermined occlusal enamel provided by restorative materials. Quintessence Int. 2001; 32(4):287-91.
10. Camacho GB, Gonçalves M, Nonaka T, Osório AB. Fracture strength of restored premolars. Am J Dent. 2007; 20(2):121-4.
11. Kennington LB, Davis RD, Murchison DF, Langenderfer WR. Short-term clinical evaluation of post-operative sensitivity with bonded amalgams. Am J Dent. 1998; 11(4):177-80.
12. Cvar JF, Ryge G. Criteria for clinical evaluation of dental restorative materials. US Public Health Service, publication 790. San Francisco: Government Printing Office; 1971.
13. Soares PV, Santos-Filho PC, Martins LR, Soares CJ. Influence of restorative technique on the biomechanical behavior of endodontically treated maxillary premolars. Part I: fracture resistance and fracture mode. J Prosthet Dent. 2008; 99(1):30-7.

14. Sagsen B, Aslan B. Effect of bonded restorations on the fracture resistance of root filled teeth. Int Endod J. 2006; 39(11):900-4.
15. Santos AC, Meiers JC. Fracture resistance of premolars with MOD amalgam restorations lined with Amalgambond. Oper Dent. 1994; 19(1):2-6.
16. Hadavi F, Hey JH, Ambrose ER, elBadrawy HE. The influence of an adhesive system on shear bond strength of repaired high-copper amalgams. Oper Dent. 1991; 16(5):175-80.
17. Dias de Souza GM, Pereira GD, Dias CT, Paulillo LA. Fracture resistance of teeth restored with the bonded amalgam technique. Oper Dent. 2001; 26(5):511-5.
18. Bonsor SJ, Chadwick RG. Longevity of conventional and bonded (sealed) amalgam restorations in a private general dental practice. Br Dent J. 2009; 206(2):E3; discussion 88-9.
19. Takarada K, Kojima M, Ishihara K, Nakabayashi N. [Durability of bonding between 4-META/MMA-TBB resin to dentin pretreated with 10-3. The effect of 10-3 pretreating period and subsequent glutaraldehyde treatment]. Shika Zairyo Kikai. 1990; 9(6):831-40.
20. Nakabayashi N, Ashizawa M, Nakamura M. Identification of a resin-dentin hybrid layer in vital human dentin created *in vivo*: durable bonding to vital dentin. Quintessence Int. 1992; 23(2):135-41.
21. Mahler DB, Engle JH, Simms LE, Terkla LG. One-year clinical evaluation of bonded amalgam restorations. J Am Dent Assoc. 1996; 127(3):345-9.
22. Edgren BN, Denehy GE. Microleakage of amalgam restorations using Amalgambond and Copalite. Am J Dent. 1992; 5(6):296-8.
23. Yu XY, Wei G, Xu JW. Experimental use of a bonding agent to reduce marginal microleakage in amalgam restorations. Quintessence Int. 1987; 18(11):783-7.
24. Lombard R, du Preez IC, Oberholzer TG. Microleakage of different amalgams bonded with dual cure resin cements. SADJ. 2007; 62(2):056, 058-61.
25. Cenci MS, Piva E, Potrich F, Formolo E, Demarco FF, Powers JM. Microleakage in bonded amalgam restorations using different adhesive materials. Braz Dent J. 2004; 15(1):13-8.
26. Myaki SI, Rodrigues CR, Raggio DP, Flores TA, Matson MR. Microleakage in primary teeth restored by conventional or bonded amalgam technique. Braz Dent J. 2001; 12(3):197-200.
27. Klausner LH, Green TG, Charbeneau GT. Placement and replacement of amalgam restorations: a challenge for the profession. Oper Dent. 1987; 12(3):105-12.

About the Authors

Farzaneh Ahrari, DDS, MS

Dr. Ahrari is an assistant professor in the Department of Orthodontics, Dental Research Center of Mashhad University of Medical Sciences in Mashhad, Iran. Her research interests include laser dentistry and dental materials. She is a member of the Iranian Association of Orthodontists.

e-mail: farzaneh.ahrari@gmail.com

Mahsima Nojoomian, DDS, MS

Dr. Nojoomian is an assistant professor emeritus, Department of Restorative Dentistry, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran.

Horieh Moosavi, DDS, MS (Corresponding Author)

Dr. Moosavi is an assistant professor in the Department of Restorative Dentistry, Dental Research Center of Mashhad University of Medical Sciences, Mashhad, Iran. Her research interests include microleakage, adhesive systems, and tooth-colored restorative materials. She is a member of the Iranian Academy of Cosmetic Restorative Dentistry and an IADR member in the USA.

e-mail: dentist_57@yahoo.com or moosavih@mums.ac.ir

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