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Factors influencing dentists' choice of amalgam and tooth-colored restorative materials for Class II preparations in younger patients

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Abstract

Objective. To identify factors associated with dentists' decisions on choice of restorative material in children and adolescents. ***Material and methods.*** In the period 2001–2004, 27 dentists in the Public Dental Health Service in Norway placed 4030 Class II restorations in 1912 patients. The reason for placement, previous caries experience (DMFT), oral hygiene, and characteristics of the cavity were recorded. ***Results.*** The most frequently used material was resin composite (81.5%), followed by compomer (12.7%), amalgam (4.6%), and glass ionomer cement (1.2%). Tooth-colored restorations were more frequently placed than amalgam in younger patients ($p = 0.017$). Female patients received fewer amalgam restorations than male patients ($p = 0.006$). Amalgam was more often used in patients with high DMFT ($p < 0.001$) and more commonly in treatment of deeper dentine caries than caries near the dentino-enamel border ($p = 0.021$). Amalgam was more frequently placed in molars than in premolars ($p < 0.001$). In a logistic regression model, gender, DMFT, caries severity, and tooth type were significantly related to choice of material. ***Conclusion.*** Dentists' choices of restorative material indicate that the majority prefer amalgam in more challenging restorations with respect to caries activity, lesion depth, and tooth type. The findings indicate that in a period when the use of amalgam was phasing out, resin composite was the predominant material of choice for Class II restorations in children and adolescents.

Key Words: *Choice behavior, dental amalgam, dental restoration*

Introduction

Traditionally, restorations in stress-bearing areas on the occlusal surfaces with extensions to one or two approximal surfaces (Class II) have been made in amalgam. However, in Norway, use of amalgam has been abandoned due to controversy about the effects of mercury in dental patients and environmental issues. In Scandinavia, recommendations from the health authorities encourage dentists to minimize their use of amalgam by using alternatives whenever possible [1,2]. This has led to considerable change in operative dentistry during the past decades, with a shift towards greater use of adhesive materials [3,4] and minimal intervention concepts [5]. As of January 2008, dentists in Norway are no longer allowed to use amalgam owing to the potential hazard of mercury in the environment [6], and during the preceding years guidelines from the national Health Authorities advised that amalgam should not be the first choice when placing restorations [1].

The reduced use of amalgam in Norway was reflected in a questionnaire-based study published in 2001, in which 19.9% of Norwegian dentists claimed they would use amalgam for occlusal caries in a lower 2nd molar in a 20-year-old patient [7].

Amalgam has been replaced by adhesive materials that are more technique sensitive and are claimed to have more plaque accumulation, to be associated with the development of more secondary caries, and to have shorter longevity compared to amalgam [8,9]. Resin composite, compomer, resin-modified glass ionomers and chemically cured glass-ionomer cements are different tooth-colored adhesive materials in use. The properties of these materials vary considerably [10] and are reflected in the differences in survival times [3,11–13]. It is well documented that the criteria for placing restorations

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have changed over time [11–15]. From a patient perspective, more esthetic restorations are preferable [16]. Studies have been conducted on dentists' choices of restorative material and amount of operative treatment in different grades of caries severity [17] and in relation to some patient variables [18]. These studies were conducted in the early 1990s. Less is known, however, about what influences dentists' decisions on choice of restorative material in the post-amalgam era.

This study aimed to examine the patterns of dentists' decisions on choice of restorative material in relation to patient characteristics, tooth to be restored, and cavity preparation. The research hypothesis to be tested was that among dentists who use amalgam as one of the alternative materials for Class II restorations, patient-related variables may influence the decision.

Material and methods

The present study was carried out in the Public Dental Health Service (PDHS) in Bergen, Norway, and the study protocol was approved by the Regional Committee for Medical Research Ethics. All clinicians working in a dental district (11 clinics) were invited to take part in the study, and about 60% responded positively. Altogether 27 dentists participated (3 M and 24 F) with a mean age of 42.3 years at baseline. All Class II restorations in permanent teeth placed in a certain time period were to be included in the study. Since most adolescents in Norway up to the age of 20 regularly attend the PDHS, an age-based inclusion criterion for patients was made (<17 years at baseline). The restorations were then to be followed for at least 4 years. As a result of discussions with the participating dentists, it was concluded that the inclusion of 4000 Class II restorations was a realistic goal within one year. The dentists were to follow their own standard routines concerning operative techniques and choice of restorative material.

For each restoration, a set of patient-related variables was collected on a pre-designed record form. Information about age/gender of the patient, reason for placement of restoration, previous caries experience (DMFT), oral hygiene, and size and shape of the cavity were baseline recordings. The DMFT was noted in the baseline registrations and the DMFT values at 12 years of age were collected from the clinic dental records. Oral hygiene was defined as good, medium, or poor according to the dentists' clinical judgment. Tooth number, occlusal extension, and pulpal depth of preparation were recorded; the last-mentioned categorized in thirds of the estimated total dentin thickness. The occlusal extension was expressed in thirds of the intercuspal width. The restorative material was the dentist's own choice and was recorded on the form. Predefined reasons for placement were either primary caries or replacement of old restorations. A five-graded scale was used for evaluation of the depth of primary caries. Based on radiographic interpretation, the following categories were used: grade 1 – the radiolucency was confined to the outer half of the enamel; grade 2 – the lesion penetrated the inner half of the enamel; grades 3–5 – the radiolucency was confined to the outer third of the dentin, to the middle third, or to the inner third, respectively.

In this study, specially designed software was produced to ensure a standardized registration of all baseline data. SPSS 14.0 (Statistical Package for the Social Sciences, SPSS, Chicago, Ill., USA) was used to process the data. Statistical evaluation was carried out by means of descriptive statistics with chi-square tests and logistic regression analyses. The latter was performed with *amalgam as restorative material* as dependent variable and age, gender, oral hygiene, previous caries experience (DMFT), reason for placement, cavity width, cavity depth, tooth type, and dentist (categorical variable) as independent variables. The probability level for statistical significance was set at $\alpha = 0.05$.

Results

During the time period 2001–2004, a total of 4030 Class II restorations were placed in 1912 patients (980 M and 932 F, aged between 6 and 57 years). To reach the planned number of restorations for this study ($n = 4000$), the inclusion period had to be extended to 3 years. In addition, 136 Class II restorations of 80 additional patients older than 20 years were included. These restorations accounted for 3.3% of the restorations and the majority of the patients were <25 years of age. The additional patients were regular attendees at the PDHS and therefore the restorations could be followed for the study period of 4 years.

The majority of patients ($n = 1038$, 54.3%) received one restoration; 415 (21.7%) patients received two restorations; 189 (9.9%) received three; and 270 (14.1%) received four or more restorations. The highest number of restorations placed in one patient was 19. The number of restorations per dentist varied from 9 to 472 (Figure 1). Most of the restorations were placed due to primary caries (94.2%), and 5.8% were replacements of failed restorations ($n = 3965$). In 65 restorations the caries severity was not categorized by the dentists. Most of the primary caries lesions to be restored were of severity grade 3 (76.5%, $n = 3081$); 13.7% ($n = 553$) were grade 4; and 2.4% ($n = 96$) were grade 5. Very few lesions graded 1 and 2 were filled (0.1%, $n = 5$).

Twenty-one out of 27 dentists used more than one of the alternative restorative materials grouped according to the following categories: amalgam, composite, compomer, and glass-ionomer cement.

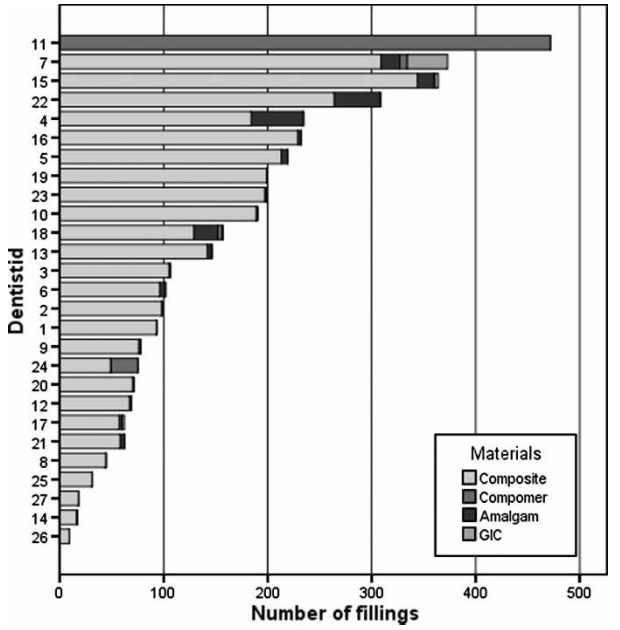

Figure 1. Distribution of restorative materials placed by each dentist.

Composite was used for 3286 filllings (81.5%), followed by compomer ($n=510$, 12.7%), amalgam ($n=184$, 4.6%), and glass-ionomer cement ($n=50$, 1.2%). This last-mentioned number was too small to allow for separate analyses. In patients receiving two or more restorations, where at least one was an amalgam restoration, decisions on the subsequent restorations were examined more closely. In the additional restorations, 8.7% of the patients received only amalgam restorations, 22.1% received both amalgam and tooth-colored restorations, and 58.4% received only tooth-colored restorations. All but six amalgam restorations were placed in molars.

Five dentists placed only composite and one only compomer restorations. All data from the dentists using only one material were excluded from the statistical analyses of factors associated with choice of restorative material. The dentist who exclusively used compomer as restorative material placed 472 restorations, which was 92.7% of the total number of compomer restorations. Thus, when excluded, the percentage of compomer in the baseline material was reduced from 12.7% to 1.1% ($n=38$). Consequently, the 'compomer' and 'glass-ionomer cement' groups were both too small to allow for separate statistical analyses, and thus the study focused on comparing only two groups of materials, namely amalgam and tooth-colored materials. Furthermore, all dentists not placing at least one amalgam restoration ($n=11$) were excluded from this part of the study. To ensure that the patient's economy did not affect the dentist's choice of restorative material, all patients ≥ 21 years of age were excluded from the analyses. In patients registered with more than one restoration, only data related to the first restoration placed were used to obtain independent units when performing the statistical analyses. Hence, this part of the study included a total of 1171 restorations placed in 1171 patients by 15 dentists.

The age of the patient was associated with the choice of restorative material. The mean age of patients receiving tooth-colored restoration was 14.5 years, as opposed to 15.4 years for patients receiving amalgam restoration ($p=0.003$). The frequency of amalgam restorations was 8.2% in the highest age quartile (≥ 16.3 years), as opposed to 2.1% in the lowest quartile (≤ 12.8 years) ($p=0.017$). Fewer female than male patients received amalgam restorations (3.8% vs 7.6%; $p=0.006$). In patients rated as having poor oral hygiene, the proportion of amalgam was not significantly higher than in patients with oral hygiene classified as medium (8.8% vs 5.5%; $p=0.178$) and good (8.8% vs 5.3%; $p=0.16$). Amalgam restorations were chosen more often in patients with high DMFT than in patients with low DMFT. When patients were grouped in quartiles according to DMFT values, more frequent use of amalgam was found in patients with high DMFT, 2.0% in the 1st quartile (DMFT ≤ 5) and 11.2% in the 4th quartile (DMFT ≥ 12), respectively ($p<0.001$) (Figure 2). Amalgam was more commonly used in treatment of caries grade 4 than grade 3 (9.9% vs 4.9%; $p=0.021$). Likewise, when dichotomizing the variable with a cut-off reflecting the severity of the carious lesion at primary caries grade 3, amalgam was more commonly used in treatment of primary caries grade 4–5 and replacement of restorations versus primary caries grade 1–3 (9.6% vs 4.9%; $p=0.007$). However, amalgam was not significantly more used in replacement of restorations than in treatment of primary caries (9.0% vs 5.6%; $p=0.26$). Amalgam

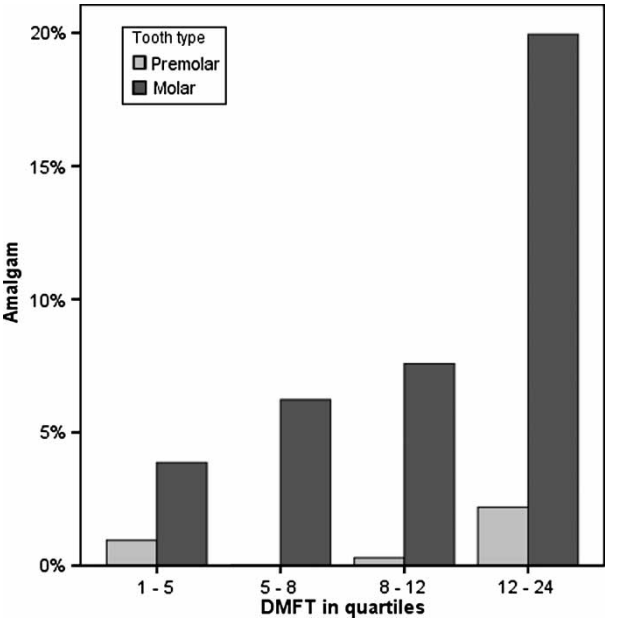

Figure 2. Amalgam use in premolars and molars by DMFT in quartiles.

was more frequently used in deep versus shallow cavities (9.1% vs 2.9%; $p=0.008$), but there was no significantly increased use of amalgam in wide cavities compared to narrow (7.3% vs 6.6%; $p=0.801$). The proportion of molars receiving amalgam restorations was 8.1%, as opposed to 1.5% in premolars ($p<0.001$). However, the position of the tooth in the upper versus lower jaw was not significantly related to use of amalgam. There was no significant difference in the frequency of amalgam restorations between upper and lower jaw neither in premolars ($p=0.42$) nor in molars ($p=0.67$). The percentage of amalgam restorations calculated for each participating dentist was not significantly related to age of the dentist ($r=0.30$, $p=0.22$).

The results from the regression analysis are presented in Table I. Age (2nd and 4th quartiles), gender, previous caries experience (2nd and 4th quartiles of DMFT), caries severity, depth of the cavity, and tooth type were all significantly related to use of amalgam (unadjusted analyses). In the adjusted analyses, only gender, previous caries experience (2nd and 4th quartiles of DMFT), caries severity, and tooth type remained significant. Accordingly, age, oral hygiene, and cavity size were not significantly related to choice of restorative material.

Amalgam was seldom used in premolars, provided that DMFT was in the first 3 quartiles (Figure 2). At the high end of caries experience (DMFT ≥ 12), amalgam was more common and constituted 22.0% of restorations in molars.

Discussion

The dentists participating in our study were not selected at random, as motivation and interest in practice-based studies were judged as a prerequisite for participation. This is in accordance with similar studies conducted in the USA [19], and participation of about 60% of the dentists invited to participate in our study was considered satisfactory. Practice-based research networks are essential when studying the impact of the collective knowledge and skill of clinicians [20,21]. Involvement of general dental practitioners in clinical research is a valuable adjunct to traditional research trials [22]. For the clinicians who volunteered to participate in the present study, it was a prerequisite that, in collaboration with the patient, they themselves would be responsible for choosing the preparation and restorative material they would use. According to current legislation in Scandinavia on patients' rights, the final decision on choice of restorative material has to be made by the patient. Thus, our study reflects everyday clinical practice and is therefore categorized as practice-based [20,23].

All cohorts in Norway up to the age of 20 regularly attend the PDHS and are enrolled in a recall program. In 2003, only 3.9% of people aged 0–18 years and 25.7% of adolescents aged 19–20 were not under treatment and supervision by the PDHS [24]. Therefore, all patients younger than 17 years who needed one or more Class II restorations were included in the study, since it was likely that they

Table I. Multivariate analysis. A multivariate analysis was performed with 'amalgam as filling material' as the dependent variable and age, gender, oral hygiene, previous caries experience (DMFT), reason for placement, cavity width, cavity depth and tooth type as independent variables. The significance level was set at $p<0.05$.

	Unadjusted			Adjusted		
Independent variables	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Age						
- 2nd quartile vs. 1st quartile	3.12	1.31–7.46	0.01	1.82	0.66–4.98	0.25
- 3rd quartile vs. 1st quartile	2.37	0.96–5.85	0.06	1.88	0.64–5.54	0.26
- 4th quartile vs. 1st quartile	3.63	1.54–8.57	0.003	2.22	0.79–6.20	0.13
Gender						
- male vs. female	0.49	0.29–0.82	0.007	0.37	0.20–0.70	0.002
Oral hygiene						
- poor vs. good	1.69	0.83–3.40	0.15	0.98	0.37–2.59	0.96
Previous caries experience (DMFT)						
- 2nd quartile vs. 1st quartile	3.50	1.38–8.90	0.008	3.02	1.09–8.35	0.03
- 3rd quartile vs. 1st quartile	1.95	0.72–5.26	0.19	2.33	0.78–6.97	0.13
- 4th quartile vs. 1st quartile	6.11	2.51–14.9	<0.001	10.9	3.79–31.3	<0.001
Caries severity						
- primary caries gr.4-5 and replacement vs. primary caries gr.3	2.05	1.21–3.49	0.008	3.01	1.28–7.10	0.01
Cavity width						
- broad vs. narrow	1.35	0.71–2.59	0.36	1.01	0.40–2.55	0.98
Cavity depth						
- deep vs. medium vs. shallow	1.78	1.18–2.68	0.006	1.23	0.62–2.43	0.56
Tooth type						
- molars vs. premolars	5.77	2.47 –13.5	<0.001	16.0	5.77–44.1	<0.001

would be in the recall system during the planned study period of 4 years.

Traditional power analyses were not performed to calculate the size of the study sample. The numbers of restorations included in previous studies of longevity vary considerably. In a review by Hickel, Manhart and Garcia-Godoy (2000) [25], 9 out of 49 studies on the longevity of composite restorations in posterior teeth included more than 1000 restorations. Based on previous studies, the inclusion of 4000 restorations was considered to be a sufficiently high number in the current study.

Tooth type was one of the strongest factors in the logistic regression analysis explaining the use of amalgam. Few amalgam restorations were placed in premolars, indicating that tooth-colored materials were preferred in more visible areas of the oral cavity. Adolescents often tend to choose esthetics before longevity [16]. The fact that amalgam was used less in female patients than in males indicates that female patients in the respective age group are more concerned about esthetics than male patients, or perhaps that the dentists regarded esthetics as more important for females than for males. These findings are in accordance with a similar study by Hawthorne et al. [18].

Previous caries experience (DMFT) was a strong factor in the regression analysis. This could indicate that dentists are more likely to use amalgam if the patient already has many restorations. The patients enrolled in our study had a higher average DMFT than the national average. Patients aged 12 and 18 years in our study could be compared to the corresponding national cohorts in Norway. Mean DMFT for all Norwegian 12 and 18-year-olds in 2004 with a DMFT ≥ 1 was calculated based on data from Statistics Norway, Dental Health [24]. In our study, mean DMFT for 12-year-olds was 5.0 as opposed to 2.9 in the national cohort. Likewise, the mean DMFT for 18-year-olds in our study was 10.0 as opposed to 5.9 for 18-year-olds in the national cohort in 2004. These differences can be explained by the fact that all patients included in our study had approximal caries experience, and accordingly their DMFT would be expected to be higher than average, since patients with approximal caries usually have more extensive caries [26].

The fact that in patients with high DMFT the use of amalgam was more frequent could possibly indicate a common apprehension that amalgam is beneficial compared to tooth-colored alternatives. It is a common belief that amalgam is associated with a lower rate of secondary caries and a better durability than the tooth-colored alternatives. This is in accordance with findings in a recent randomized clinical trial study showing that the overall risk of secondary caries was 3.5 times greater in composite restorations ($n = 892$) than in amalgam restorations ($n = 856$) in a follow-up period of up to seven years [27]. Many clinicians have experienced that use of tooth-colored, direct restorations involves a number of clinical problems related to the handling properties and physical properties of the material itself [13,28]. However, in a recent study by Opdam and co-workers [4], it is claimed that "operators who are skilled in both placing amalgam and composite fillings can achieve comparable longevity of those restorations in their own practices when appropriate materials are applied correctly".

In patients receiving amalgam restorations, tooth-colored restoration was the most common choice for the additional restorations. This indicates that the dentist's choice of amalgam as restorative material depends more on an individual consideration regarding the best material in each restoration compared to an overall evaluation based on patient characteristics such as caries activity. Thus, one amalgam restoration was not an indication that the other restorations in this patient would be amalgam.

In Norway, free dental care is offered by the PDHS to patients aged 0–18 years and treatment for patients 19–20 years of age is heavily subsidized. Most of the patients in our study therefore received dental care free of charge. Furthermore, the dentists in our study were on a fixed salary, so it is unlikely that economic factors affected treatment decisions. Thus, the patients' economic situation had a minor influence on the dentists' choice of restorative material. Patients older than 20 years of age, however, might be more concerned about prices when requiring a restoration, since the prices of the different alternatives vary considerably. In the statistical analyses dealing with use of amalgam, all patients ≥ 21 years were excluded, and consequently it is unlikely that patient economy influenced the dentist's choice of restorative material.

In conclusion, our study demonstrates that in a period of time when the use of amalgam was being phased out in Norway, resin composite was the predominant material of choice for Class II restorations in children and adolescents (81.5%). Twenty-one dentists chose between the alternative material types, but six exclusively used one material. Sixteen dentists chose amalgam for some of their restorations, and their choice of material was influenced by patient-related variables such as gender, previous caries experience, caries severity, and tooth type. Amalgam was more frequently used in male patients with higher previous caries experience and more severe caries, and more often in molars than in premolars. Thus, the research hypothesis was accepted. Among dentists who use amalgam as one of the alternative materials for Class II restorations, patient-related variables may influence their decisions.

On 1 January 2008, the use of amalgam as restoration material was banned in Norway. However, our study was conducted in a period of time when use of amalgam was being phased out as a

result of pressure from the authorities. This is similar to the situation in countries such as Denmark, Sweden, Germany, and Austria [29], and in time other countries may follow. None of the dentists used amalgam as their first material of choice, though their decisions on material and treatment were not influenced by economic incentives. Therefore, the present results indicate that dentists found amalgam to be the best material of choice in specific situations based on clinical considerations. This fact could be an argument when a decision to ban or allow amalgam is to be taken.

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