Age of restorations at replacement in permanent teeth in general dental practice

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The ages of 6,761 restorations replaced in permanent teeth, 6,088 in adults ≥19 years of age and 673 in adolescents ≤18 years, were available for analyses. The results showed that the median age of amalgam restorations in adults was 11 years and that of resin-based composite restorations 8 years. This difference in longevity was significant ($P = 0.0001$). The median age of failed conventional glass ionomer restorations in adults was 4 years and for resin-modified glass ionomer 2 years. In adolescents, the median longevity of failed amalgam restorations was 5 years and that of composite restorations 3 years, while both types of glass ionomers had a median longevity of 2 years. The data were subdivided based on clinician gender and practice setting. The results showed that the median age of amalgam and composite restorations replaced by male clinicians was higher than that for female clinicians irrespective of clinical setting. The median age of amalgam and composite restorations replaced by salaried dentists was significantly lower than that by private practitioners. Minor differences were noted in longevity of restorations between male and female patients. The age of replaced restorations was shortest for the group of clinicians with the least clinical experience and highest for those that graduated ≥ 30 years ago. □ *Amalgam; composite; gender differences; glass ionomer; practice setting*

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The longevity of restorations is a measure of the degree of success of the restorative procedure. All factors that affect the restoration are taken into account: the properties of the restorative material, including technique sensitivity, clinician proficiency, patient factors like oral hygiene and bruxism, size of the restoration, and a number of other issues (1–3). The frequency an individual changes his/her dentist may also influence the longevity of restorations (4, 5). However, many uncontrollable factors can affect the result from practice-based studies, including variations in the treatment decisions of clinicians (6), non-respondents, clinicians misunderstanding instructions, and provision of incorrect answers (7). Despite these inherent problems, practice-based studies are required to provide real-life data from everyday dental practice. Confidence in such studies may be increased when they involve a large number of restorations placed in unselected patients by a large group of unselected practitioners (8).

Longevity studies of restorations can have a longitudinal design or be cross-sectional based on past treatment records. A literature review has shown that most longevity studies have been cross-sectional of the age of failed amalgam restorations (9). The data available on the age of restorations that have not failed are limited (2, 3).

The longevity of replaced restorations may be expressed as a mean or median age, or as a percentage of restorations which are functional after a defined period of time (10). The mean age is the average age of all replaced restorations. The failure rate at specified time intervals is sometimes recorded, but it is difficult to compare data from different studies because the time intervals usually vary (3, 11, 12). The median age is defined as the time when 50% of the restorations have failed. Reporting on the median age ('half life') has the advantage that it allows comparison of results from different studies, and it compensates for outlier values.

Data on longevity of restorations are important for assessing the long-term cost of restorative therapy (13, 14). The present paper was part of a large, practice-based study including a survey of materials used for different clinical conditions (15) and of reasons for placement and replacement of restorations (16). It reports on the median age of restorations using different restorative materials at the time of replacement.

Materials and methods

The 243 clinicians involved in the study were considered representative of dental practitioners in Norway (15). They had been instructed to report on demographic information such as age and gender of patients, the examining clinician's gender, and number of years since graduation as well as practice setting, private or salaried practitioner. Provided the treatment record contained information on the date a restoration to be replaced had been inserted, the age was to be recorded in years, rounded off to the nearest whole year, but if less than 1 year old the number of months was reported. The ages of the replaced restorations were analyzed separately with respect to restorative

Table 1. Median age in years and number (*n*) of replaced restorations in all permanent teeth ($n = 6{,}761$), and in subgroups of adults (≥19 years) and in adolescents (≤18 years)

	All teeth		Adults		Adolescents	
	Median	(*n*)	Median	(*n*)	Median	(*n*)
Amalgam	10	(3,881)	11	(3,629)	5	(252)
Composite	8	(2,197)	8	(2,037)	3	(160)
Glass ionomer	3	(409)	4	(242)	2	(167)
R-M Glass ionomer	2	(156)	2	(74)	2	(82)
Other materials	15	(118)	18	(106)	3	(12)

materials used, type of restoration, patient's age, clinician's gender and experience, and the clinical diagnosis which led to the replacement of the restoration. The criteria for the replacements had been given to the participants in writing. They included secondary caries, discoloration (bulk and margin), fracture of restoration (bulk and margin), tooth fracture, poor anatomic form, pain/sensitivity, change of material and 'other' reasons, and they have been published in detail elsewhere (17, 18).

The clinicians were not calibrated in recording of the reasons constituting failure and the codes used for recording replacement of restorations. Each clinician had been asked to report on 100 consecutive restorations placed in their own practice to reflect the everyday situation in general practice, including those that replaced failed restorations, irrespective of who had placed the restoration.

All data management and statistical analyses were performed using the Statistical Analysis System (SAS). The study was mainly descriptive in nature using the Univariate Procedure. The non-parametric median test was used to compare the median age of amalgam and composite restorations.

Results

The ages of 6,761 (57%) of 11,800 failed restorations (16) in permanent teeth were available, 6,088 in patients 19 years or older and 673 in patients 18 years or younger (Table 1). The median age of replaced amalgam restorations in all permanent teeth irrespective of patient age was 10 years and that of composite restorations 8 years (Table 1). This difference in median age between amalgam and composite restorations was statistically significant ($P = 0.0001$). The median age of the glass ionomer restorations was 3 years and of replaced resin-modified glass ionomers 2 years. The sample size was small for resin-modified glass ionomers (16), but the short longevity of these materials was predominant for all classes of restoration. Significant ($P = 0.0001$) differences in the median longevities of amalgam and composite restorations in permanent teeth were found between adults and adolescents (Table 1).

The median age of replaced amalgam and composite restorations in adults as a function of Classes I–V is shown in Fig. 1. The median age of amalgam restorations was significantly ($P = 0.0001$) greater than that of composite restorations for Classes I, II, and V. The greatest difference between these two types of restorations was 5 years for Class II restorations. The least difference between the two materials was noted for Class III and Class IV restorations, 2 years, but the sample size for these types of amalgam restoration was small.

Looking at practice setting, private versus salaried clinicians, the results showed that the median age of replaced amalgam restorations in adults by salaried dentists was significantly ($P = 0.0001$) shorter than in private practice (Table 2). The median age of replaced composite restorations in adults was also significantly ($P = 0.003$) shorter for salaried clinicians than for private practitioners. Differences in the median age of replaced amalgam and composite restorations in adults were also sometimes noted as a function of the clinician's gender (Table 2). The median age of amalgam restorations in adults replaced by salaried clinicians and those in private practice was not significantly different for male clinicians,

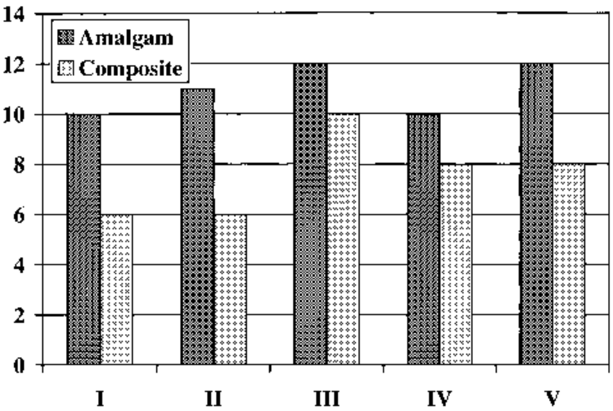

Fig. 1. Mean age of failed amalgam and composite restorations in adults as a function of class of restoration (Classes I–V). The differences between amalgam and composite restorations were significant $P = 0.0001$) for Classes I, II, and V restorations and not significant for Classes III and IV.

Table 2. Median age in years of replaced amalgam and composite restorations in permanent teeth of individuals ≥19 years as a function of practice setting (parentheses on left side) and clinician's gender (parentheses on right side)

* (Amalgam private vs. Amalgam salaried)	Amalgam (n = 1,988)		
	private/female	10	NS
	private/male	12	
* (Composite private vs. Composite salaried)	Composite (n = 1,219)		
	private/female	7	*
	private/male	9	
	Amalgam (n = 783)		
	salaried/female	9	*
	salaried/male	10	
	Composite (n-352)		
	salaried/female	5	*
	salaried/male	8	

Parentheses with an asterisk indicate statistical significance ($P \leq 0.05$) between groups.
NS, not significant.

but those replaced by female clinicians in private practice had a significantly ($P = 0.0001$) higher median age than those in salaried positions. The median age of composite restorations replaced by male clinicians in salaried and private practice was not significantly different, but for female clinicians the median age was significantly ($P = 0.003$) higher in private practice than those replaced by salaried clinicians. It should be noted that information on practice setting and gender was not reported by all clinicians, which explains the difference in number of restorations in Tables 1 and 2.

Subdividing the clinicians into 10-year experience groups (≤9, 10–19, 20–29, and ≥30 years since graduation) showed that the least experienced groups replaced restorations with a lower age than those with ≥30 years of clinical experience. For amalgam restorations the median ages were 10 years for the ≤9 year and the 10–19 year groups, 11 for the 20–29 year group, and 13.5 years for the ≥30 year group. The median age of replaced composite restorations showed an increase from 6 years for the ≤9 year group, 8 years for the 10–19 year group, 9 years for the 20–29 year group and 10 years for the ≥30 year group. The same gradual trend was noted for conventional glass ionomer restorations which were replaced at 3 years for the ≤9 year group and at 5.5 years for the ≥30 year group. The resin-based glass ionomer groups were small after subdivision into the four groups of clinicians based on years since graduation. The shortest median longevity was 1 year (n = 11) for the ≥9 year group of clinicians and the highest was 5.5 years for the 10–19 year (n = 12) and the ≥30 year (n = 14) groups, while the other 20–29 year group was at 2 years (n = 37). The heterogeneous group of other materials with inlays, onlays and crowns also showed lower median age for those replaced by the two groups with ≤19 years experience (10 years and 9 years) compared to those replaced by the two more experienced groups (20 years and 25 years).

Small differences in the median age of replaced restorations were noted between male and female adult

Table 3. Median age in years of restorations in permanent teeth of individuals ≥19 years replaced under different clinical diagnoses

Clinical diagnosis	Amalgam	Composite
Secondary caries	11	8
Bulk fracture	11	6
Marginal fracture	14	6
Bulk discoloration	—	12
Marginal discoloration	—	10
Fracture of tooth	12	8
Poor anatomic form	10	10
Pain/sensitivity	10	5
Change of material	15	12
Other reasons	11	7
All reasons	11	8

patients. There was a trend seen in a slightly higher median age of all types of replaced amalgam and composite restorations in female than in male patients.

The age of replaced amalgam and composite restorations in permanent teeth as a function of the diagnoses which led to the replacement is given in Table 3. Since the mode of failure of the two materials is likely to be different, detailed analyses and statistical comparisons *per se* are not justified. The oldest amalgam restorations replaced were those due to 'change of material', 'marginal fracture', and 'fracture of tooth'. All others were replaced at an age close to the overall median age. Within composite restorations, older restorations were found for 'bulk and margin discoloration', 'poor anatomic form', and 'change of material', while 'fractures' and 'pain/sensitivity' showed relatively shorter median age at the time of replacement compared to the overall median age. Small differences from the overall median age were noted as a function of the reason for replacement for both types of glass ionomer restorations in permanent teeth, but the sample size for subdivisions of these restorations was small and they will not be reported on in detail.

Discussion

The ages of just over 57% of the failed restorations were provided. This relatively low proportion of ages reported was comparable to that in similar cross-sectional studies in the USA (57%) (12), Germany (60–68%) (19, 20), and in the UK (55%) (14, 21). In another American study the age of only 20% of the failed restorations was reported, but since the restorations of this subsample were replaced for the same reasons as the rest, the authors felt that the longevity data reflected the age for all failed restorations (22). Response rates of 70–80% on the age of the failed restorations have been reported in studies where the recordings were part of continuing education courses (18, 23, 24), but a rate as low as 24% has also been reported (25). The most likely reason for not reporting on the age of restoration is that the information was not available because it had been placed in another dental practice. It is also time-consuming to seek information in treatment records on restorations inserted many years previously.

It may be questioned if the age of failed restorations represents the longevity of restorations at large. Limited data are available on the age of functional restoration, i.e., those that have not failed. In a cross-sectional study of 10,091 restorations, where 99.5% of the ages had been recorded, the ages of both failed and acceptable restorations were similar, suggesting that the age of failed restorations in cross-sectional studies is valid for clinical performance (2). In a longitudinal 5-year study recording the treatment outcome of large (4/5 surface) amalgam restorations and crowns in a practice-based study, successful outcomes varied from 65% to 84%, being highest for crowns (3). In both of these studies, a number of variables affecting the longevity of restorations were outlined and discussed. It is feasible that the age at failure is a measure of the longevity of restorations.

The age of replaced amalgam and composite restorations in the present cross-sectional study was higher than that reported previously from Scandinavia (23, 24). Shorter longevities of these types of restorations have been published from the UK (11, 15, 23). Studies in the USA by Klausner et al. (12) indicate a *mean* longevity of amalgam restorations of about 11 years in Michigan, which is shorter than the calculated mean age of 12.7 years in the present material. Recent data from a study of a limited number of restorations in Florida showed 15 years *mean* longevity for amalgam and 8 years for composites (14), which in this particular set of data was calculated to be the same as the median age.

The increased longevity of amalgam and composite restorations in recent studies may be due to a variety of reasons. Improvements in the quality of the materials could be a major factor. High copper amalgams, for example, introduced in the 1970s have been shown to exhibit better clinical performance than conventional amalgams (27, 28). With regard to composite restorations, improvements in the quality of the materials are also a likely explanation for the increased longevity. However, the learning curve for practicing dentists can also play a role, because teaching in the case of certain types of composite restorations has been limited (29, 30). Technique issues may also affect the longevity of restorations. For example, acid etching of enamel was initially hard to accept by the profession at large. In recent studies, only 3–4% of all composite restorations in adults were replaced due to marginal staining (16, 17, 25). In a study performed during 1980–82, 9% of restorations in patients 16 years of age or younger were replaced with the diagnosis marginal discoloration (31).

Dental amalgam has not changed much in composition and quality since the introduction of so-called non-gamma-two amalgams in the early 1970s. The increases in longevity found in recent studies (17, 25) may to some extent be due to a change in the indications for amalgam therapy. As is seen from the selection of restorative materials in this series of investigations (15), amalgam was predominantly used in Class I and Class II restorations 10–15 years ago. Similar results were found in Denmark 10 years ago (23). Data from Sweden in 1993/95 indicated that the majority of composite restorations were in stress-bearing areas and relatively few amalgam restorations were inserted (25). The general improvement in the caries situation may have resulted in the need for smaller restorations and, consequently, a change in the restorative materials used. In addition, a small proportion (4%) of old amalgam restorations were removed because of a desire by the patient to change to another restorative material.

The differences in median longevity of amalgam and composite restorations replaced by salaried and private practitioners and by females and male clinicians is difficult to understand. The dentist population is fairly uniform with most dentists having graduated from one of the two dental schools in Norway. A possible explanation may be that salaried practitioners and female clinicians are stricter in their criteria of what constitutes a failed restoration. However, their recorded reasons for replacements were similar (15, 16).

The effect on the median age of restorations replaced in adults based on years since graduation was quite striking for all types of restoration and most marked for ‘other’ restorations. These findings may reflect a difference in the criteria used by the most experienced clinicians compared to the younger group. It is also possible that the older group of clinicians had a more stable and older group of re-call patients which required less attention to minor defects than the patients in the younger group of clinicians. The few adolescent patients (10% of the total number of restorations) were mainly treated by the younger clinicians and adolescents have a shorter life span of restorations than adults as shown by Qvist et al. (23, 24) and confirmed in the present study.

Few large-scale investigations have been carried out to study the longevity of glass ionomer restorations in general practice. The early studies focused on the percentage of lost restorations, often in practices by individual practitioners (32). More recent studies in general practice indicate that the median longevity of all glass ionomer restorations as a group is about 3 years (18, 25). In the present study the median age of replaced traditional glass ionomer restorations in all permanent teeth was 3 years and 2 years for resin-modified glass ionomer restorations. In adolescents the longevity of glass ionomer restorations was 2 years for both types of glass ionomer restoration, but the longevity of composites for this age group was also short (3 years). Since the resin-modified glass ionomer materials have been on the market shorter than any of the other materials, this comparison is unfair. Clinicians may still be on the learning curve for using these materials. It is also possible that the use of resin-modified glass ionomers on adolescents has been so recent that long-term data cannot be expected. However, it is thought-provoking that glass ionomer materials are predominantly used for restorations in young individuals (15). Since long-term cost is a function of placement cost and longevity of restorations (13), the use of materials with short longevities will inevitably result in increased long-term costs (14). However, in this context it is important to keep in mind that cross-sectional studies usually do not assess the proportion of the total number of restorations of each type that is replaced.

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