

From amalgam to composite: selection of restorative materials and restoration longevity in Finland

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The aim of this study was to obtain information on restorative dental care in Finland and to analyze the changes in treatment over a 5-year period. A random sample of dentists was drawn from the registers of the health authorities and the dental association in Finland, and in the spring of 1997 a questionnaire was sent requesting the dentists to record information for each restoration placed during a given period. A total of 1,229 dentists were contacted, and 659 responded. The dentists treated 5,305 adults during the study period and placed 6,322 restorations. The most common restorative material was composite resin, which was used in 74.9% of the restorations, whereas amalgam was used in 4.8% and glass ionomers in 9.4% of the restorations. The median ages of failed restorations were nearly 12 years for amalgam, slightly less than 5 years for composite, and slightly more than 4 years for glass ionomer. The results indicate that clinical dentistry in Finland has made a definite step towards the post-amalgam era. However, the functional periods of the failed tooth-colored restorations were disappointingly short and warrant some serious consideration. □ *Clinical performance; dental amalgam; dental restorations; longevity*

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The debate on the possible negative health effects of dental amalgam has been going on for years, and during this time several expert groups in different countries have carefully evaluated the available scientific research on the health effects of dental amalgam. No direct evidence has been found that the use of mercury in dentistry has adverse effects on the general health of the amalgam bearers (1–4). However, growing environmental awareness together with technical developments has diminished the intended use of mercury in equipment and processes in general. In parallel, there has been a change in the selection of dental restorative materials from amalgam to tooth-colored restorative materials in several countries (3, 5). The suspicions of the public towards the safety of amalgam restoration may also to some extent have contributed to this trend (6).

In 1992 a survey in Finland showed that 29% of all restorations and up to 40% of the restorations in premolars or molars placed in adults were amalgam, whereas the rest were tooth-colored restorations (5, 7). The results of the survey indicated that both composite resins and glass ionomer cements were to some extent used as alternatives to amalgam, whereas gold or ceramics were seldom used. During the 1990s tooth-colored restorative materials have established their position as major restorative materials, but too little is known about their durability and longevity in everyday clinical use.

The aim of this study was to collect information on the restorations provided in Finland and, by comparing the data with those from a previous survey, to analyze the changes in restorative treatment over a 5-year period. Our

hypothesis was that the use of amalgam has been in constant decrease since the previous data collection. At the time of the recent survey about half of the adults seeking dental treatment were treated in health centers and half in private practices, whereas most of the children were treated in health centers. This article deals with the information on adults' restorative treatment. Data on the children will be reported later.

Materials and methods

A random sample of regional health centers was drawn from the list of Finnish health centers (47 health centers, with 579 dentists), and a sample of private dental practitioners (650) was drawn from the membership register of the Finnish Dental Association (98% of Finnish dentists are members). The sample size was designed to cover about 25% of public dentists and private practitioners. Dentists 65 years of age or older were omitted. In the spring of 1997 a questionnaire was sent requesting the dentists to record information on patients who had restorative treatment and on the restorations placed. To guarantee information on adult patients, the recording covered 1 ordinary working day in private practices but 3 days in health centers, where most patients are children and teenagers. The respondents were asked to record the material chosen for both the new restoration and the failed, replaced restoration and to give the major reason for the restorative treatment from five possible alternatives, which were briefly described in the instructions. The age of

Table 1. Age distribution of the patients

Age	Private sector <i>n</i> (%)	Public sector <i>n</i> (%)	Total <i>n</i> (%)
17–39 years	297 (21.4)	2568 (65.5)	2865 (54.0)
40–59 years	724 (52.3)	928 (23.7)	1652 (31.1)
60 years or more	363 (26.3)	425 (10.8)	788 (14.9)
Total	1384 (100)	3921 (100)	5305 (100)

the failed restoration was also recorded if known. In addition, the dentists were asked to record whether the patient had any amalgam restorations in his or her mouth at the time when the ongoing treatment period ended.

The chi-square test was used to compare the frequency differences between the care sectors, the age groups of the patients, and the sex and years in practice of the dentists.

Results

Replies were received from 407 health center dentists, who collected data in 42 health centers (responses were obtained from 70.2% of health centers, and dentists not performing restorative treatments were excluded), and from 303 private practitioners. Of the private practitioners 51 had not been active during the period studied due to maternity leave, sick leave, or retirement and were excluded. The final data for private practitioners thus consisted of answers from 252 persons, giving a response rate of 42.1%. The inquiry was based on total anonymity, and no reminders were sent.

As background information on the respondents, health care sector, number of years in practice, and sex were elicited. In health centers 20.8% of respondents were male, whereas 46.4% were male among private practitioners. The proportion of dentists who had worked for 10 years or less was 29.3% in health centers and 16.9% in private practices. The corresponding figures for dentists who had worked 11 to 20 years were 44.1% in health centers and 33.3% in private practices, and those for dentists who had worked at least 21 years were 26.6% in health centers and 49.8% in private practices.

The dentists treated 5,305 adult (17 years or older) patients during the study period and placed 6,322 restorations (on average 1.2 restorations per patient).

The percentage age distribution of the patients showed that private practitioners treated more middle-aged and elderly patients than did public dentists ($P < 0.001$) (Table 1).

Restorative materials used

There were no significant differences between the two health care sectors, between male and female dentists, or between different numbers of years in practice with regard to the selection of restorative materials (chi-square test). The results for the material selection are therefore presented combined.

The most common restorative material was composite resin, which was used in 74.9% ($n = 4,730$) of the restorations, whereas amalgam was used in only 4.8% ($n = 304$) of them. The use of amalgam in different age groups varied from 3.5% in 17- to 29-year-olds to 6.2% in 40- to 49-year-olds. Conventional glass ionomers were used in 9.5% ($n = 603$), and resin-modified glass ionomers in 9.3% ($n = 588$) of the restorations, respectively. The number of gold and ceramic restorations was small ($n = 30$), and no further analyses were performed for data on them.

Reasons for restorative therapy

The main reason for the restorative treatment in young adults (17–29 years) was primary caries, whereas in patients aged 30 years or older secondary caries and fractures of the tooth or restoration were given as main reasons for the treatments (Table 2). Aesthetic reasons were rare in all age groups, whereas other reasons, which included restorative treatment after endodontics, were more common in older than in younger patients (Table 2). The distribution of the reasons for restorative treatment in the 1992 survey and in the present one in adults of different age is depicted in Fig. 1.

In 46.5% of treatments ($n = 3,748$) a restoration was replaced, and the previous material was known. The most common reasons for re-restorations were fractures of the tooth or restoration when the original material was composite, and secondary caries when the original material was amalgam (Table 3). Fractures and secondary caries were given equally often as the main reason for failure of conventional glass ionomer restorations (Table 3). Failures of resin-modified glass-ionomer restorations

Table 2. Distribution of the reason for treatment in different age groups

Age of the patient (years)	Reason for restorative treatment					Total <i>n</i>
	Primary caries % (<i>n</i>)	Secondary caries % (<i>n</i>)	Fractures of tooth/filling % (<i>n</i>)	Aesthetic reasons % (<i>n</i>)	Other reasons % (<i>n</i>)	
17–29 years	65.8 (1181)	15.1 (267)	12.5 (221)	0.8 (12)	5.8 (103)	1764
30–59 years	24.0 (862)	32.1 (1151)	31.7 (1137)	2.8 (100)	9.4 (335)	3585
60 years or more	19.1 (186)	36.5 (355)	31.8 (309)	2.1 (20)	10.5 (103)	973
Total	34.9 (2209)	28.0 (1773)	26.4 (1667)	2.1 (132)	8.6 (541)	6322

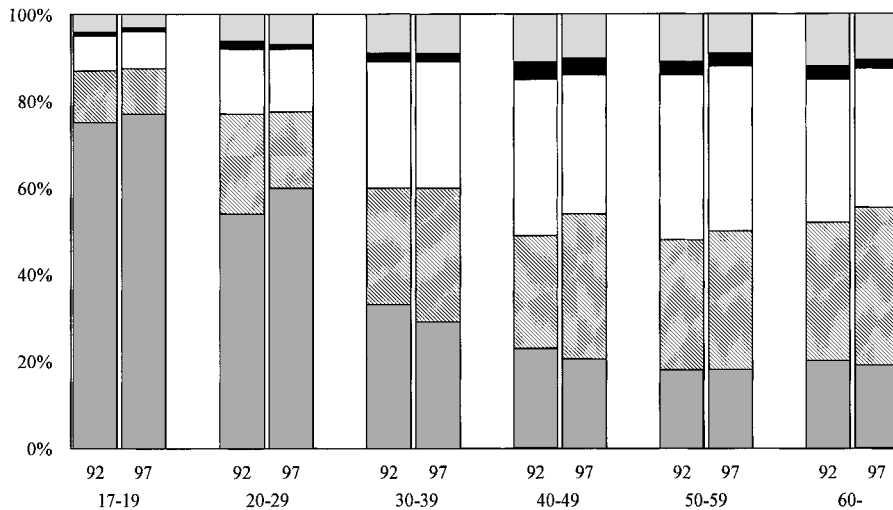


Fig. 1. Frequency distribution of the reason for restorative therapy in different age groups (in years) in the 1992 and 1997 surveys. (■) Primary caries, (▨) secondary caries, (□) fractures of the filling or tooth, (■) aesthetic reasons, (□) other reasons.

and gold crowns/inlays were also reported, but they were too few to be analyzed.

Age of the replaced restorations

The ages of 53.7% ($n = 2,012$) of the failed restorations were reported, including 898 amalgam, 920 composite, and 170 glass ionomer restorations. The median age of failed amalgam restorations was 10.5 years (quartiles, 8 and 15 years) in 20- to 39-year-olds ($n = 354$) and 13.5 years (quartiles, 10 and 20 years) in patients 40 years or older ($n = 529$). The median age of failed composite restorations was 4 years (quartiles, 2 and 7.5 years) in 20- to 39-year-olds ($n = 302$) and 5.8 years (quartiles, 3 and 10 years) in patients 40 years or older ($n = 586$). The median age of failed glass ionomer restorations was 4.5 years (quartiles, 3 and 7 years) in 20- to 39-year-olds ($n = 68$) and 5.0 years (quartiles, 3 and 6.5 years) in patients 40 years or older ($n = 71$). There were also some reports of restoration failures ($n = 78$) in 17- to 19-year-olds, but the low number of different types of restorations did not enable further calculations. In Fig. 2 the cumulative percentage distribu-

tion of the ages of the failed amalgam, composite, and glass ionomer restorations is shown. The points at which the 50% horizontal line crosses the curves represent the median ages of the failed restorations at the abscissa.

Proportion of amalgam bearers

Most of the adult patients treated had one or more amalgam restorations at the end of the ongoing treatment period. The proportion of amalgam bearers was lowest in the youngest age groups: 42.9% of 17- to 19-year-olds and 87.4% of 20- to 29-year-olds had amalgam restorations. In the age groups from 30 to 59 years (10-year intervals) more than 94% were amalgam bearers, whereas in the oldest age groups the proportion of amalgam bearers had decreased to 86%.

Discussion

The response rate of 42.1% for private practitioners must be considered low, especially when a similar survey by the

Table 3. Distribution of reasons for replacement of restorations as a function of previous material

Reason for restoration	Previous material		
	Amalgam % (n)	Glass ionomer % (n)	Composite % (n)
Secondary caries	50.0 (914)	42.4 (131)	38.6 (598)
Primary caries elsewhere in tooth	6.5 (119)	4.9 (15)	2.5 (39)
Fractures	33.4 (610)	39.2 (121)	46.9 (726)
Aesthetic reasons	1.7 (31)	1.0 (3)	3.5 (54)
Other reasons	8.4 (153)	12.6 (39)	8.5 (131)
Total no. of restorations	1827	309	1548

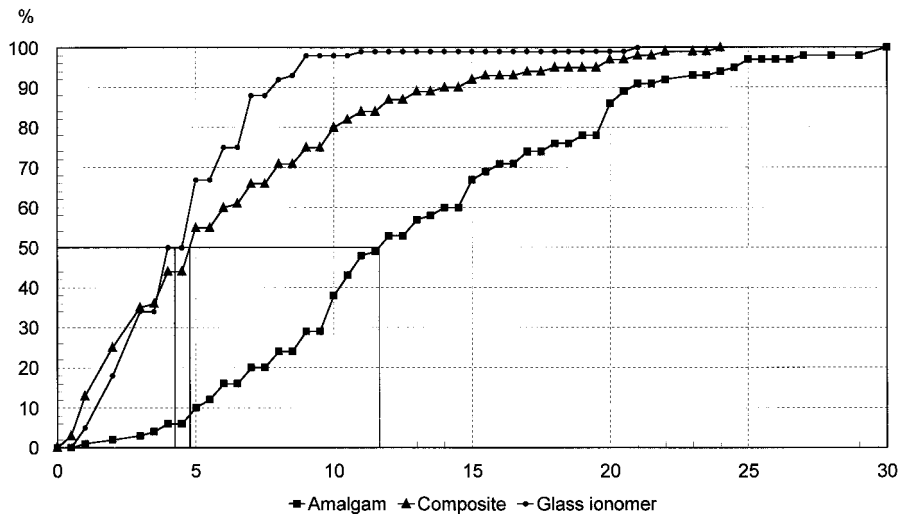


Fig. 2. The cumulative percentage distribution of the age (in years) of failed amalgam ($n = 898$), composite ($n = 920$) and glass ionomer ($n = 170$) restorations in adults' dentition. The points at which the 50% horizontal line crosses the curves represent the median functional period of the failed restorations at the abscissa.

same authors gave a response rate of 57.3% 5 years earlier. No reminders were sent at either time. The profile of the respondents was compared with that of the member register of the Finnish Dental Association (98% of practicing dentists are members) with reference to working sector, sex, and number of years in practice. The comparison showed a rather even distribution, but the private sector in general and especially young dentists working in the private sector were underrepresented. The age distribution of the patients in the private sector was, however, similar to that in a recent epidemiologic survey (8).

In general, the willingness of Finnish dental practitioners to respond to inquiries and surveys has been fairly good. One factor that may have influenced the response rate is the severe economic recession in Finland at the time of the survey, which caused a lack of working opportunities in the public sector and an increase in the number of private practitioners, at the same time as many patients postponed their dental treatments for economic reasons. As a consequence, there may have been underoccupation among private practitioners. Unwillingness to reveal the number of treatments during 1 day may partly explain the low response rate. The low proportion of young private practitioners among the respondents supports this explanation. In addition, as other inquiries have shown, the proportion of temporarily non-active dentists especially among young female practitioners is high (Widström, personal communication), and some of the non-respondents may have belonged to that group.

The results of the study showed that the use of amalgam was only an exceptional choice in Finnish dental care. Five years earlier amalgam was still used in about one third of all restorations in adults, but now the respective propor-

tion was less than 5%, thus confirming our hypothesis. Probably mainly due to high costs of crowns and ceramic restorations and no reimbursements for most middle-aged and elderly people, the use of composite resins is common even in large restorations. According to a recent inquiry, Finnish dentists felt that the change in material selection from amalgam to tooth-colored materials has not caused any major problems (9). According to our results, however, the functional periods of the failed composites and glass ionomers were disappointingly short. For composite restorations, this is in clear contrast to favorable reports published on the long-term survival of posterior composites (see, for example, Refs. 10, 11). For glass ionomers the result was not so surprising, as prospective follow-up studies in children have shown that their longevity is relatively short (12).

Recently, in a systematic review on the longevity of routine dental restorations, Downer et al. (13) pointed out that cross-sectional studies involving retrospective case record examination by non-standardized examiners can give insights into effect modifiers such as the dental care system, but such studies do not rate highly in the hierarchy of acceptable evidence. The authors also warned about confusion in the nomenclature: median survival time is the lifetime that any individual restoration has a 50% change of exceeding. The expression is commonly, but somewhat misleadingly, used also in cross-sectional studies, when it would be more correct to speak of, for example, median functional periods of failed restorations. In addition, the functional periods of failed restorations cannot be directly compared with data in longitudinal studies. According to Downer et al. (13), cross-sectional studies such as the present survey probably give an underestimation of the average lifetime of routine restorations.

In spite of the recognized methodologic shortcomings, cross-sectional surveys are used to get at least some insight into the problems in restorative dentistry, which are difficult to tackle. Mjör and colleagues (14, 15) have used a similar method repeatedly and have recently published a survey on restorative treatments by Swedish dentists (16). The median functional periods were 6 years for failed composite resin restorations and just over 3 years for glass ionomers—that is, longer for composite resins but shorter for glass ionomers than those in our study. Similar surveys dating from the 1980s or early 1990s (17–19) have shown median functional periods for composite resin restorations to be less than 4 years in Italy and Germany and 6 years in Denmark. Lately, in a similar survey performed in the United Kingdom, the mean ages for failed restorations were 4.5 years and 3.8 years for composite and glass ionomer restorations, respectively (20).

In each of the surveys referred to, failed amalgam restorations have shown longer functional periods than failed composite restorations, median periods for amalgams being nearly 5 years in Italy, 5 years in Germany, 8 years in Denmark, and 9 years in Sweden, whereas the mean age of failed amalgams was 6.8 years in the United Kingdom (16, 20–23). In our study failed amalgam restorations had served even longer—that is, nearly 12 years. When interpreting the results of recent surveys one has to bear in mind, however, that most amalgam restorations possibly in need of replacement are old, since the use of amalgam has been in decline for many years. Nevertheless, the inferiority of functional periods of composite restorations compared with those of amalgam restorations warrant some serious consideration.

In our previous survey (5, 7) there were differences between public and private sectors with regard to the selection of restorative material: private practitioners used amalgam more often and glass ionomer less often than dentists in the public sector. In the present study these differences have disappeared. The use of amalgam had almost ended in both sectors, and the use of glass ionomer by dentists in the public sector had decreased: the figure in the earlier survey was 23%–35% in different age groups, whereas the combined proportion of glass ionomer and resin-modified glass ionomer restorations in the most recent survey was 15%–26% (slightly less than half were conventional glass ionomers). This suggests that dentists in health centers have re-evaluated the indications for glass ionomer cements.

An interesting but not very surprising finding was that the proportion of primary caries as a reason for treatment was strongly dependent on the patients' age. Primary caries was the reason for most of the restorative treatments in the population younger than 30 years, which indicates that they have not yet entered the cycle of repeated restorative treatments. In the 20- to 29-year olds the proportion of primary caries as a reason for restorative treatment had increased from 54.5% to 60.2% during the 5-year period between the surveys. This finding suggests that younger age cohorts have less past caries experience

than 5-year-older cohorts. After the age of 30 years the proportion of primary caries as a reason for restorative treatment dropped dramatically, and restorations were mainly placed for secondary reasons, such as secondary caries and various other types of failures in teeth that already had a restoration. Compared with our previous survey there were no major differences in this respect.

Aesthetic reasons seemed to comprise a minor part of restorative therapy in all age groups. On the other hand, it is possible that aesthetic reasons act as contributing factors in treatment decisions, even though not registered as a main reason. Even though new amalgam restorations were placed only occasionally, most adults still have amalgam restorations left. This suggests that most people are not worried about amalgam and have not wanted their functionally valid amalgam restorations to be replaced.

The relative cost of different types of restorations was recently analyzed by Mjör et al. (24), who estimated that the long-term costs of small composite restorations were about four times those of amalgam restorations, and the difference was even greater in large restorations. The cost-effectiveness of restorative treatment in the post-amalgam era seems to be low, as indicated by the short functional periods of restorations in our survey. On the other hand, there are also many clinical studies showing fairly good results (10, 11). Perhaps the present results may partly be explained by the transition period from amalgam to composite. In the future the quality aspects of restorative therapy should be highlighted, since the high proportion of re-treatments and the low age of failed restorations are unsatisfactory in terms of both health policy and economics.

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