

The reasons for replacement and the age of failed restorations in general dental practice

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Mjör IA. The reasons for replacement and the age of failed restorations in general dental practice. *Acta Odontol Scand* 1997;55:58–63. Oslo. ISSN 0001–6357.

A cross-sectional survey among practitioners in Sweden treating adult patients was initiated to record the reasons for replacement of composite, amalgam, and glass ionomer restorations and to compare the findings with those obtained about 16 years ago. The age of the failed restorations was also recorded. The clinical diagnosis of secondary caries was the main reason for the replacement of all three types of restorations. This diagnosis was significantly higher for amalgam restorations than for composite and glass ionomer restorations. No statistically significant differences could be found in the diagnosis of secondary caries between composite and glass ionomer restorations. Major changes in the reasons for replacement of composite restorations were noted by comparing the present results with those from 16 years ago. A notable difference was seen with regard to a decrease in the relative frequency of replacements due to composite degradation/wear and an increase in the replacements due to bulk and marginal fractures. The reasons for replacement of amalgam restorations had remained much the same over the 16 years. The report that half the glass ionomer restorations replaced had the diagnosis secondary caries was by far the most surprising result. The age of the failed restorations was reported for a limited number of restorations. The median age was about 6 years for composite, almost 9 years for amalgam, and just more than 3 years for glass ionomer restorations. □ *Amalgam; clinical survey; composite; glass ionomer materials; operative dentistry*

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Changes in dental restorative treatment patterns for various reasons—including changes in disease prevalence, introduction of new and improved restorative materials and techniques, and changes in attitudes of dental patients and the public at large towards dental restorations—are all factors that may affect the reasons for replacement of dental restorations. Since marked changes in the use of restorative materials have occurred in Sweden during the past 15–20 years (1), the present study focused on the reasons for replacing composite, amalgam, and glass ionomer restorations. The aim of this study was to evaluate any significant differences in the modes of failure for different restorations. Data from the same organization of practitioners (Praktikertjänst AB, Stockholm, Sweden) had been collected during 1978–79 (2–4). Therefore, attention was paid to the collection of data that could be compared with those obtained at that time, including the age of failed restorations.

Materials and methods

The survey design was similar to that used in 1978–79 (2–4) and in many subsequent studies (5–14). However, some details related to the criteria used were modified or slightly different from those used in the original surveys in which only amalgam and composite restorations were examined. Glass ionomer restorations were

also included in this study. All clinicians involved in the survey treated adult patients in general dental practices in Sweden.

Practitioners who had signed up for a 3-year program in continuing dental education during 1993–95, including a course in restorative dentistry, were requested to record the reasons for replacement of all composite, amalgam, and glass ionomer restorations in a defined 2-week period about 2 months before attending the continuing education course, so that the results could be summarized and presented to the group. The clinicians were randomly sent one of four survey forms; one form focused on composite restorations. More clinicians responded to the composite form than to the amalgam/glass ionomer form (1).

No calibration in caries diagnosis or in criteria for failure of restorations was done, but the following explanations/definitions were provided: 1) secondary caries is caries found in contact with an existing restoration; 2) poor margins include marginal fractures, 'ditching', and crevices without secondary caries; 3) poor anatomic form results from degradation and wear of the bulk of the restoration, including loss of contact point; 4) fracture of restoration is exemplified by isthmus fracture but also includes any fracture through the bulk of the restoration. It should be differentiated from marginal fracture, which is recorded separately; 5) fracture of tooth includes all types of fractures of tooth tissue adjacent to restorations, such as cusp fractures

Table 1. Reasons for replacement of composite ($n = 2431$) amalgam ($n = 1062$) and glass ionomer ($n = 538$) restorations expressed as percentages

Clinical diagnosis	Composite	Amalgam	Glass ionomer
Secondary caries	38	50	50
Discoloration	12	—	4
Bulk	8		2
Margin	4		2
Poor anatomic form	9	—	12
Fracture of restoration	20	29	18
Bulk	16	18	12
Margin	4	11	6
Fracture of tooth	13	15	—
Bulk (cusp)	9		
Enamel	4		
Other	7	6	16

and small enamel fractures. For composite restorations, small enamel fractures are recorded separately; 6) discoloration applies to tooth-colored materials only and includes all mismatches between the color of the tooth and that of the restoration which result in replacement of the restoration. Marginal discoloration and discoloration of the bulk of the restoration are recorded separately; 7) pain and sensitivity, irrespective of type and duration, which result in the replacement of the restoration are also recorded; and 8) other reasons include any reasons other than those listed above.

The dentists were also asked to record the age of failed restorations, provided the date of placement of restorations could be found in the treatment record. The age was recorded in years, and in years and months if the restoration was less than 4 years old. If the age was unknown, it was recorded as such. All clinicians were supplied with a completed sample form.

The results were statistically analyzed using a random effect logistic regression model clustering on dentists using an epidemiologic statistical software package (ERGET, CERC, Seattle, Wash., USA) to evaluate the reasons for restoration replacement of the three materials. Odds ratios (OR) were calculated—that is, the odds of having a specific failure of a restoration after it is placed compared with the odds of the same failure of another type of restoration. If the OR is near one, there is no association. A ratio higher than one proves an association is established. If the OR is less than one, an inverse or negative association has been established. P values <0.001 were considered significant.

Results

A total of 177 clinicians participated in the survey, representing an overall response rate of 71% (1). The reasons for replacement of 2431 composite, 1062 amalgam, and 538 glass ionomer restorations as a result of diagnosed failures of previous restorations were reported. In addition, 288 (11%) of the composite

restorations were inserted because of a change from amalgam; the change per se rather than failure of the restoration was the reason for inserting a composite restoration. Some of the reasons for replacement of restorations were pooled, to simplify the presentation of the results and to enable direct comparison with a similar survey carried out in 1978–79. However, detailed information of each itemized reason for replacement is provided in Table 1.

The reasons for replacement of amalgam, composite, and glass ionomer restorations are shown in Table 1. The clinical diagnosis 'secondary caries' was the main reason for replacement of composite, amalgam, and glass ionomer restorations. Half of the replaced amalgam and glass ionomer restorations and more than a third of composite restorations were replaced with this diagnosis as the reason for failure.

The statistical analysis showed that the odds of an amalgam restoration being replaced because of secondary caries was significantly higher than that for composite (OR = 2.163) and glass ionomer (OR = 2.329) restorations. No significant difference was found in the odds of composite relative to glass ionomer restorations being replaced because of secondary caries ($P = 0.211$).

Failures of composite restorations, in addition to secondary caries, comprised bulk fracture and marginal fractures, which together accounted for every fifth composite restoration being replaced (Table 1). Discoloration, especially bulk but also marginal discoloration, and poor anatomic form were cited as reasons for replacement. A variety of 'other' reasons resulted in replacement of composite restorations, including cusp fracture and small enamel fractures. Replacement of restorations due to pain/sensitivity was a minor problem, and it was also included under other reasons.

Failures of amalgam restorations in addition to secondary caries included marginal degradation/'ditching', bulk fracture, and tooth fracture (Table 1). 'Other' reasons included 4% replacements due to pain/sensitivity.

For glass ionomer restorations fracture of restorations, including bulk fracture and marginal fracture, and poor anatomic form were the main reasons for failure in addition to secondary caries (Table 1). Discoloration, both of the bulk and marginally, was not a major problem associated with glass ionomer restorations; neither was pain/sensitivity, which was included as part of 'other' reasons.

The odds of a restoration being replaced because of marginal fracture or marginal degradation/'ditching', was significantly greater for amalgam than for composite (OR = 4.135) and glass ionomer (OR = 3.939) restorations. No significant difference existed between composite and glass ionomer restorations with regard to marginal degradation ($P = 0.802$).

Analysis of the bulk fractures showed that the odds of an amalgam restoration being replaced relative to a

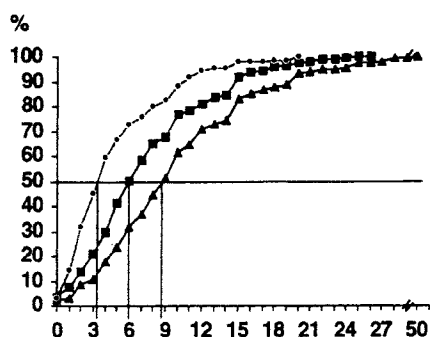


Fig. 1. The accumulated percentage distribution of the age of failed composite ($n = 537$), amalgam ($n = 282$), and glass ionomer ($n = 155$) restorations. The points at which the horizontal 50% line crosses the curves represent the time on the abscissa when 50% of the restorations had failed—that is, the median longevities: almost 9 years for amalgam, 6 years for composite, and just over 3 years for glass ionomer restorations.

composite restoration were not significant ($P = 0.546$). However, the differences in bulk fracture between amalgam and glass ionomer ($OR = 3.235$) and between composite and glass ionomer restorations ($OR = 2.192$) were significant.

The odds of an amalgam restoration being replaced because of tooth fracture were significantly greater than for a composite restorations ($OR = 1.924$). Tooth fracture, such as cusp fractures, as a reason for failure of glass ionomer restorations was not recorded separately, because such restorations are not used in large restorations of permanent teeth.

Discoloration as a reason for replacement of restorations is limited to tooth-colored materials. The odds of a composite restoration being replaced because of bulk discoloration were significantly higher than those for a glass ionomer being replaced ($OR = 12.850$). The odds ratio between these two materials with regard to marginal discoloration were significant at the $P = 0.002$ level.

Failure of anatomic form occurs in materials that degrade and wear. No significant difference was found between composite relative to glass ionomer restorations ($P = 0.281$).

Few restorations failed because of pain/sensitivity, and no significant differences were noted among amalgam, composite, and glass ionomer restorations, but the odds of an amalgam restoration being replaced relative to a composite was significant at the $P = 0.009$ level.

Age of restorations

The ages of only 974 failed restorations were reported, including 537 composite, 282 amalgam, and 155 glass ionomer restorations. The median longevities were about 6 years for composite, almost 9 years for

amalgam, and just over 3 years for glass ionomer restorations (Fig. 1).

Discussion

Cross-sectional surveys of reasons for replacing restorations differ in many respects from controlled prospective longitudinal studies of the performance of restorations. In the design of a controlled study the operator, often only one or two, and the assistant may be specially trained and standardized for the specific procedure. Factors like operative technique and the handling of materials according to manufacturer's instructions are regulated. The patient population is often selected from reliable, easily available individuals like dental students, hygienists, and dental school faculty and staff, who are likely to return for recall examination. The lesions treated are usually selected and restricted to the indications for use of the materials. The recall criteria are defined, and the clinicians doing the recall examination are calibrated. Ideally, the recall examinations are performed by clinicians different from those inserting the restorations. Furthermore, replicas, photographs, and other recordings may be regularly done to assist in the evaluation of the restoration over time.

Cross-sectional surveys of restorations are less well defined than controlled prospective studies. The restorative material used can usually only be differentiated as types of materials—for example, as amalgam or composite. The technique used, including the use of rubber dam, and the condition of the preparation are unknown factors. Furthermore, it is often difficult or impossible to find out how long the restorations have been in service. The criteria for the assessment may be the same as those in a controlled longitudinal study, but the progressive effect of service over time cannot be evaluated. Certain advantages of cross-sectional studies include that many restorations can be examined in a relatively short time, and many identified and unidentified clinicians are involved. Thus, a real-life type of setting exists. The involvement of a large number of clinicians is important, because it has long been established that restoration failures are often due to operator faults (15). The studies reflect the type of dental care the patients receive rather than the performance of restorations in approximate ideal situations in a controlled study. This is noteworthy because if the aim of dental research is to improve the quality of dental care, then the problems in general practice must be mapped out and form the basis for the research agenda.

In the present cross-sectional survey the clinicians were provided with simple, easily understandable explanations of the different reasons for replacement of restorations. However, it was not attempted to calibrate their criteria for failure of restorations or the clinicians' interpretation of the criteria. The clinicians

used their own judgement in deciding on the replacement of restorations—that is, a true real-life situation. Most of the reasons for replacing restorations as outlined in Materials and methods are easy to understand and practice, but some are more difficult than others, notably secondary caries. Since 177 clinicians were involved in the study, it is likely that a representative expression of the situation in Swedish general dental practice is recorded. However, since the practitioners involved voluntarily had signed up for a 3-year continuing dental educational program, they must be regarded as a specially interested group of clinicians.

Secondary caries was the main reason for replacement all three types of restorations, which confirms results from the many similar cross-sectional surveys with regard to amalgam and composite restorations. The result with regard to glass ionomer restorations that release fluoride *in vivo* (16–18) is surprising but confirms the preliminary data from this study (19). As outlined in the preliminary report, it had been anticipated that the release of fluoride from glass ionomer materials would reduce the incidence of secondary caries, although the fluoride concentration required to obtain a long-term anticariogenic effect has not been established. The possibility of misdiagnosing submarginations or crevices as secondary caries must be taken into consideration and possibly also the presence of residual caries that was left in the hope that the glass ionomer materials would remineralize the lesion. All in all, however, the frequency with which secondary caries was cited as a reason for replacing glass ionomer restorations was surprising.

The reasons for replacing composite restorations in this 1993–95 study differed markedly from those reported in 1978–79 (4). The main clinical problem with composite restorations two decades ago was material degradation resulting in wear of the restorations. Resin-based materials have since been gradually improved, with a resulting change in the relative frequency of the reasons for replacement of composite restorations (20). Material degradation and wear—that is, loss of anatomic form—has decreased markedly according to information from surveys similar to this one. In the 1978–79 survey loss of anatomic form as a reason for replacement constituted about 40% of all failures of composite restorations versus 9% in the present study, which is in agreement with the incidence reported in other recent studies (10, 14). Surveys from 1987–88 have an intermediate position (8).

Improvements in the properties of composites which result in less degradation and wear have provided materials that show a fairly high incidence of bulk fractures which is not significantly different from that of amalgam restorations. This change in reasons for failures could also be due to differences in the type of composite restorations inserted in 1978–79 and in 1993–95. The present data demonstrate that about half of the composite restorations are now in stress-bearing

areas (1), contrary to the situation in many parts of the world (8, 10, 11). This situation is probably related to the pending legislation to ban amalgam in Sweden, a situation that leaves resin-based composite materials as the only realistic alternative for a direct restorative material for class-I and class-II restorations. The fact that 11% of the composites inserted were associated with a change of a functional amalgam restoration also points to a move towards composite as the universal restorative material in Sweden, despite the higher short- and long-term costs (21). However, other factors like improved tooth-colored restorative materials, changes in caries prevalence, and disease progression must also be taken into consideration.

Secondary caries was cited as a reason for replacing amalgam restorations slightly less seldom than reported in the 1978–79 survey (14) but somewhat more frequently than reported in other studies (7, 13). These results contrast with those in controlled longitudinal studies (22). However, the likelihood of several false-positive diagnoses of secondary caries must be taken into consideration, especially for amalgam (23–26), but also for composite restorations (27). No such attempts have been made to validate the diagnosis of secondary caries associated with glass ionomer restorations, although Tyas (28) makes the assumption that if marginal discoloration is a precursor of secondary caries, then less caries will occur adjacent to glass ionomer than adjacent to composite restorations.

A relatively high incidence of failure because of bulk (isthmus) fracture and tooth fracture has been reported for class-II amalgam restorations in surveys similar to that in the present study and also in controlled studies (22) and in longitudinal studies involving a limited number of clinicians (29). The present findings confirm these results. Marginal degradation of amalgam restorations is still a fairly significant cause for failure (11%), and this failure rate is significantly greater than that for composite restorations. This diagnosis of failure for amalgam restorations resulted in 5% replacements in 1972 and 21% in 1984 in Canadian surveys (30). This increase was considered to be a result of overtreatment as a result of disease reduction, increased manpower, and poor economic climate for dental services. Marginal degradation as a reason for replacement of amalgam restorations remains a controversial issue. Hamilton et al. (31) indicate that marginal failure is not a predictor of longevity, whereas Osborn et al. (32) claim that marginal fracture is a good forecaster of the loss of amalgam restorations.

All other reasons for replacement of glass ionomer restorations were at the 6–12% level, except discoloration, which both marginally and in the bulk of the material was a rare cause of failure. Since similar surveys of glass ionomer restorations have not previously been carried out in general practice, the results need to be confirmed, but preliminary data from a survey in selected general dental practices in the UK

(Wilson, Burke and Mjör, 1996. Unpublished observations) show similar results.

Pain/sensitivity was an infrequent reason for replacement for all three types of restorations. It was more common for amalgam restorations than for composite and glass ionomer restorations. Amalgam has traditionally been the material of choice for large restorations, and it is more likely that these restorations would tend to be most vulnerable to pain/sensitivity.

The overall longevity of composite and amalgam restorations in the present study is comparable to that in the 1978–79 survey (4) and to the 1987–88 surveys in Denmark (7, 8). The relatively short longevity of glass ionomer restorations is greater than that from a dental hospital in Australia (33). Recent data from three Australian general practices involving 20 clinicians indicate a much longer survival of glass ionomer restorations (34). In a UK study (Wilson, Burke and Mjör, 1996. Unpublished observations) the median longevity of glass ionomer restorations was 4.75 years. However, a direct comparison of longevities for different types of restorations should be made with great caution for several reasons; for example, the extended use of composite materials in stress-bearing areas in the present material may have an effect on the overall longevity of different restorations (8). Enhanced quality of the materials over time may also have more effect on one group of materials than on another. Furthermore, amalgam has been in use for about 100 years, while resin-based composite materials have been in use for 25–30 years and glass ionomer restorative materials for about 15–20 years. Thus, comparison of longevity data in cross-sectional surveys should be limited to restorations of the same category, using the same type of restorative material.

Results from cross-sectional surveys reported on and referred to in the present paper from general practice are very different from the results of longitudinal studies, which are conducted under controlled conditions in which the clinicians work without time constraints and often with dental students or dental hospital personnel as patients. As pointed out by Standford (35) and Tyas (36), results from controlled studies do not reflect the situation in general dental practice. For example, in the longitudinal study by Letzel et al. (22), secondary caries as a reason for failure of amalgam restorations was negligible, whereas in all cross-sectional surveys from general practice this particular clinical diagnosis was the main reason for failure of all direct restorative materials (4–14). Lack of calibration of the clinicians and the lack of verification and validation of the actual diagnoses are inherent difficulties in the type of surveys reported in the present paper. However, the studies have the decided advantage that the diagnoses reflect real-life dentistry. Any improvements in diagnosis, restorative technique, and materials must focus on the situation in general dental practice to have an optimal beneficial effect on the

treatment of patients. Controlled clinical studies are academically rewarding, but they may be of limited significance for general dental practice. Thus, a mapping out of diagnoses and problems as they are encountered in general practice is an essential part of health services research and research related to education of dental health professionals.

Acknowledgements.—The author would like to thank the staff at Praktikertjänst AB and the clinicians who participated in this survey for the time and effort spent to complete this survey. The assistance in the statistical analysis by Jacquelyn Moorhead, M.Stat., is greatly appreciated. This study was supported in part by NIH/NIDR grant 2P50 DE 09307–07.

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Received for publication 25 June 1996

Accepted 24 September 1996