The age of restorations in situ

Asbjörn Jokstad, Ivar A. Mjör and Vibeke Qvist
Dental Faculty, University of Oslo, Oslo, and NIOM, Scandinavian Institute of Dental Materials, Haslum, Norway, and School of Dentistry, Faculty of Health Sciences, University of Copenhagen, Copenhagen, Denmark

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In a cross-sectional survey the age of restorations in situ was recorded in three patient groups. Group A were randomly examined regular attenders, group B were irregular attenders randomly chosen from patient treatment records, and in group C the age of posterior gold and composite resin restorations was recorded in selected regular attenders. The study material included 8310 restorations in group A, 1281 in group B, and 500 restorations in group C. The three materials amalgam, composite, and gold accounted for more than 90% of all restorations. In group A 3.3% of the restorations were scheduled for replacement. The most prevalent reasons for replacement were secondary caries, bulk fractures of the restoration, and tooth fractures. The median age of the failed restorations was fairly similar to the median age of the acceptable restorations in situ among the regular patients (group A). The data indicate median ages of 20 years for gold restorations, 12–14 years for amalgam restorations, and 7–8 years for composite resin restorations. The restoration ages were influenced by the type and size of the restoration, the restorative material used, and possibly also the intra-oral location of the restorations. □ *Cross-sectional study; dental materials; dental restoration; operative dentistry*

Asbjörn Jokstad, Department of Prosthetic Dentistry, Dental Faculty, PO. Box 1109 Blindern, N-0317 Oslo, Norway

Different study strategies have been used to determine the longevity of dental restorations, which is reflected by the numerous terms and indices used to describe their clinical performance (1). One approach is to record the age of restorations needing replacement, using a cross-sectional study design (2–6). A common index used in these studies is the median age—that is, the function period of 50% of the failed restorations (2). Other study approaches are to record percentages of restorations still in service after a certain time (7) or to estimate survival rates in longitudinal studies or retrospectively from patient treatment records (7). Finally, indications of restoration longevity may also be derived by recording, cross-sectionally, the age of restorations that persist—that is, persistence analysis (8). The aim of the present survey was to record the age of restorations in situ made from different restorative materials in patients who visited their dentist on regular and irregular bases.

Materials and methods

Patient group A

After attending postgraduate courses in operative dentistry, Scandinavian dentists were invited to report the restorative status of the teeth of their regular patients. Written instructions were made available to the dentists who volunteered to participate in the survey. The material included a description of the aims of the survey, recording charts, an example of a completed recording chart, and guidelines for recording the condition of the restorations on the charts.

The criterion for the inclusion of a patient in group A was that he or she had been a regular attender for at least 10 years. The dentists were instructed to record the restorative status of the teeth of the first 10 consecutive such examined patients after receiving the written instructions described above. The guidelines for recording the con-

dition of the restorations on the charts were as follows:

1. The age must be given for each restoration if possible. In case a restoration had been extended by placing an adjoining restoration, these were counted as two restorations.

2. The extent of the restorations must be sketched on the recording chart. Amalgam restorations had to be marked with pencil shadowing and composite resins with ink; silicate and glass-ionomer restorations had to be indicated with 'Si' or 'Gi'. Cast restorations and crown and bridges had to be denoted with striped areas, and the material used, such as gold, metal-ceramic, gold-acrylic, and all-ceramic, had to be noted.

3. Restorations that were to be replaced had to be marked with red, and the main reason for replacement noted.

The DMFS index and average number of restorations per patient were calculated from the recorded data.

Patient group B

The irregular attenders were all patients in a private dental practice in a rural town in southern Norway. The treatment records of 40 patients were randomly selected among 560 patients who had attended the practice irregularly—that is, not yearly and without any recall appointments—during the past 10 to 20 years. During this period nine dentists had been engaged at the dental practice, although each patient had been treated by a different number of dentists. Only the location and the age of the restorations were recorded. Thus, the status of the restorations at the time of recording from the patient treatment records were unknown.

The DMFS index and average number of restorations per patient were calculated from the recorded data.

Patient group C

Few posterior gold and composite resin restorations were recorded among the regular patients (group A). To increase the number of such restorations in the survey material, a special request was made to the dentists in group A to also include patients with such restoration types. Thus, the group-C data differed from those of group A in the patient selection and in the focusing on the posterior gold and composite resin restorations.

No DMFS index or average number of

Table 1. The prevalence of different dental materials used for restorations recorded in three patient groups: regular attenders ($n = 383$), irregular attenders ($n = 40$), and selected patients with gold and composite restorations ($n = 152$)

	Group A, regular patients		Group B, irregular patients		Group C, gold/composite subgroup	
	n	%	*n*	%	*n*	*
Amalgam	5404	(64.8)	781	(61.0)	0	
Composite	2263	(27.4)	316	(24.7)	56	
Gold	256	(3.1)	58	(4.5)	292	
Glass-ionomer	38	(<1)	14	(1)	0	
Silicate	69	(<1)	32	(2.5)	0	
Gold-acrylic	75	(<1)	31	(2.5)	23	
Metal-ceramic	135	(1.6)	49	(3.8)	91	
All-ceramic	25	(<1)	0		38	
Unknown/no age	45	(<1)	0		0	
Total	8310		1281		500	

* The percentages are presented only in the groups for which the full dental status was recorded.

restorations per patient was calculated, since the recorded restorations were selected.

Patient groups A and C

All tooth surfaces—that is, 100 posterior and 48 anterior surfaces plus 12 incisal edges—were classified as intact, restored, or missing. The restored surfaces were either complete, fractured, carious, or replaceable for other reasons. The restorative material used and the age of the restoration covering the specific tooth surface were also recorded. Finally, the patient age and the number of years since the patient was first treated were also recorded. In case the restoration age was not reported, the restoration age was recorded as the age of the patient treatment record.

The data for the separate restored surfaces were compiled using a standard database program (dBaseIII, Ashton-Tate, Amsterdam, The Netherlands). An algorithm enabled the database program to transform automatically the observation unit from tooth surface to single- or multi-surfaced restorations when adjoining surfaces had the same age. In the present survey the statistical unit for the calculations of age was the individual restoration.

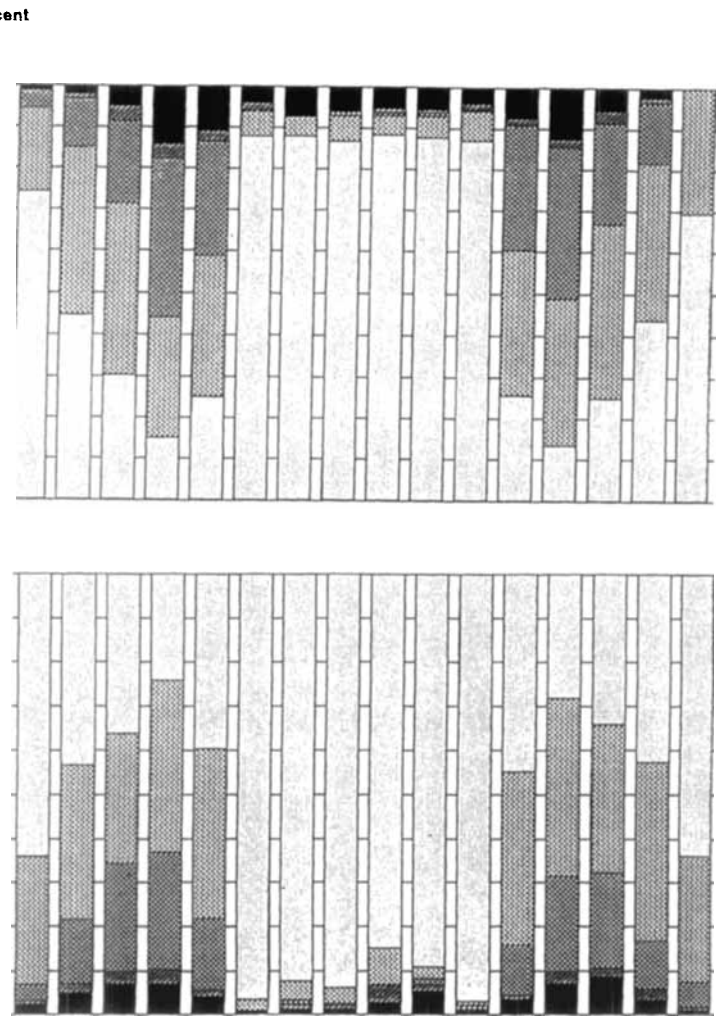

Fig. 1. The number and location of restorations by size. Light shading represents one-surfaced restorations, increased shading represents two-, three-, and four-surfaced restorations, and black indicates crowns. The numbers above the mandibular (lower) and under the maxillary (upper) columns represent the number of restorations recorded (n = 10,091).

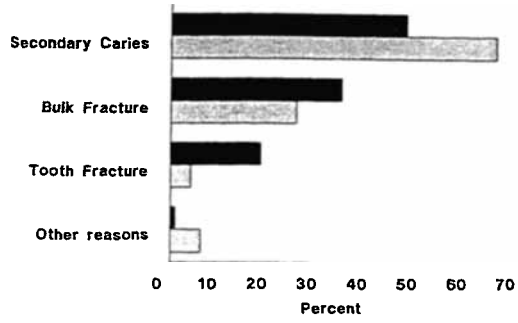

Fig. 2. The reasons for replacing amalgam (dark shading; $n = 153$) and composite resin restorations (light shading; $n = 69$).

The calculation of restoration median ages could theoretically be influenced by the age of the patient treatment record. Separate calculations were made for amalgam, composite resin, and gold restoration subgroups as functions of the age of the patient treatment records, to assess this possible association.

Results

The regular patients (group A, $n = 383$) included 8310 restorations, recorded by 41 dentists. The dentists practiced in Denmark ($n = 30$), Norway ($n = 7$), Sweden ($n = 2$), and Finland ($n = 2$). The patients' average DMFS index was 64 (varying from 2 to 140), the average number of restorations per patient was 21.6, and the mean age of the patients was 45 years. The irregular patients (group B, $n = 40$) included 1281 restorations, completed by 9 dentists in 1 Norwegian clinic. The patients' DMFS index varied from 62 to 140 (mean, 84). The average number of restorations per patient was 32, and the mean age of the patients was 54 years. The selected patients (group C, $n = 152$) with posterior gold and composite resin restorations included 500 restorations by 24 dentists in Denmark. The average age of these patients was 50 years.

The recorded restorative materials are shown in Table 1. In the regular patients (group A) the three materials amalgam, composite, and gold accounted for 95% of all restorations, whereas the respective number for the irregular patient group (B) was 90%. Other restorative materials used were silicate and glass-ionomer cements, metal-ceramics, gold-acrylics, and ceramics. The dental material used or the age had not been recorded for 45 of 10,091 (0.5%) restorations.

The number, size, and location of the restorations in the whole study sample is shown in Fig. 1. One-surfaced restorations prevailed in the anterior teeth, and multi-surfaced restorations in the posterior teeth. The maxilla had a higher proportion of multi-surfaced restorations than the mandible, and these restorations were also larger than the restorations in the mandible.

The examination of the regular patients (group A) resulted in 271 restorations scheduled for replacement—that is, 271 of 8310 = 3.3% of the restorations. The failure rates of the amalgam (3.4%) and composite resin (3.2%) restorations were fairly similar, although the type of restorations and the reasons for failure varied slightly (Fig. 2). Discoloration was rarely the major reason for replacement of the composite resin restorations ($n = 6$; 2%).

The median age—that is, the age of 50%—of the failed restorations and of the acceptable restorations in situ among the regular patients (group A) was 10 years. In both the regular and irregular patients (groups A and B) the ages of the restorations varied slightly with the intraoral location (Fig. 3), with median ages between 9 and 11.5 years. The anterior restorations in the maxilla showed slightly lower median ages than those in the mandible. The posterior restorations had similar ages in the upper and lower jaws. Moreover, the median ages were almost similar on the patients' right and left sides.

The restorations made in gold had longer median ages than the other dental materials for all restoration types (Table 2). Furthermore, the median age of different restoration classes varied slightly. Finally, the median restoration ages were fairly comparable in patient groups A, B, and C (Table 2). The restoration group with the longest median age consisted of 14 class-IV gold

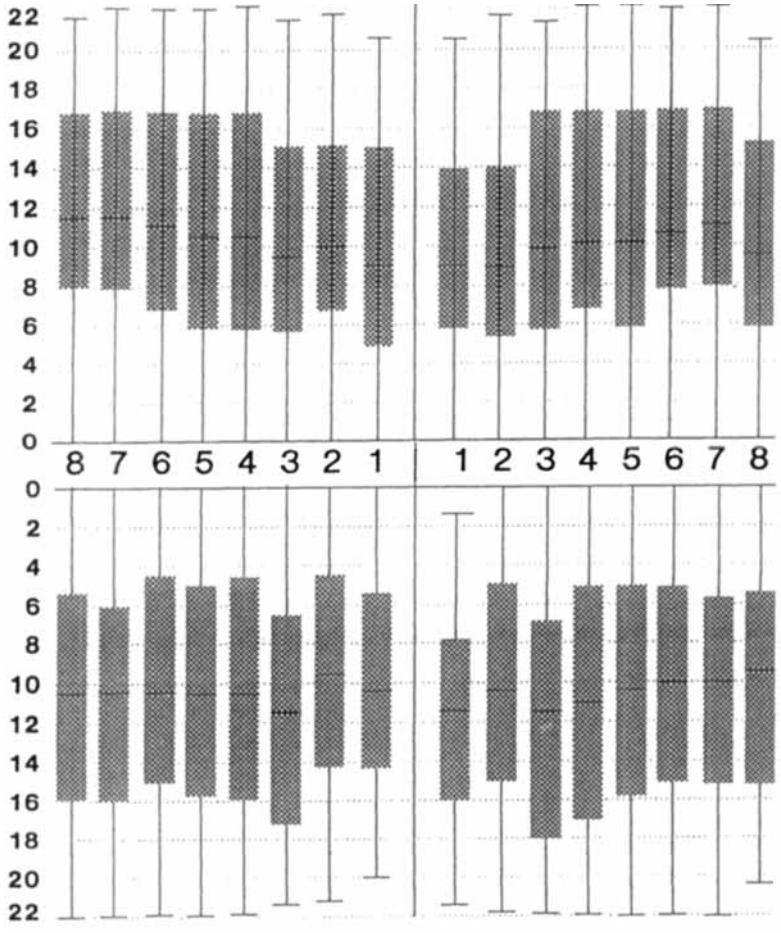

Fig. 3. The age of restorations in situ by intraoral location in the regular and irregular patients (groups A and B, n = 9591). The horizontal lines in the shaded boxes represent the age of 50% of the restorations in situ—that is, the median age—and the upper and lower edges of the shaded boxes indicate the upper and lower 25% quartiles of the restoration ages. The vertical lines indicate 95% of the restoration age ranges.

restorations among the selected patient group (C), with a median age of 20 years. The shortest median age was 2 years for 27 class-V glass-ionomer cement restorations, in the regular patient group (A), most of which were repairs of crown margins. All large restorations had shorter median ages than the small restorations, both among the regular and the irregular patients (groups A and B).

The association between the median age of the restorations and the length of the patient treatment records in the dental practice is shown in Fig. 4. The median age increased with the treatment record for the amalgam, gold, and composite resin restorations up to a certain point, depending on the restorative material. The median age recorded for amalgam restorations in patients with 10- to 12-year-old treatment records was 8 years, increasing with the treatment record age and remaining around 12–14 years when the treatment records were more than 16 years old. The median ages of the composite resin restorations remained constant around 7–8 years, despite increasing age of the patient treatment records. For the gold restorations the median ages increased with increased age of the patient treatment records up to 22 years and remained around 20 years with the older treatment records.

Discussion

The representativity of the data from the present survey varied with the patient groups and their selection procedures. Although the regular patients (group A) were included randomly, the representativity of these data is uncertain, since the dentists participating in the present survey may have had above-average qualitative treatment standards, shown by their voluntary participation in the present survey. The irregular patients (group B) were also selected randomly but from only one dental practice in a rural town in southern Norway. The data from group B can, therefore, not be extrapolated to the population, owing to the limited spectrum of patients and geographic area. Nor is the subgroup of regular patients with posterior gold and composite resin restorations (group C) representative of the population.

The best estimates of the attainable lifetime of dental restorations are made by using survival statistics on clinical prospective longitudinal study data (1). However, the generalization of the results from such studies is hampered by problems such as selection of patients, loss of patients, and the few, and often specially trained, dentists involved in the studies (9). Moreover, dentists vary in their clinical decision-making (10, 11), and only studies involving many dentists may thus provide relevant information on the actual longevity of dental restorations. An additional advantage of using a cross-sectional study design involving many dentists and patients is that it is possible to obtain information on the relative use of different materials, the rate of replacement, depending on variables such as type of restoration and material, and the prevailing reasons for replacing restorations (3–6).

The group-A data in the present survey might have been subjected to survival statistic modeling. However, the data would have had to be considered 100–3.3% censored. In situations with high proportions of censored data, lifetime estimates compiled on the basis of survival statistics may be unreliable (12). On the other hand, persistence analyses, such as used in the present paper, may underestimate true restoration longevity, since restorations that persist would not have had the time to fail (8).

It is probable that regular attenders are more conscious of dental health than irregular attenders. Furthermore, it is common that dentists at recall control correct minor discrepancies, which otherwise jeopardize the prognosis of restorations. One should, therefore, presume an improved longevity of the restorations in regular attenders (group A) compared with those in the irregular attenders (group B). However, there are no experimental investigations in the literature in which such a hypothesis has been tested, and there are opinions critical of the assumption (13). The present survey data showed fairly similar restorations ages for the regular and irregular attenders, with a few exceptions. Thus, the lack of difference between the two patient groups may support the hypothesis that regular attenders often are subject to restorative treatment on questionable indications (14–16).

The reasons for replacement coincide with several other cross-sectional studies, with secondary caries as the prime reason for replacement (17). The disparities in the replacement reasons between amalgams and composite resins were probably caused by the different cavity types and sizes (Fig. 2). It is important in this context to keep in mind that the composite resin restorations were usually one-surface restorations in anterior teeth, whereas metallic restorations were usually multisurfaced in posterior teeth. Further analyses of the effect of the clinical variables on the replacement reasons were not carried out because of the low number of failed restorations.

The present survey showed similar age distributions for the failed and the acceptable restorations in situ, suggesting that the age of failed restorations in cross-sectional studies may be a valid indicator of clinical performance (2). On the other hand, the validity of using the median age of failed restorations as a criterion for restoration performance has been questioned by other authors (18).

The prevalence of failed restorations in the regular patients (group A) was relatively low, as compared with other quality assessment studies of dental restorations in

Table 2. The median ages (M; in years) of different restorations in accordance with restoration type and dental material used. Recorded in three patient groups: regular attenders (n = 383), irregular attenders (n = 40), and selected patients with gold and composite restorations (n = 152). The median ages are only shown for restoration types with more than 10 observations

	Group A, regular patients		Group B, irregular patients		Group C, gold/composite subgroup	
	M	(n)	M	(n)	M	(n)
Class I						
Amalgam	14	803	16	108		0
Composite	4	22		6		0
Gold		0		0		1
Class II, MO and DO						
Amalgam	11	2027	10	282		0
Composite	5	21	3	40	5	21
Gold	17	15		5	15	17
Class II, other two surface						
Amalgam	10	63		8		0
Composite	7	28	3	13		0
Gold		0		0		0
Class II, MOD						
Amalgam	11	1023	10	172		0
Composite	4	40		5	5	11
Gold	16	34	16	12	16	78
Class II, other three surface						
Amalgam	6	83	6	11		0
Composite	4	10		0		1
Gold		0		0		0
Class II, four surface						
Amalgam	7	87	7	14		0
Composite		9		4		9
Gold	17	53	16	14	12	62
Class III						
Amalgam	13	238	14	45		0
Composite	9	1461	7	100		0
Gold		3		0		1
Class IV						
Amalgam		0		0		0
Composite	7	72	7	44		3
Gold		10		1	20	22
Class V						
Amalgam	11	1045	9	130		0
Composite	6	580	7	98		0
Gold		6		0		9
Crowns						
Amalgam	8	35	8	11		0
Composite	3	26		6	4	11
Gold	15	135	15	26	15	102
Gold acrylic	12	75	14	31	19	23
Metal-ceramic	8	135	9	49	11	91
All-ceramic	17	25		0	18	38
All restorations						
Amalgam	11	5404	11	781		0
Composite	8	2263	7	316	5	56
Gold	16	256	16	58	15	292

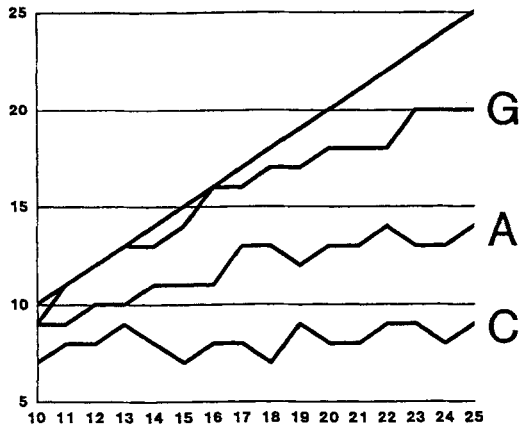

Fig. 4. Median ages of restorations made from amalgam (A), gold (G), and composite resins (C) as a function of the age of the patient treatment records. The diagonal line represents the theoretically highest possible age of the restorations—that is, the age of the patient treatment record.

Scandinavia (11, 19). However, these assessments were made in dental school environments, which do not reflect the situation in 'real-world' dental practices (20). With a 3.3% failure rate at the last examination of the group-A restorations, 15 examinations are needed before 50% of the restorations are recorded as failed (3.3%*15 = 50%). As the observed median restoration age was 10 years, this implies that the patients in the present survey on an average visit their dentist every 8 months. This frequency seems realistic and thus confirms the representativity of the results.

A general problem with retrospective clinical analyses is that the patient treatment records often do not extend back to the date of the restoration placement. Estimating restoration longevity by survival statistics may in these cases be biased owing to the truncated observation period (1, 8). By calculating the median ages as functions of the age of the patient treatment records (Fig. 4), we obtained data in the present survey indicating median ages of 20 years for gold restorations, 12–14 years for amalgam restorations, and 7–8 years for composite resin restorations.

The median restoration ages of the restorative material varied. The higher median age of the gold restorations than amalgam and the significantly higher age of the gold than the composite restorations confirm previous observations (21, 22). This trend is also in agreement with the longevity data obtained from previous surveys and survival studies of dental restorations (1). However, it should be emphasized that comparisons between median ages of different dental materials must be evaluated carefully. In the clinical situation the choice of which dental material to use is often restricted by patient variables and functional and esthetic limitations. Unfortunately, the study sample included such a low number of posterior gold and composite resin restorations that any intermaterial comparisons of class-2 restorations were precluded. Moreover, composite resins have only been in use as posterior restorations for a limited period, and their calculated median ages are therefore necessarily underestimations of their true age potential.

The restoration ages were, furthermore, influenced by the type and size of the restoration, and possibly also by the intraoral location of the restorations. The relationship between restoration size and age is also in agreement with other longitudinal and cross-sectional studies (1). The observation in the present study that facial composite resin restorations had a lower median age than the other single-surfaced composite resin restorations may reflect a stricter requirement for high esthetics in this area. However, in the present survey few restorations failed because of discoloration, which contradicts results by Qvist et al. (4, 6). These contradictory observations may reflect improvements in the quality of composite materials over time or too low replacement frequencies in the restoration recordings.

Crowning teeth can theoretically be made with many types of dental materials. In the present material the crowns made from composite resin, however, had a markedly lower age than the other materials (Table 2), which indicates that this material should not be used for crowns. This is in accordance with other clinical studies (7, 23). The higher age of gold crowns than of metal-ceramic and

gold-acrylic crowns is also in accordance with previous studies (7, 23, 24). On the other hand, the relatively high median age of the all-ceramic crowns contrasts with other data (7, 23–25). In the present study 45 of the 63 all-ceramic crowns were located in the upper front teeth. The reported 19-year median age of the all-ceramic crowns is, therefore, probably not representative, as these patients furthermore were selected. Indeed, the high age of such restorations also in the regular patients (group A) shows that all-ceramic crowns may perform satisfactorily for many years, provided the technical limitations of the material are taken into account when placing the crown. However, previous studies conclude that all-ceramic crowns either fracture after relatively short periods or remain in situ for many years (7, 25).

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