Selection of restorative materials in permanent teeth in general dental practice

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In this study, we recorded the type of restoration and the materials used in 24,429 restorations in permanent teeth by 243 Norwegian clinicians in general practice. Demographic information included patient's gender and age, and clinician's gender, years since graduation, and practice setting (private or salaried). The overall recorded use of restorative materials in permanent teeth shows that 32% are amalgams, just over 40% composites, and about 25% glass ionomer type materials. Three percent are "other" materials. A marked shift away from amalgam restorations is noted both in the clinician's estimated use during the last 2 decades and by comparing the present use of materials with that in failed restorations. Tooth-colored materials are more commonly used in adolescents, especially glass ionomer materials, and in female patients. In patients ≤18 years, amalgam is used in 25% of all restorations. The use of amalgam is similar in private practice and in public health service practice, but private practitioners use more composites and salaried dentists more glass ionomers. The clinician's gender does not have any effect on the selection of restorative materials. The change from amalgam to tooth-colored material is particularly noticeable for Class I and Class V restorations. Amalgam is the predominant material in 2- and 3-surface Class II restorations. □ *Amalgam; classes of restorations; composite; gender differences; glass ionomer*

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Factors recognized as important in the selection of restorative materials include size and location of the prepared cavities and physical properties of the materials. The improved caries situation has called for a shift in operative procedures, especially in the use of restorative materials (1). Esthetics, too, has become increasingly important over the past 20–30 years, as manifested by the increased use of tooth-colored restorative materials (2–5). Furthermore, the general biological awareness in society at large has focused attention on the toxic and allergenic properties of restorative materials. In addition, glass ionomer materials have been introduced. Despite the fact that changes in the use of restorative materials have an impact on the initial and long-term cost of dental treatment (6), little information is available to monitor these shifts. Such data are important when making assessments of the cost-effectiveness of the restorative care provided by the dental healthcare system (7).

Other factors that may affect the selection of restorative materials include the dentition treated, the age and gender of the patient, the type of practice (private or public health), socio-economic status, and the experience and gender of the clinician. Third-party payment systems, including insurance coverage, and political restrictions on the use of certain materials may also have an effect on the availability and selection of restorative materials.

The aim of the present study was to estimate the past use of restorative materials and record the present use in general dental practice, including materials used in primary restorations, replacement restorations, and those in failed restorations. The impact of the class of restoration, patient's and clinician's gender, experience, and type of practice were also evaluated.

The present project was carried out in Norway, an industrialized country with a high gross national product. The dentist/population ratio is among the highest in the world, ≈1/1000 countrywide, but with a skewed distribution resulting in a high concentration of dentists in urban areas. Oral hygiene is generally good, and most individuals brush their teeth once or several times a day using fluoride toothpaste (8, 9). Restorative dental treatment is free through age 18 and a school dental service covers almost all individuals up to this age. The cost of restorative treatment for adults is fully covered by the patients, whether treated in private practice or by salaried dentists in the public dental health service. In the rural part of Norway, the dentist may be part-time employed in the school dental service and work part-time as a private practitioner. In other areas, the dentist may be 100% salaried and work part-time on children and adolescents and part-time on a fee-for-service basis on adults, the fee being paid to the public dental health service. The school dental service does not allow freedom in the selection of the dentist, but adult patients are free to select treatment by any dentist; however, the geographic distribution of dentists limits the choice in rural areas.

Material and methods

Recording forms were mailed to every fourth, randomly selected member of the Norwegian Dental Association,

1000 mailings in all, 500 to private practitioners and 500 to salaried clinicians employed by the Public Dental Health Service. More than 95% of all practicing dentists are members of the national dental association. The recording forms were accompanied by a letter inviting the clinicians to participate in the survey. The clinicians were instructed to report on 100 consecutively inserted restorations starting on a specific date during the Fall of 1997. The data requested included the number and surfaces of the tooth treated, class of restoration, and the materials used. Restorations at the cusp tip or of the incisal edge had to be designated Class VI restorations. "Others" included indirect restorations such as inlays, onlays, crowns and temporary fillings. A special column allowed for comments pertaining to the restorations inserted.

Demographic information included age and gender of the patients and the gender, number of years since graduation, and practice setting (private or public health practice) of the clinician.

Prior to starting the consecutive recording of restorations, the participating clinicians were asked to *estimate* (in percent) their current and past use of amalgam, composite, glass ionomer, resin-modified glass ionomer and other dental restorative materials in Class I and Class II restorations. The past use was assessed in 5-year increments; 1–5, 6–10, 11–15 and more than 15 years ago. The recorded use of materials is referred to here as the actual use.

The material used in the primary restoration of any tooth was reported for primary caries, non-carious defects such as wedge-shaped abrasions, abfractions, eroded sites or traumatic fractures, and "others". The materials selected to replace failed restorations were recorded irrespective of the reason for failure. In addition, the restorative material of the failed restoration was noted.

The clinicians were not provided with any guidelines for the selection of restorative materials. Furthermore, they were not calibrated in the diagnosis of reasons for placement of the first restoration on a tooth surface, nor in those used for replacement of restorations.

The study was mainly of a descriptive nature, and the Chi-square procedure was used to test measures of association between dependent and independent variables. All data management and statistical analyses were performed using the Statistical Analysis System (SAS).

Results

Demographics

A total of 312 dentists responded to the survey, an overall response rate of 31%. However, 68 respondents did not record restorations for a variety of reasons; 33 were specialists, of which 23 were orthodontists, and 35 were in administrative positions, retired or on sick leave. Thus, 243 clinicians participated in the study; an effective response rate of 24%.

The mean number of years since graduation of the participating clinicians was 21.7, with a range of 1–43. The female:male ratio of the respondents was 34:66 and 58% were private practitioners. The actual ratio in the Dental Association is 30:70 and 64% are private practitioners. Further detailed information showed that 68% of males were private practitioners, whereas 61% of the women were in salaried positions.

Most of the clinicians completed the requested information on 100 restorations, but a few reported on less and some on more than 100, making the total number of restorations 24,429 (12,211 in female and 12,218 in male patients). Primary restorations comprised 51% of the total and 49% were replacements. In adult patients $\geq$19 years, 32% were primary restorations and 68% replacements. In those $\leq$18 years, 85% were primary restorations and 15% replacements. In both adults and adolescents, about 90% of all primary restorations were placed due to caries. The mean age of the patient was 32.9 years, with a range of 1–97 years. The female:male ratio of the patients was 50:50.

Estimated and recorded use of restorative materials

The estimated current and past use of materials for Class I and Class II restorations in 5-year increments is shown in Fig. 1. The decline in the use of amalgam and the increase in the use of composite materials over the last 2 decades is apparent. According to these estimates, glass ionomer materials came into use 10–15 years ago. After the introduction of resin-modified glass ionomers 5–10 years ago, their use has gradually increased, partly at the expense of the traditional glass ionomer materials, which were estimated to have declined relatively over the last 5 years (Fig. 1). "Other" materials, comprising a heterogeneous group including such diverge restorations as gold

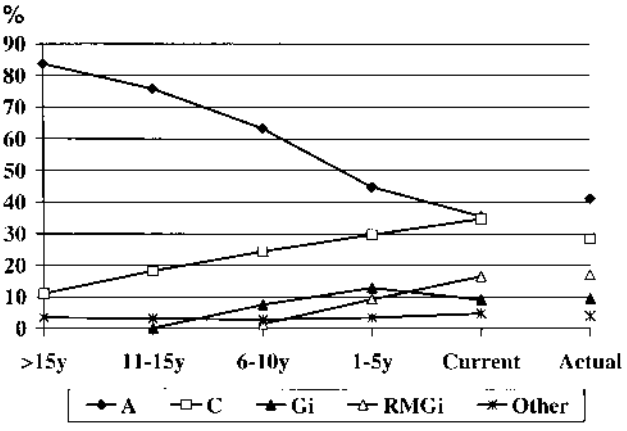

Fig. 1. The estimated use of materials in Class I and Class II restorations expressed as percent of current use and at 5-year intervals up to and more than 15 years ago. Note the crossover after the 1–5 year interval for the 2 types of glass ionomer materials. The recorded use in this survey is shown on the right of the illustration. A, amalgam; C composite; Gi, traditional glass ionomer materials; RMGi, resin-modified glass ionomer materials.

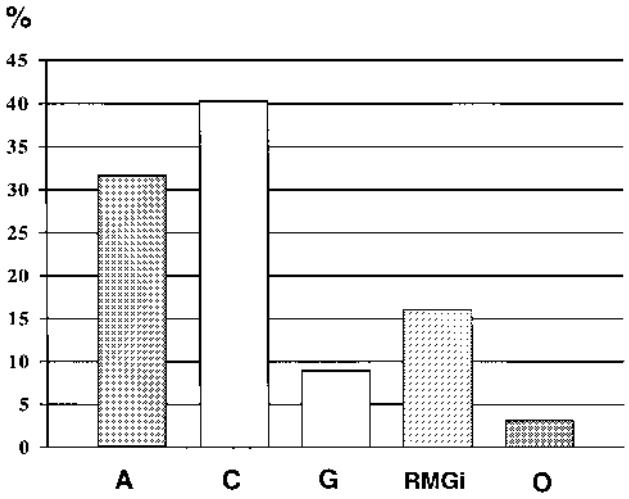

Fig. 2. Materials used in all restorations inserted in permanent teeth, irrespective of type, patient's age and gender, and clinician's practice setting, gender or years since graduation. A, amalgam; C, composite; G, traditional glass ionomer material; RMGi, resin-modified glass ionomer material; O, other materials.

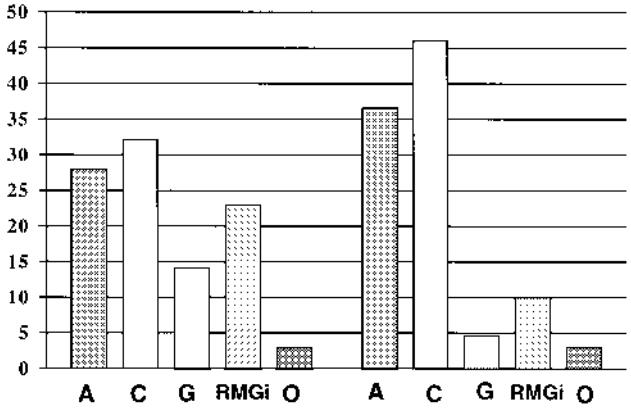

Fig. 3. Materials used in primary restoration in permanent teeth with caries lesions (left) and in those replacing failed restorations (right). A, amalgam; C, composite; G, traditional glass ionomer material; RMGi, resin-modified glass ionomer material; O, other materials.

castings, porcelain inlays, and temporary fillings, have remained at the 3–4% level during the last 2 decades.

The actual recorded use of materials in Class I and Class II restorations in the present survey is shown on the right side of Fig. 1, where it can be seen that clinicians on average currently use slightly more amalgam and slightly fewer composite materials than they had estimated. Glass ionomer, resin-modified glass ionomer, and other materials showed consistent results for estimated and recorded use.

The recorded use of materials in all types of restorations inserted showed that almost a third were amalgams and two-thirds were tooth-colored restorations, of which 40% were resin-based composites (Fig. 2). However, the selection of material was dependent on many factors, e.g., whether it was for primary restoration in a tooth in the treatment of caries or for replacement restorations (Fig. 3). In the material as a whole, caries was the reason for the placement of 93% primary restorations, while 4% were due to non-carious defects and 3% to "other" reasons. There was a significant association ($P < 0.05$) between the selection of restorative materials and the placement of primary versus replacement restorations. It was apparent that glass ionomer type materials were used more in the treatment of primary caries than for replacement of failed restorations. In non-carious defects, tooth-colored materials were predominant and 61% were composites. "Other" materials comprised only about 3% of both primary lesions and replacements.

Patient age had a significant impact on the use of direct restorative materials, especially in the treatment of primary caries. Tooth-colored materials, especially glass ionomer type materials, were used more in patients $\leq$18 years than in patients $\geq$19 years. Only 25% of all restorations inserted in the treatment of primary caries in adolescents were amalgams; 30% were composites and 42% glass ionomer type of materials. In adults, 32% amalgams, 35% composites, and 31% glass ionomers were used in the treatment of primary caries.

A subdivision of the data on the basis of patient gender showed that more tooth-colored materials were used on female (64%) than on male patients (57%), especially in the treatment of primary caries (73% vs 65%). The female:male ratio for tooth-colored restorative materials of failed restorations was 40:36%. Resin-based composites comprised the largest part of tooth-colored materials in failed restorations. In the treatment of primary caries, glass ionomer type materials were predominant.

The results showed that practice setting had an effect on the selection of materials. More composite materials were used by private practitioners than by salaried dentists. However, glass ionomer type materials were used more frequently by salaried dentists than by private practitioners, and the use of amalgam was similar in both practice settings. It should be noted that salaried dentists treated more younger patients than private practitioners. The clinician's gender had no significant effect on the use of any of the groups of restorative materials recorded in this study; in fact, the difference between female and male clinicians was 1% or less for all materials, including "other" materials.

The effect on the use of the different materials as a function of number of years since graduation was evaluated by subdividing the clinicians into 4 groups based on years since graduation. Small differences were noted from group to group. By comparing the most recently graduated group with those that had more than 30 years clinical experience, it was apparent that the older age group used 8% more amalgam and 4% more composite than the younger clinicians. The young clinicians used 10% more glass ionomer materials and 2% more "other" materials than their older colleagues. These differences may be

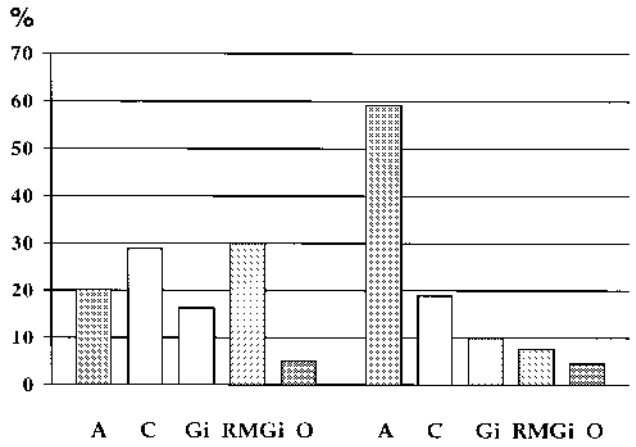

Fig. 4. Materials in all new restorations inserted (left) and in failed restorations Class I (right). A, amalgam; C, composite; Gi, traditional glass ionomer material; RMGi, resin-modified glass ionomer material; O, other materials.

explained by the fact that the median age of patients treated by young dentists was 15 years lower than that of the group treated by the more experienced dentists.

Seventy-six percent of Class I restorations inserted were tooth-colored and the majority of these were glass ionomer type restorations. This distribution of materials was different from that in the failed Class I restorations, which were predominantly amalgams (Fig. 4). Amalgam was the most common material in both 2- and 3-surface Class II restorations, especially in failed restorations, but also in all new restorations (Fig. 5). Composite materials were used in almost 70% of all new Class III restorations and in 85% of all Class IV restorations. Most of the failed Class III and Class IV restorations were also resin-based composites. Class V restorations, on the other hand, showed a wide distribution of materials similar to that of Class I restorations (Fig. 4). The increased use of tooth-colored materials, especially glass ionomer type materials, in new Class V restorations was significantly different ($P < 0.001$) from that of the failed Class V restorations.

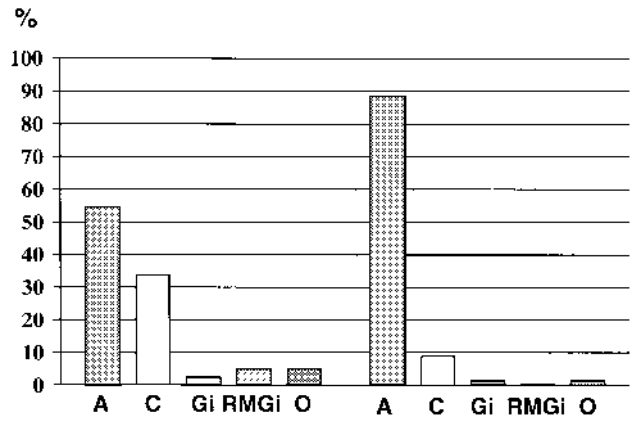

Fig. 5. Materials in all new 3-surface Class II restorations (left) and in failed restorations (right). A, amalgam; C, composite; Gi, traditional glass ionomer material; RMGi, resin-modified glass ionomer material; O, other materials.

Discussion

The 24% response rate in the present study was relatively low, which was to be expected following an open invitation to a randomly selected sample of all practicing members of the Norwegian Dental Association. It compares favorably with open invitations in similar studies in the USA (21%) (10), Germany (21.2%) (11), and in the UK (10%) (12). A better rate of participation (71–78%) has been obtained when the recordings were made by clinicians participating in continuing dental education courses (5, 13–15). Open invitations to a specialty group of dentists have resulted in an intermediate rate (47%) of participation (16).

The respondents represented an experienced group of clinicians covering all geographic areas with an overall relatively lower rate of private practitioners (21%) a slightly higher rate of salaried clinicians (28%) responding and a slight under-representation of male dentists. The mean years since graduation of the clinicians indicated that mean age of female clinicians, especially those in private practice, was slightly lower than the national average and that of male clinicians slightly higher. Overall, the present sample is considered to reflect the dental care providers in Norway, and as pointed out by Martin and Bader (17), a study based on a large group of unselected patients by a large group of unselected general dentists will increase confidence in generalizing the findings.

An estimation of the past use of restorative materials can only be expected to indicate major trends in the use of materials. However, estimated current use and actual recorded use show good agreement, although the possibility that clinicians adjusted the estimated current use to their own recorded use cannot be excluded. A comparison of the materials used in failed and in all new restorations confirms the changes that have occurred. Furthermore, the estimated use of materials for Class I and Class II restorations in Norway during the past 2 decades is consistent with the changes in the use of amalgam and resin-based composite materials that have been found in Florida (5). A more marked change in the use of materials for Class I and Class II restorations during the past 2 decades has been reported in Sweden (4). In 1978/79, Swedish dentists used amalgam as the direct restorative materials in 2 out of every 3 Class I and Class II restorations, while in 1993/95 only 1 of every 5 were amalgam restorations.

Teaching programs for posterior composites at dental schools in North America and Europe have restrictive indications for 2- and 3-surface Class II restorations (18, 19), and the present findings are in conformity with the restricted indications. Also, by comparing the past prevalence of materials in failed restorations with that in newly inserted Class II restorations, a significant shift in favor of resin-based composite materials has occurred.

Similar changes have been expressed (2, 3) and recorded in surveys similar to those in the present study (4, 5, 13).

In adults, replacement of failed restorations comprised 60–80% of all restorations inserted in the 1960–80s (7, 14, 15, 20, 21), which is in conformity with present findings. Recent data from Sweden indicate that this proportion has diminished to about 50% (4, 13). Any change in the proportion of primary and replaced restorations is likely to have an effect on the selection of restorative materials. In patients ≤18 years of age, only 15% are replacements, which is slightly less than that reported in Denmark in a similar survey in 1987–88 (14, 15).

The use of glass ionomer materials is relatively high, especially in the treatment of primary caries and in adolescents. Their overall use in adults is similar to that in a Swedish study (19%) (4). In Florida, glass ionomer materials are reportedly used in 5–6% of all restorations (5). The estimated and recorded use of glass ionomer materials shows a trend toward a preference for the resin-modified type. The easier handling of these materials, especially the possibilities to finish the restorations at the time of insertion, is a likely explanation for their preference over the traditional glass ionomer materials.

A reduced rate of primary caries has been shown on surfaces adjacent to glass ionomer restorations compared to surfaces adjacent to amalgam restorations after 3 years (22, 23). Another 3-year study of 239 open sandwich restorations with glass ionomer cement exposed at the cervical margin resulted in only one restoration with secondary caries (26). Thus, the potential benefit of the fluoride release on the development of secondary caries is one of the perceived advantages of glass ionomer materials and probably a reason for their selection. However, recent studies have questioned any fluoride effect from these materials, since secondary caries is the main reason for the replacement of glass ionomer restorations in general dental practice (12, 13, 25). The relatively short-lasting release of fluoride from glass ionomer restorations might explain these observations (26, 27). Furthermore, the clinical diagnosis of secondary caries may not be directly associated with the histopathology of caries lesions (28). Recent studies (29) also indicate that the fluoride release from glass ionomer materials may be effective in reducing secondary caries in vitro but not in vivo. However, the indications for these materials in small primary lesions based on their physical and esthetic properties may be the decisive reasons for selecting the materials. On the other hand, it is reassuring to note that preventive dentistry results not only in less primary caries and in lower DMF, but also in a reduction of secondary caries (30, 31). Any additional beneficial effect of fluoride may, therefore, be difficult to demonstrate.

"Other" materials comprised mainly indirect restorations like inlays, onlays, and crowns. The estimated and recorded use indicates about a 3% use in the present study. This finding is in conformity with data from Sweden (4). In Florida, 11–18% of all restorations are estimated to be "other" materials (5). This difference between Scandinavia and Florida could be due to different indications for indirect restorations, but it may also reflect a difference in the need for more extensive restorations in Florida than in Scandinavia.

The results from the present study indicate that tooth-colored materials are used more frequently on female than on male patients, reflecting a higher demand for esthetic materials by women than by men. Such differences are not noted in the materials of failed restorations. Adolescents also receive more tooth-colored restorative materials, probably because the indications for these materials (18, 19) are greater in the younger than in the older population, since they generally need relatively small restorations. Those that received glass ionomer restorations at a young age may also have been considered to have been at high risk for caries and, therefore, were given the benefit of the alleged anticaries properties of these materials.

The clinician's gender has no effect on the selection of restorative materials. The fact that private practitioners use relatively more composite materials may reflect a difference in the patient populations in private and in public dental health practice.

The consequences of the marked shift in the use of restorative materials during the last 2 decades will undoubtedly have an effect on the immediate and long-term cost of restorative dentistry (6, 25). The reasons for the increased cost are due to an initial higher cost of composite restorations (6, 32, 33) and the short longevity of these restorations in general practice when compared to amalgam restorations (15, 34, 35). The short longevity of glass ionomer restorations in general dental practice (12, 15, 34–36) will be important in an assessment of the long-term cost of restorative treatment (6), especially for young adults, since these materials are used extensively in adolescents. Thus, the expected financial benefit of improved oral health with less caries may be reduced or eliminated by the selection of more costly treatment alternatives.

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